Economics of
Energy and Natural resources

Lesson 1. *Economics of Natural Resources: basic concepts*

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Economics Thought

Classical economists: 1700-1800 century

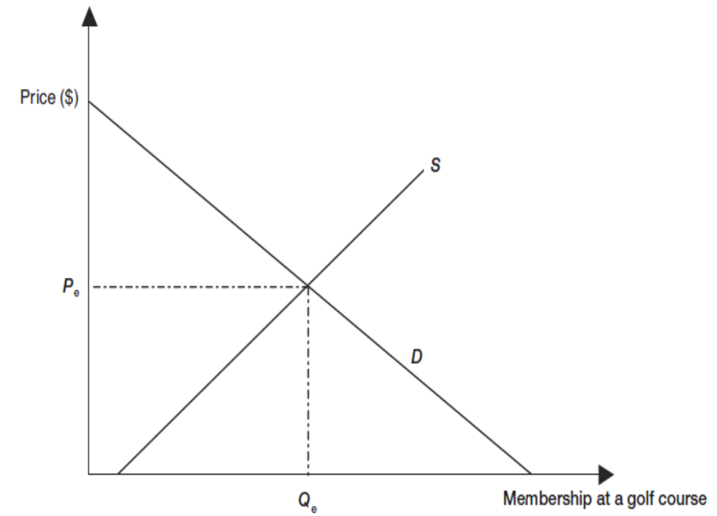
- Development of natural resource (NR) economics;
- Adam Smith: markets and allocation of resources, invisible hand
- Malthus: population growth geometric and food output growth arithmetic
- Ricardo: subsistence wage level in steady state, land in varying quality
- John Stuart Mill: diminishing returns, but also growth of knowledge and technical progress. Amenity values, first environmental economist?

Neoclassical economics: marginal theory and value in exchange (and diminishing returns).
Natural resources are:

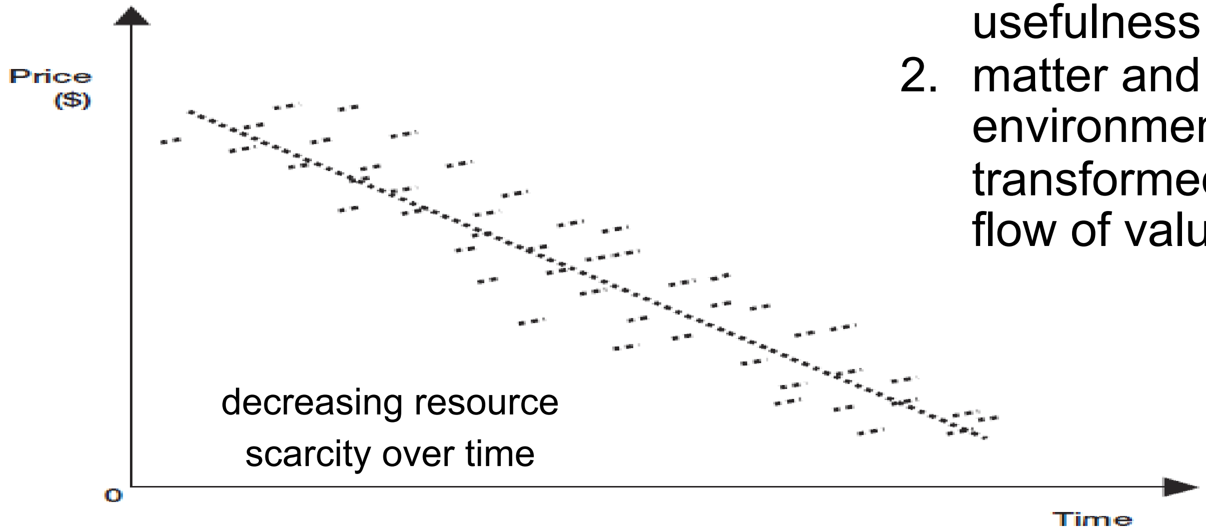
- ✧ NR are essential <u>factors of production</u>
- ✧ NR are *scarce*
- ✧ The economic value of NR is determined by *consumers' preferences*, and these preferences are best expressed by a freely operating private *market system*.
- ✧ *Market price* can be used as an indicator of resource scarcity.
- ✧ NR can always be replaced (partially or fully) by the use of other resources that are manufactured or natural.
- ✧ Technological advances continually augment the scarcity of natural resources.
- ✧ Natural Ecosystem is treated as being outside the human economy and exogenously determined.
- ✧ The Market as a provider of information about resource scarcity.
- ✧ Perfect information
- ✧ Competition
- ✧ Mobility of resources
- ✧ Ownership rights well and completely allocated

Price signals:

- Free good –> no price
- Scarce good –> positive price



Price as a signal of ***emerging resource scarcity***



1. the value of resources is assumed to emanate exclusively from their usefulness to human;
2. matter and energy from the natural environment are continuously transformed to create an immaterial flow of value and utility;

Objective Function of the Human Community$_t$ = Φ (INA_t, Y_t, min $\mathcal{Effort}_t$)

Where:

INA_t = Immaterial and Natural Amenities = αKN_t

KN_t = Natural Capital = Stock of (given – at time "t") Natural Resources

Y_t = available (in the Market – for Consumers) Production of Goods and Services (by human activites).

Y_t = *General Function of Production$_t$* = f (K_t, L_t, KN_t, E_t, θ_t $\mathcal{Effort}_t$)

KN = Land …... Natural Resources

Land includes all natural physical resources – e.g. fertile farm land, the benefits from a temperate climate or the harnessing of wind power and solar power and other forms of renewable energy. Some nations are richly endowed with natural resources and then specialise in the their extraction and production – for example – the high productivity of the vast expanse of farm land in the United States and the oil sands in Alberta, Canada. Other countries such as Japan are heavily reliant on importing these resources.

L = Labour ….. Skilled Labour

Labour is the human input into production e.g. the supply of workers available and their productivity. An increase in the size and the quality of the labour force is vital if a country wants to achieve growth. *In recent years the issue of the migration of labour has become important. Can migrant workers help to solve labour shortages? What are the long-term effects on the countries who suffer a drain or loss of workers through migration?*

K = Capital …. Technological and intertemporal non-human inputs

Capital goods are used to produce other consumer goods and services in the future. Fixed capital includes machinery, equipment, new technology, factories and other buildings. Working capital means stocks of finished and semi-finished goods (or components) that will be either consumed in the near future or will be made into consumer goods. New items of capital machinery, buildings or technology are used to boost the productivity of labour*. For example, improved technology in farming has vastly increased productivity and allowed millions of people to move from working on the land into more valuable jobs in other industries*

E_t = Energy availability **θ_t = available Technological know-how, solutions & Instruments**

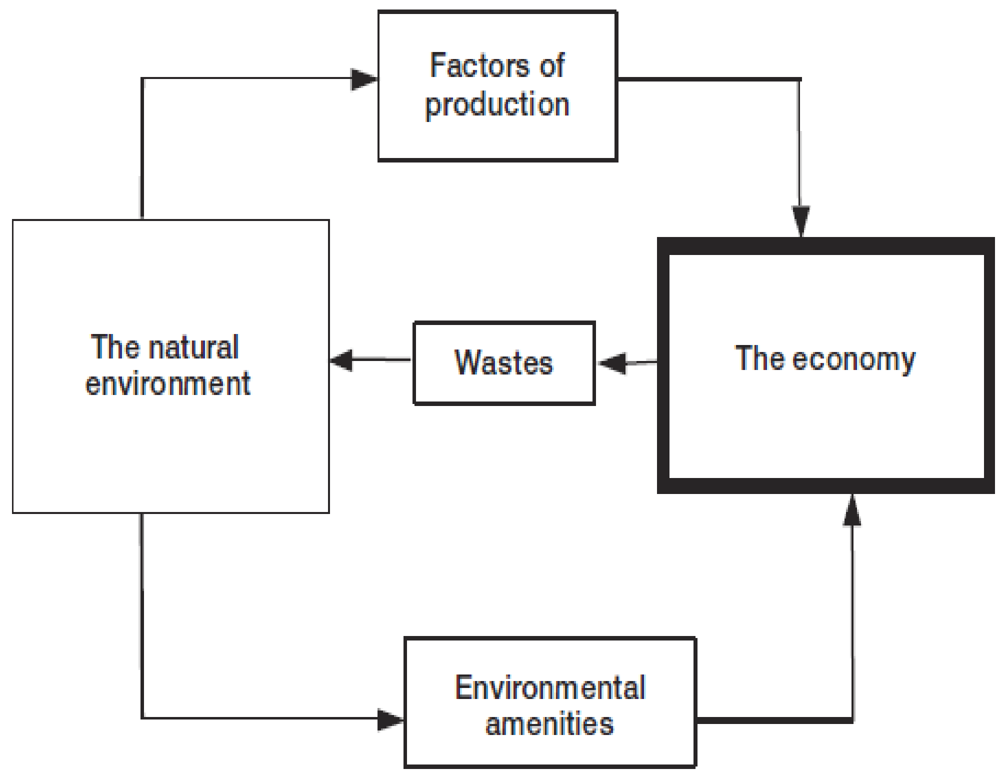
Environmental Economics → primary focus is how to use or manage the natural environment (air, water, landmass) as a valuable resource for the disposal of waste.

Economy is assumed to *depend* on the natural environment:

1. the extraction of nonrenewable resources and the harvest of renewable resources
2. the disposal and assimilation of wastes
3. the consumption of environmental amenities

ECOLOGICAL PERSPECTIVE:

a) Environmental resources of the biosphere are *finite*
b) Mutual interdependencies: everything is related to everything else
c) Biosphere is characterized by *a continuous transformation of matter and energy*
d) Material recycling is essential for the growth and revitalization of all the subsystems of the biosphere
e) Nothing remains *constant* in nature
f) The human economy is a *subsystem* of the biosphere



Focus on:

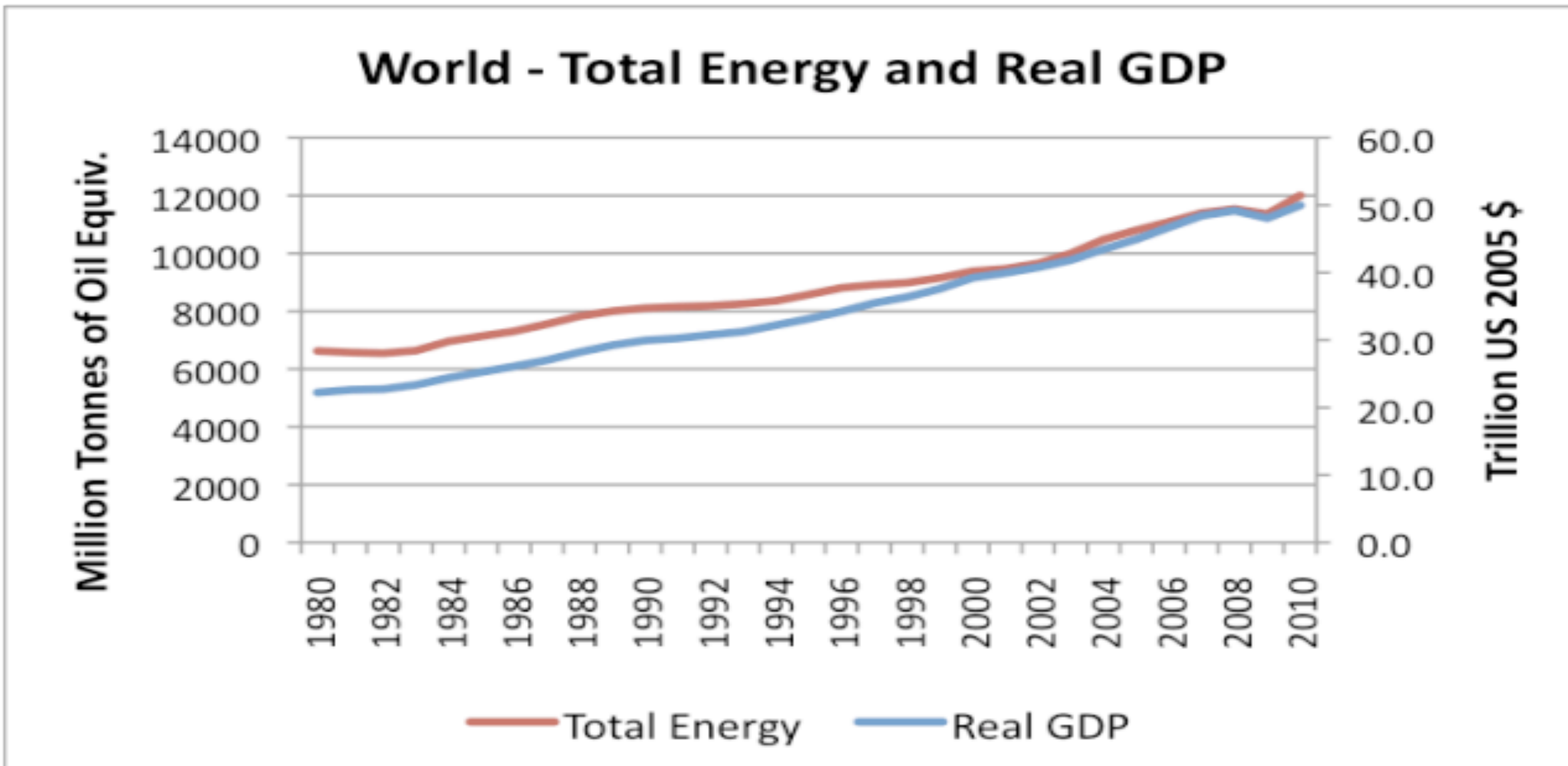
•**Economic growth**: importance of natural resources (KN)

•**Living standards** in the long run subject to constraints (KN)

Economic growth:

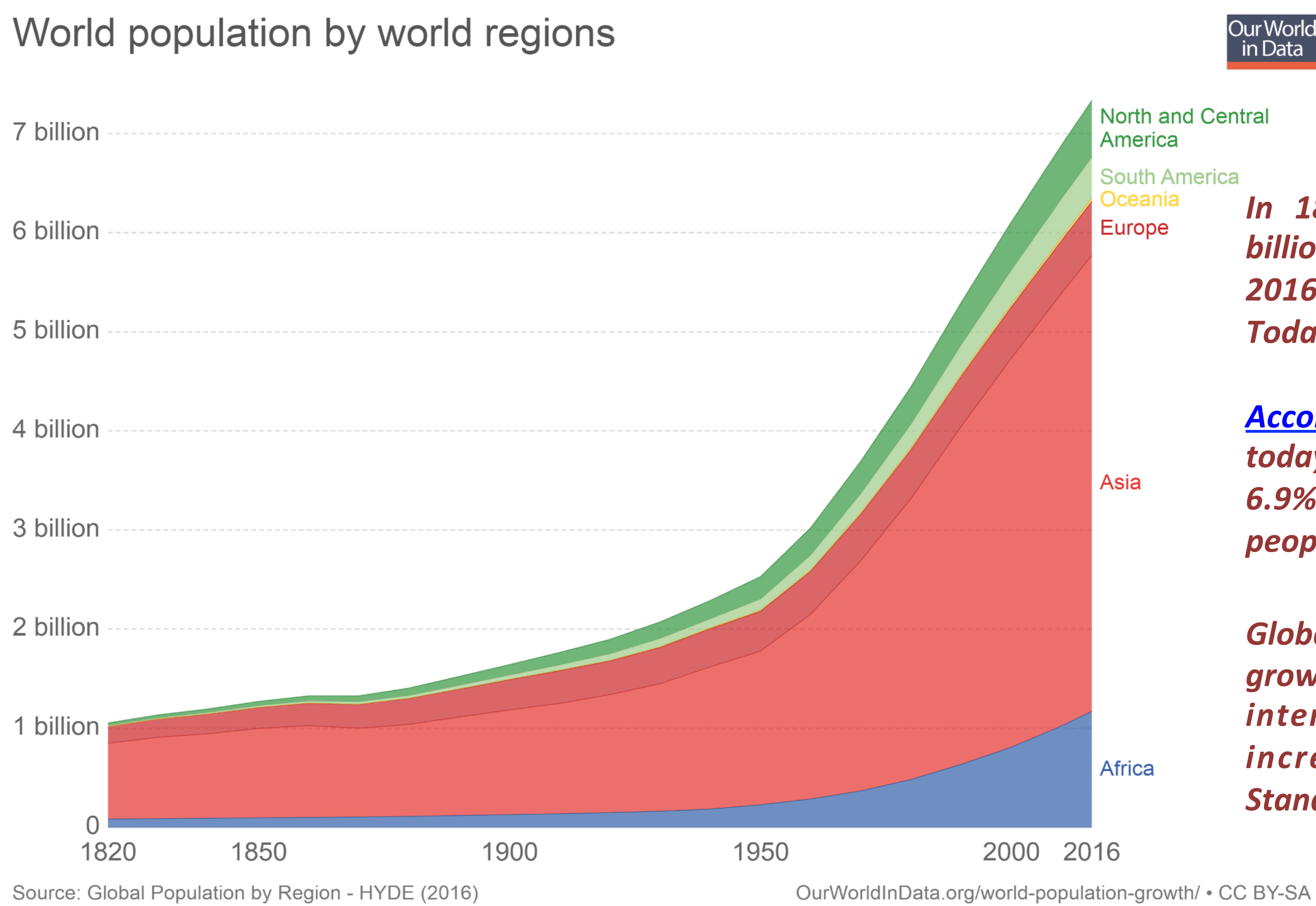
importance of Natural Resources for Energy production (*energy supply*) = Energy Needs (*energy demand*) & Sources

$$E_t = \gamma\ KN_t,\ \theta_t$$



QUESTIONS

- Can the global economic system continue to grow without undermining the natural systems, which are its ultimate foundation?
- Can poverty be alleviated in such ways that do not affect the natural environment in such a way that future economic prospects suffer
  - Interrelationship between poverty, economic development and the state of the natural environment
  - World Commission on Environment and Development 1987 Our Common Future
  - **Sustainability**



In 1820 there were about one billion humans living on earth. In 2016 there were 7.33 billion. Today we are close to 7.5 billion.

According to recent estimates, today's population is about to 6.9% of the total number of people ever born.

Global Demand is more and more growing, both as a whole and in internal structure … toward increasing needs for Living Standards

the **growth** of the economic subsystem is ‘bounded’ by a nongrowing and finite ecological sphere

nature acts as both a *source* of and a *limiting factor* on the basic material requirements for the human economy

A functioning **natural ecosystem** is characterized by a **constant transformation of matter and energy**. *Natural ecosystems require continual energy flows from an external source*

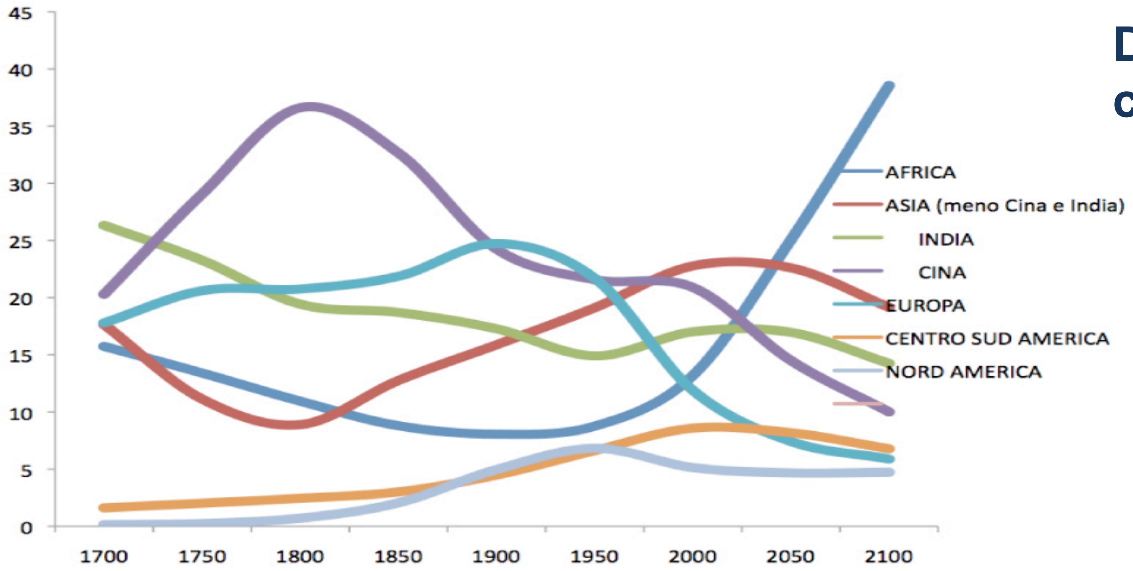
Energy and thermodynamics

1. The first law of thermodynamics: principle of conservation of energy - matter and energy can neither be created nor destroyed, only transformed.
2. The second law of thermodynamics: energy transformations – in every energy conversion some useful energy is converted to useless (heat) energy (*entropy)*

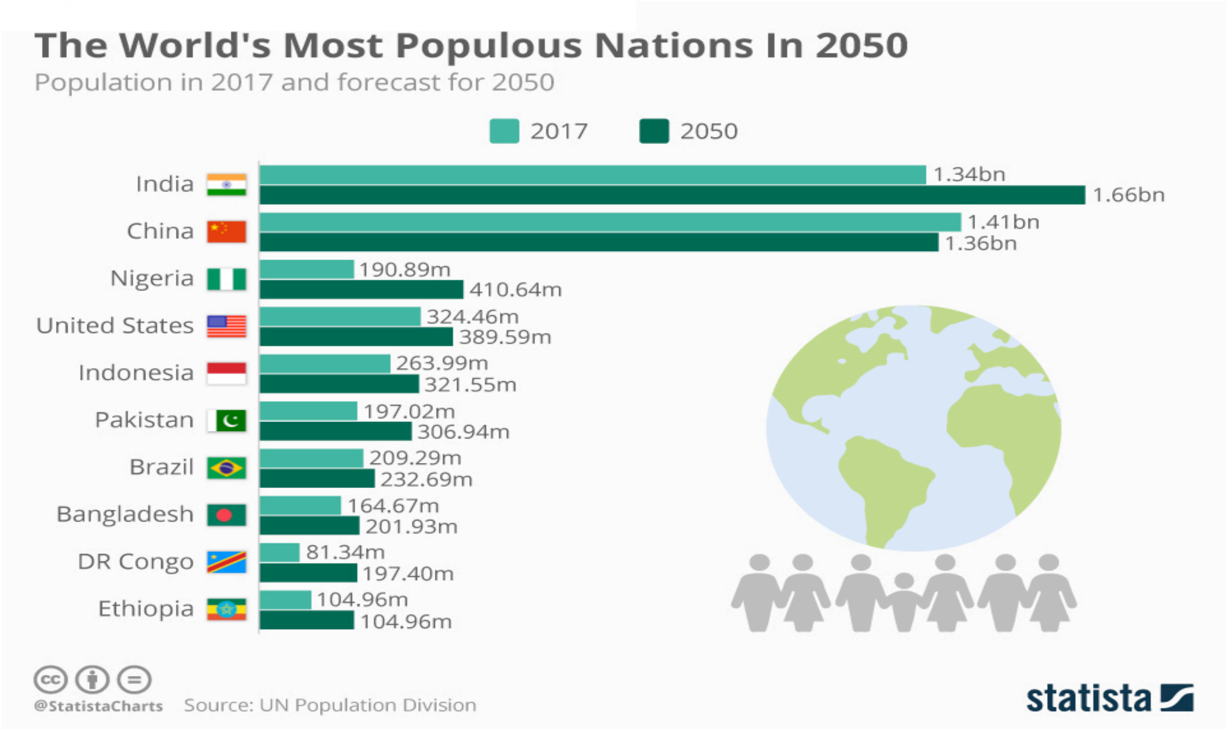
Material recycling is essential for the growth and **revitalization** of all the components of the ecosphere

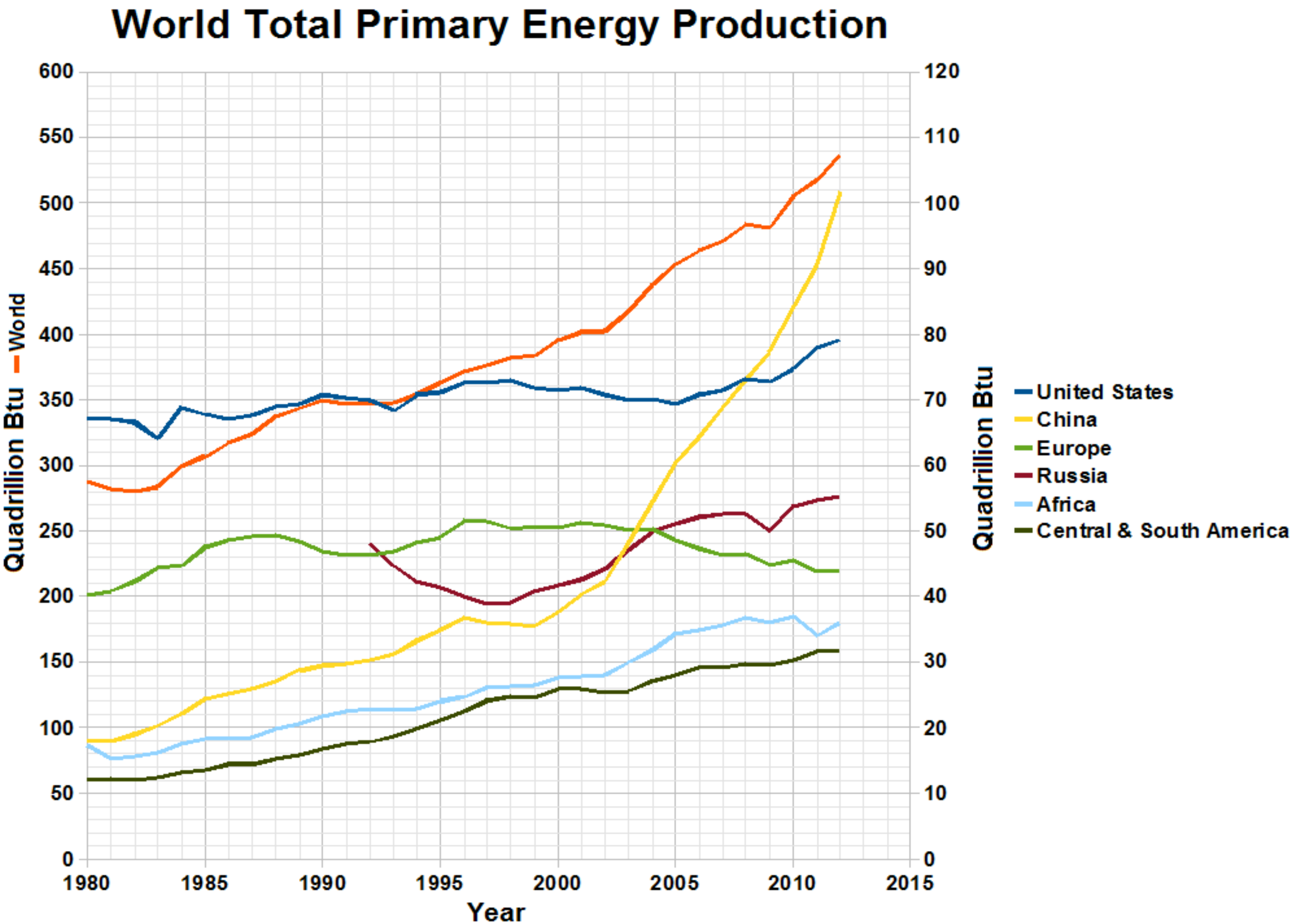
Different growth paths ….. changes in "Living standards"

FIGURA 1 – LA POPOLAZIONE DEI CONTINENTI (% della popolazione del mondo), 1700-2100



Fonte: Massimo Livi Bacci, Il Pianeta Stretto, Il Mulino, Bologna, 2015




World Total Primary Energy Production
Quadrillion Btu
World
Quadrillion Btu
Year
600
550
500
450
400
350
300
250
200
150
100
50
0
120
110
100
90
80
70
60
50
40
30
20
10
0
1980
1985
1990
1995
2000
2005
2010
2015
United States
China
Europe
Russia
Africa
Central & South America

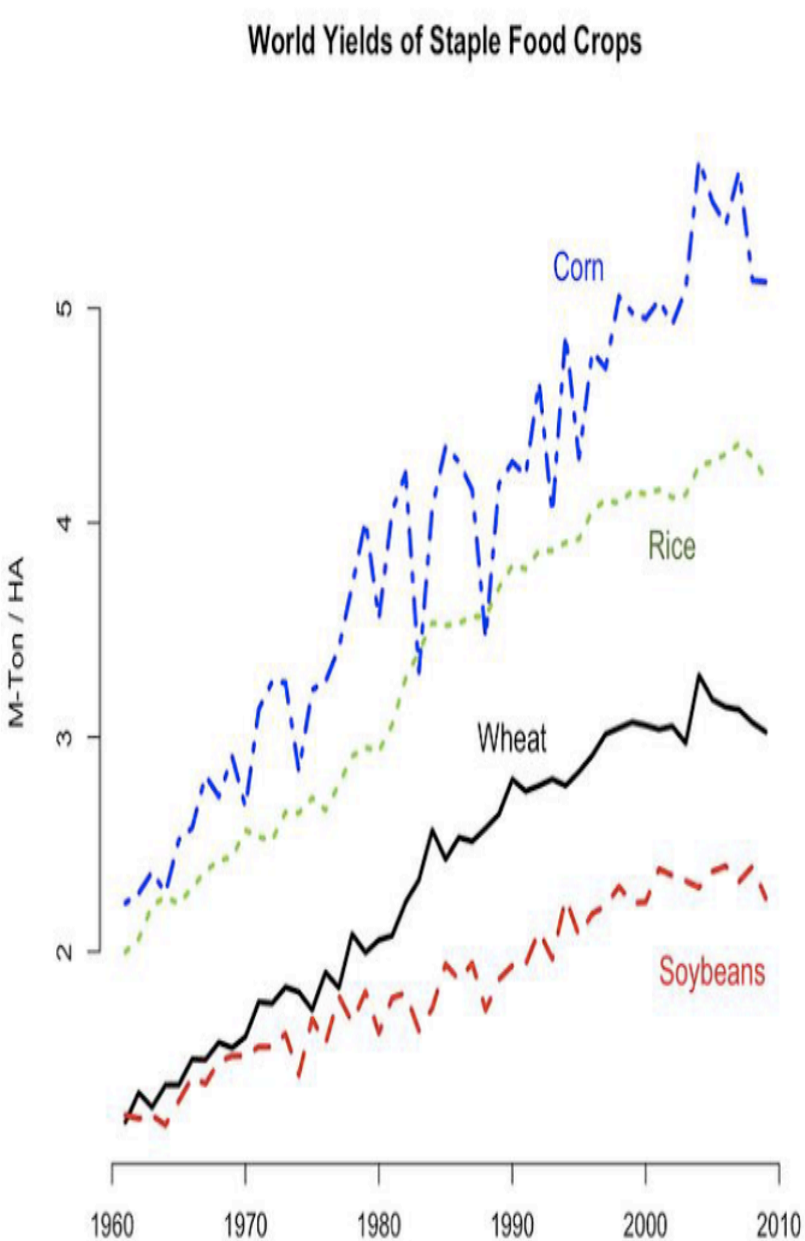
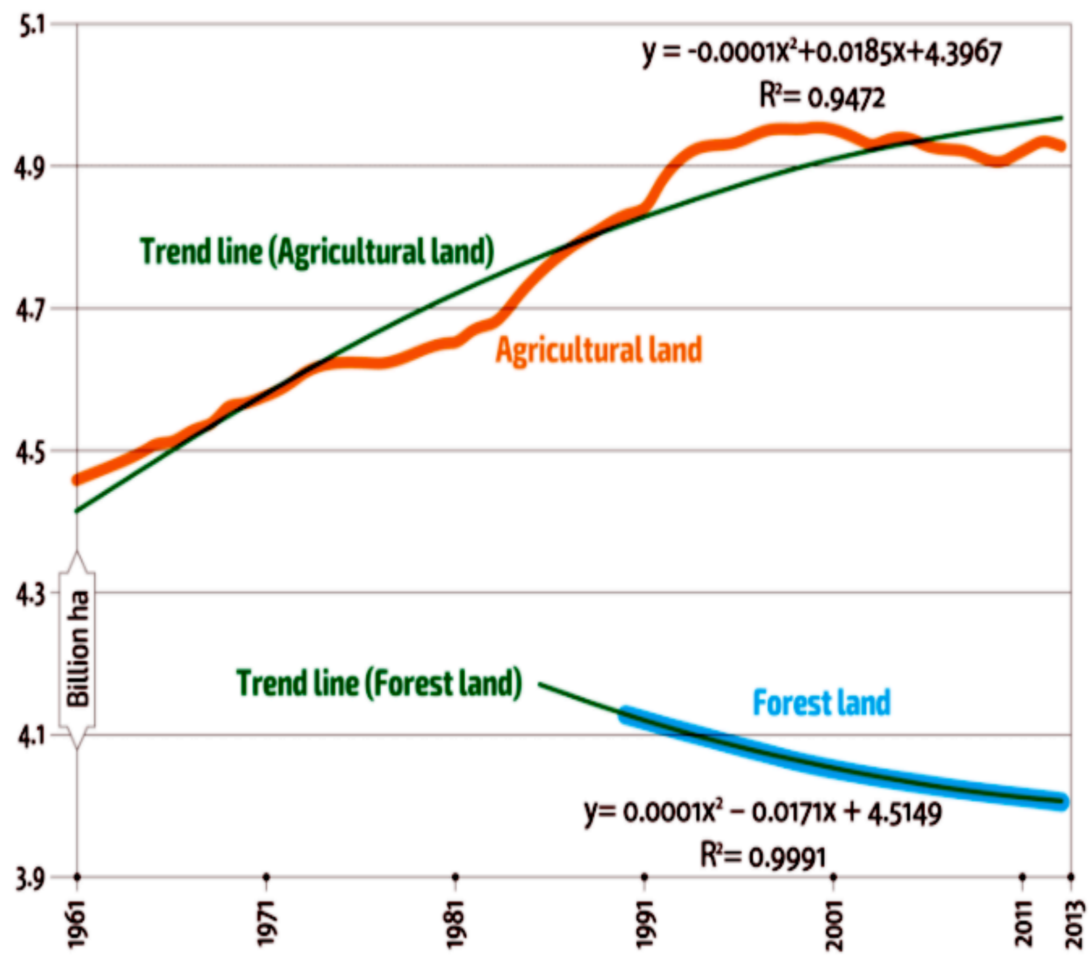


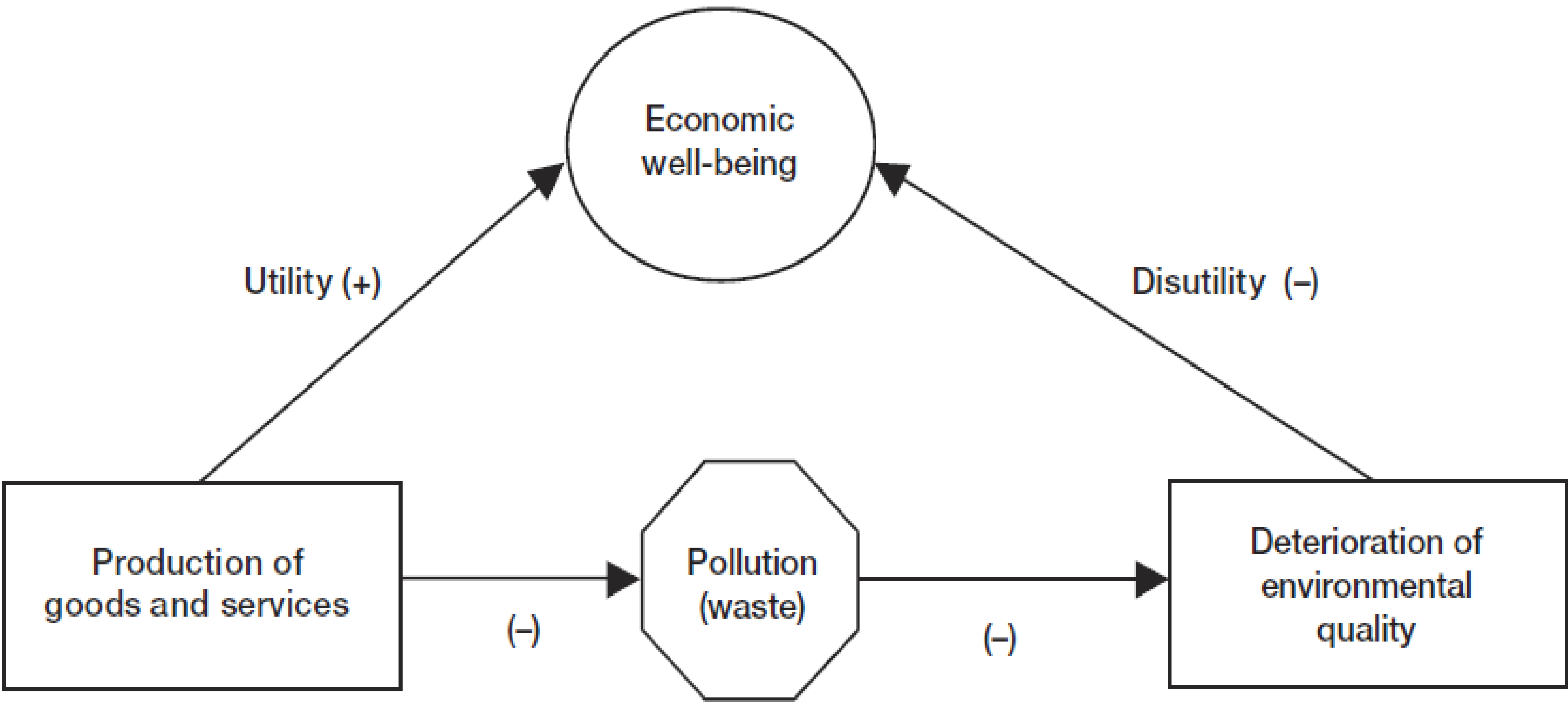
Figure 3.1 **Changes in agricultural and forest land use, 1961-2013**



Source: FAO Global Perspectives Studies calculations based on FAO, 2016b.

Natural resources cannot be viewed merely as factors of production
Otherwise, humans lead to .... industrial pollution (waste)

- *waste-absorptive capacity* of the natural environment: *ecological threshold*
- *trade-off between economic goods and environmental quality*



L'impatto ambientale

I primi tentativi di formalizzare l'impatto ambientale delle attività umane risalgono agli anni '70 del XX secolo, in particolare da parte dell'ecologo Paul Ehrlich e dall'esperto di energia John Holdren.

Schematicamente → l'impatto ambientale **I** sarebbe il prodotto di tre diversi fattori: la popolazione **P**, il consumo medio pro capite di beni materiali **A**, il danno ambientale generato dalle tecniche necessarie a produrre i beni consumati, **T.**

$$I = P \times A \times T$$

Questa formula fu molto discussa, e furono apportate negli anni alcune modifiche: con **A** si misura il "consumo umano pro capite" di materia ed energia, con **T** si intende "impatto ambientale per unità di consumo".

***ImpattoAmbientale = Pop. x ConsumoProCapite x ImpattoAmbient** per unità di consumo*

Analizziamo l'andamento dei singoli fattori dell'equazione:

1. La popolazione è aumentata dal 1800 ad oggi di circa sei volte.
2. Anche i consumi pro capite hanno avuto un andamento decisamente crescente (per esempio il consumo di energia pro capite, dal 1850 ad oggi, è triplicato).
3. L'analisi si complica al terzo fattore, T: in generale l'impatto ambientale per unità di consumo tende a diminuire nel tempo, soprattutto nelle economie di mercato che premiano l'efficienza.

We have to hope in ....Technological Advance Perspective

- the ability to produce a given amount of output by using less of *all* inputs
- conservation of resources
- the amount of resource conservation depend on the impact that technological advance has on the *relative productivity* of each of the inputs

- **The assimilative capacity** of the environment is *limited.*
- The assimilative capacity of the natural environment depends on the *flexibility* of the ecosystem and the *nature* of the waste.

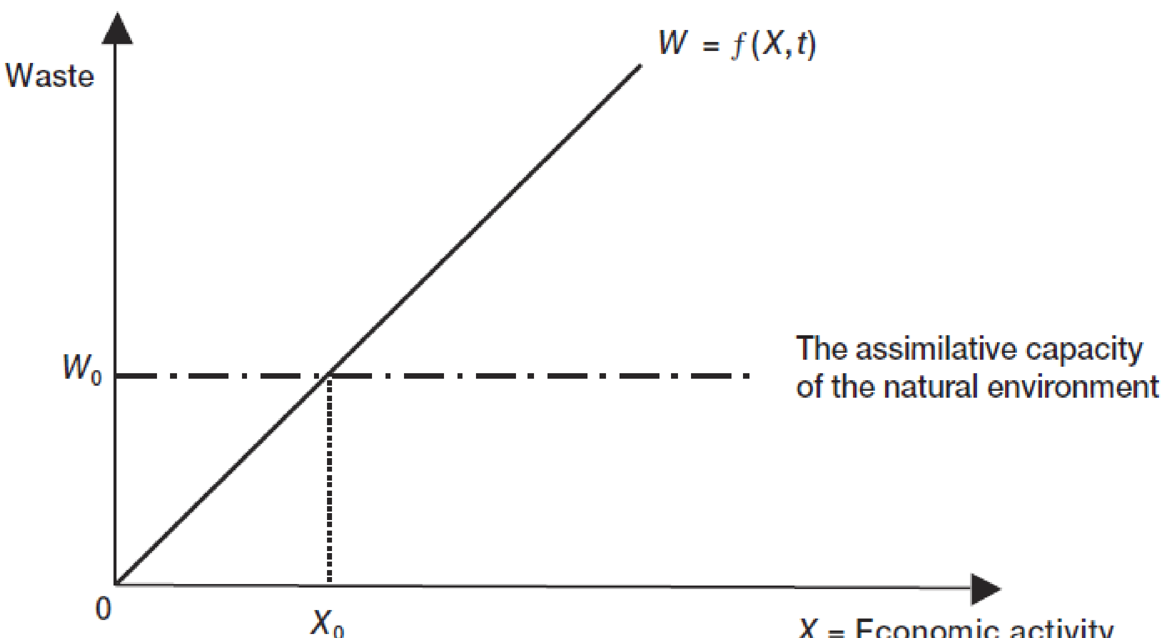
Assume a linear relationship between waste and economic activity

$$W = f(X, t)$$

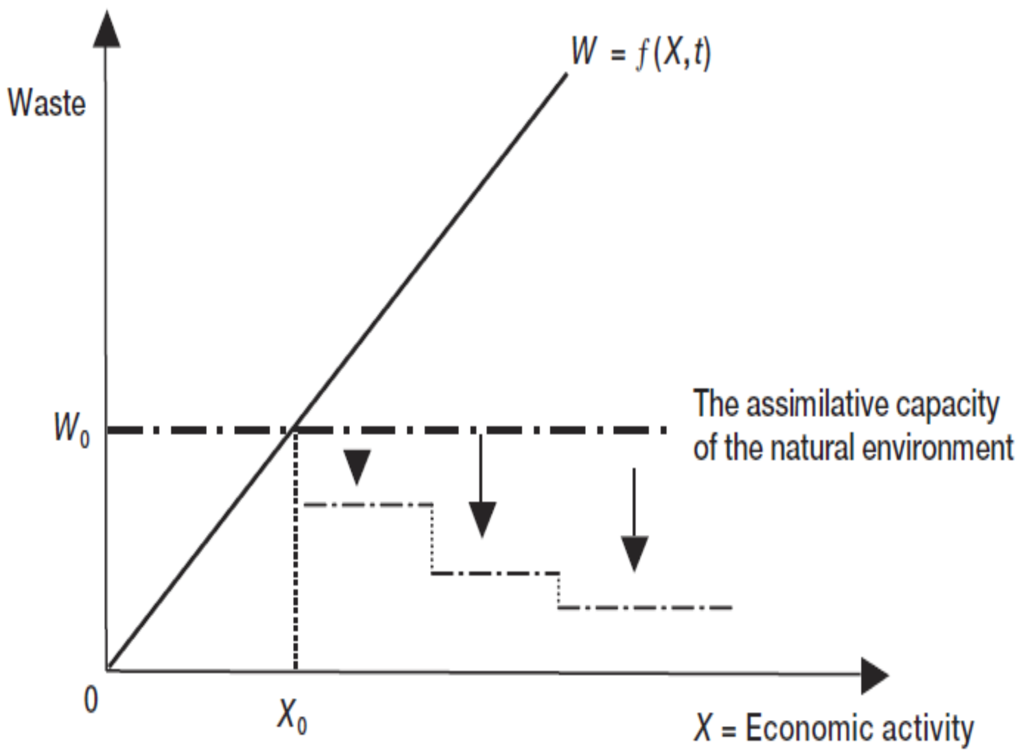
W : level of waste generated
X : production of goods and services
t : technological and ecological factors

if t assumed constant;

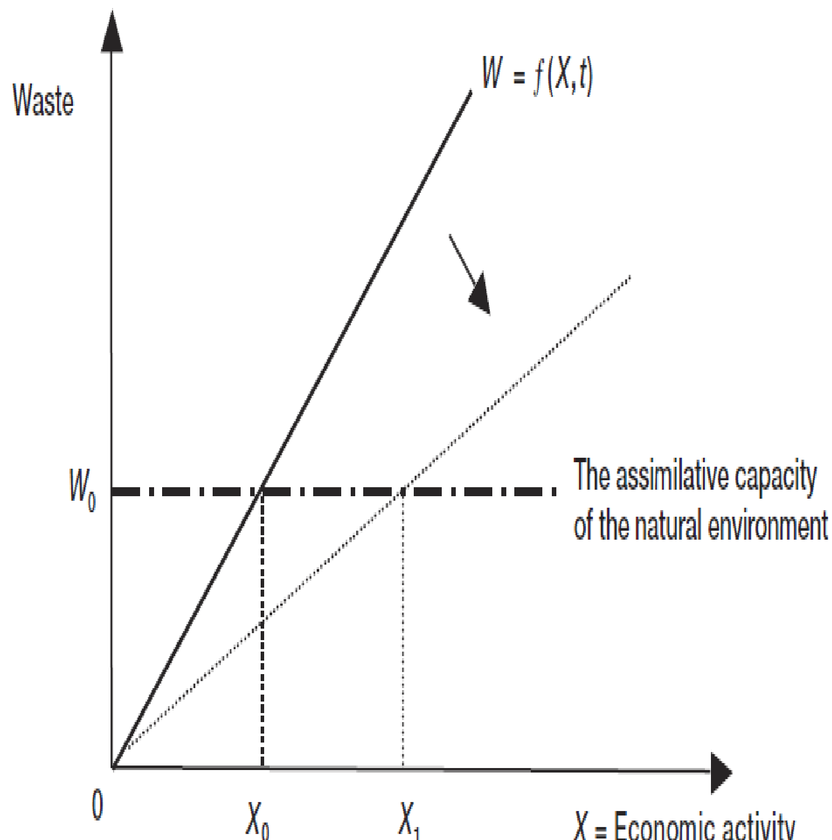
$$W = \beta X$$



pollution reduces the capacity of an environmental medium to withstand further pollution



Technological advances



Issues in resource economics

- TYPES OF NATURAL RESOURCES
  - FLOW RESOURCES
    - NONSTORABLE RESOURCES
      Various species of Biological resources (plants and animals) can be irreparably damaged if they are exploited beyond a certain critical threshold
    - STORABLE RESOURCES
  - FUND RESOURCES
    - RENEWABLE RESOURCES
      Fish, forests, water, solar radiation, wind, metalic minerals (iron, aluminium, copper, uranium, etc...)
    - NONRENEWABLE RESOURCES
      either exist in fixed supply or are renewable only on a geological timescale, whose regenerative capacity can be assumed to be zero for all practical human purposes.
      (Minerals, oil, gas, coal)
      - NON-RECYCLABLE RESOURCES
      - RECYCLABLE RESOURCES

Questions to face with:

- Optimal depletion of non-renewables
- Optimal harvesting of renewables
- Waste management of non-recyclable resources
- LCA to support both storability of flow resources and recyclability for fund resources
- Demand Side management for non storable flow resources

Quantitative Expression of Natural Resources

- Nature of Flow resources

  $Ft = Rt + St + Wt$

  Ft=Flow resource obtained with in t time

  Rt=Consumed amount of flow resources

  St= stored amount of flow resources

  Wt=Wasted amount of flow resources

- Nature of fund resources

$$St = \sum(Ft - Rt - Wt) + Ft$$

St= stored fund resource at t time

Ft=Fund resource at t time

Rt= Consumed amount of fund resource

Wt= Wasted amount of fund resource

- Nature of Biological resources

$$St = S0 - \sum(Rt - Ht$$

St= Current biological mass

S0= Biological mass at the beginning

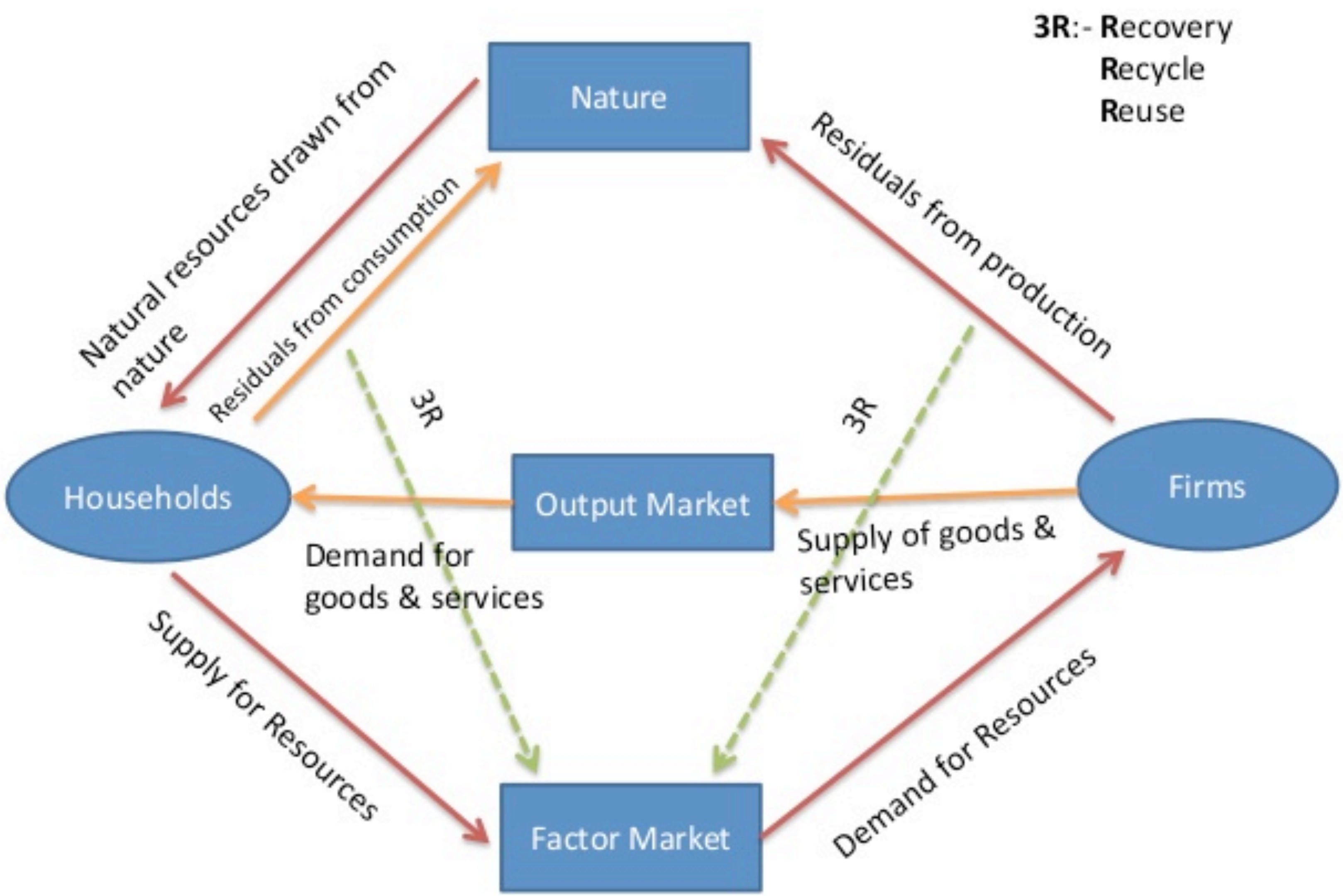
Ht= Harvested bio mass during t time

Rt= Net new addition of bio mass during t time

1.Natural Resource as an Asset

- In economics environment is considered as a complex asset that provides different services
- It is a very special asset that ensures not only our existence but also development of economics .
- The resources are limited but our wishes are unlimited.
- Therefore there is a tendency that the speed of extraction and use of natural resources is growing to the maximum but the resources are limited.
- Complexity of environmental economics is determined by meeting these contradictive conditions and restrictions.
- It is essential to compare all costs and outcome but also evaluate efficiency of use of natural resources.

Material Balance Model



2.Economic Approach

- It provides better understanding about connection between economic system and natural assets.
- Positive economics shows what is, what was and what will be.
- Normative economics answers the question what should be.
- Argument between these economics ensures continuous development and both approaches are important.

Ex:- Positive economic approach

- In order to evaluate dynamics of use of natural resources.
- It helps determine whether use of resources has increased, decreased or has stayed on previous level.

Ex:-Normative economic approach

- To determine whether the speed of utilization of natural resources is acceptable or not and also to analyze possible ways of using natural resources.

3. Normative criteria for decision making

- If it is essential to find out whether the proposed actions are desirable, the first step should be determination of benefits and losses.
- If benefits are higher than losses then action is desirable.
- This simple system is economic basis in decision making.

- It can be formulated as follows: if B is benefit from use of natural resources and C is costs then:
  - o B>C action desirable;
  - o B< C action to be rejected
  - o B = C point of no losses
- All benefits and costs are evaluated taking into consideration their effect on development of humankind

Steps proceeded by Normative Analysis

1. Identify an optimal outcome
2. Understand extent to which institutions produce optimal outcomes and where conflicts occur.
3. Design appropriate policy solutions.

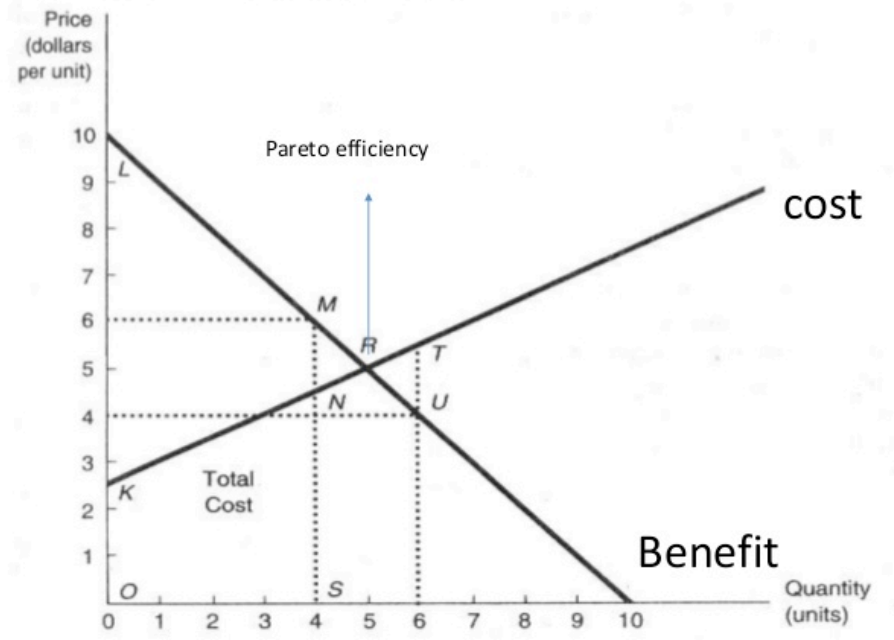
Static Efficiency and Dynamic Efficiency

- Comparing benefit- cost analysis occur at different points in time.
- With the consideration of time there are 2 types of efficiency decision making concepts
  - Static efficiency
  - Dynamic efficiency

Static Efficiency

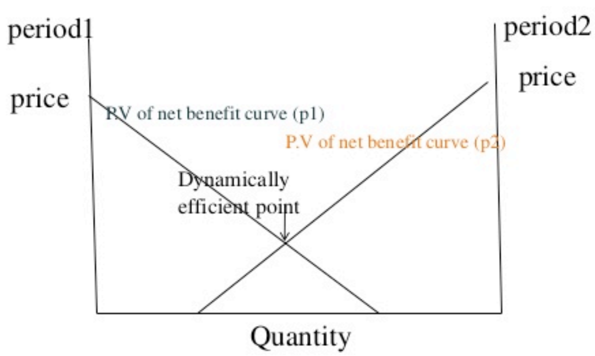
- An allocation of resources is said to satisfy the static efficiency criterion if the economic surplus derived from those resources is maximized by that allocation.
- Economic surplus is the sum of consumer's surplus and producer's surplus.

THE DERIVATION OF NET BENEFITS.



Dynamic Efficiency

- Benefit-cost analysis requires comparing benefits and costs that usually occur at **different points in time.**
- The problem is how to compare net benefits in one period with the net benefits received in another time
- The traditional criterion used to find an optimal allocation when time is involved is called dynamic efficiency



– An allocation has achieved **dynamic efficiency** if it maximizes the *present value* of net benefits

– **Discounting** is the process of calculating present value.

- The present value of a one-time net benefits received n years from now is

$$PV = \frac{FV}{(1+i)^n}$$

- Present value of a net benefit received in "n" year

$$PV[B_n] = Bn / (1+i)^n$$

– Present value of steam of net benefits receive over "n" period of n year

$$PV[B_1 - B_n] = \sum Bn / (1+i)^n$$

i = interest rate.

Conclusions

- Effective use of natural resources promotes development of a country.
- Ineffective use of natural resources decreases potential of sustainable development of a country.
- Ineffective use of resources can also cause considerable losses to environment and economics.