Economic Issues

Supplement to Chapters 2

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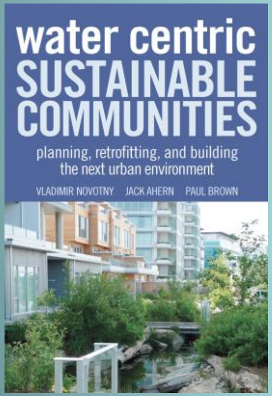
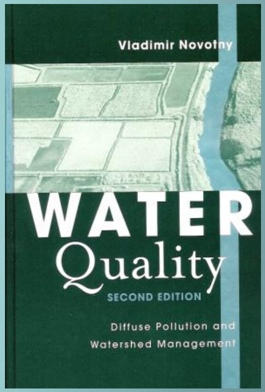




Environmental economy analysis answers the question

1. WHAT goods and services should be produced
2. WHEN should they be produced
3. HOW should they be produced

in the context of the Triple Bottom Line analysis

RESOURCES

NON –RENEWABLE

Coal
Oil

RENEWABLE

Water (part)
Crops
Wind, water
solar energy

Groundwater

WATER USES - Withdrawal
Returned
Consumed

- In stream

Water is categorized as public goods

- Decisions related to water allocation and resource protection is a concern of the public sector or Government

RESOUCES ALLOCATION AND USE

- Efficiency criterion
  - Efficient resource allocation of the use and allocation of resources in such a way as to produce, at the least possible cost, those goods that are wanted most to meet consumer priorities with the least sacrifice of scarce resources
- Equity criterion
  - Benefits and costs should be distributed in such a way that no group is receiving more benefits (or less cost) than another group involved in the project
- Distributional equity - income redistribution
- Efficiency and equity often conflict each other
  - E.g., desire to give more benefits to poor (equity) may conflict with the desire to gain maximum profit (efficiency)

Measures of Efficiency

- Benefits/cost > 1 (Marginal (B/C) = 1
- Benefits – cost > 0 Net benefit
- (Benefits-cost/investment)>%discount rate/100 internal rate of return

- BENEFITS
  - Tangible expressed in $s
  - Intangible e.g., aesthetics
- COST
  - Capital
  - Operation, Maintenance and Replacement - OMR

- AMMORTIZATION PERIOD
  - Time at which Σ benefits = Σ costs (including the cost of borrowing the money to develop and operate the project)
  - Amortization period ≠ Life time of the project

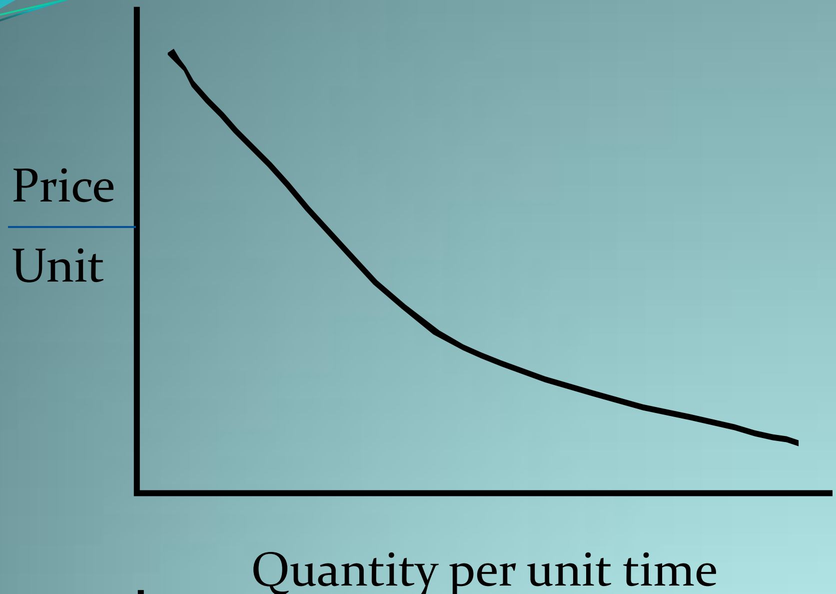
- OPPORTUNITY COST
  - Production cost - associated with producing the output
  - Opportunity cost – other outputs sacrificed with producing the output

  Opportunity cost denotes the output sacrificed or forgone when a society uses resources for one output rather than another.

Examples of opportunity cost

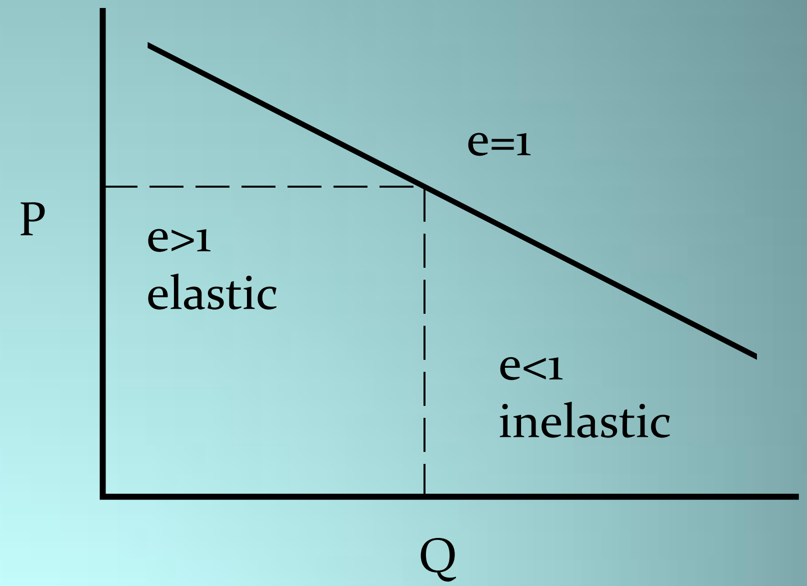
- Project is used for irrigation
  - Opportunity cost – outputs and money lost that could be derived from other uses such as navigation, water supply, etc.
- On financial market
  - Opportunity cost alternatives are interest paid on bonds or yield on stocks
  - Efficiency of the project must be measured against the opportunity cost

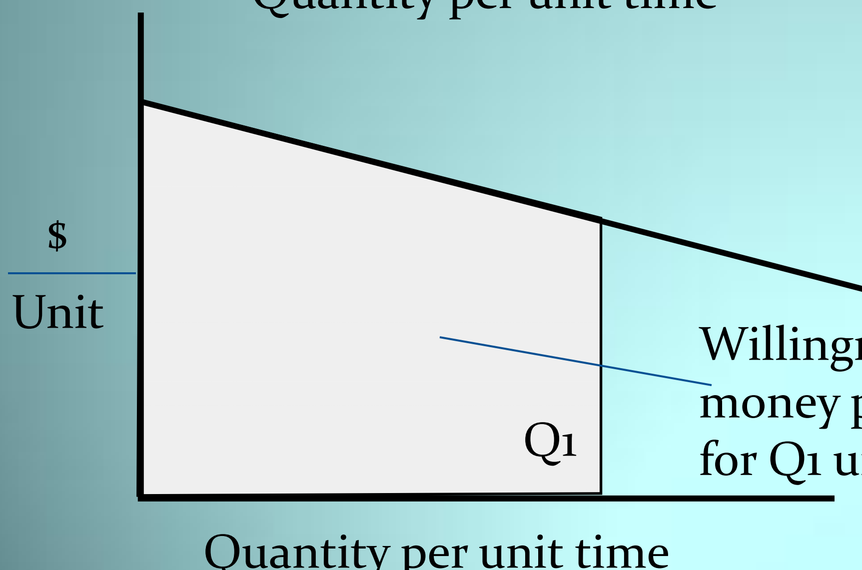
DEMAND



Price elasticity

$$e = \frac{\Delta Q/Q}{\Delta P/P} = \frac{\%\text{change in quantity}}{\%\text{ change in price}}$$





Willingness to pay (total sum of money people are willing to pay for Q1 units in a year)

Externality

- Historically, the price for water included only the cost of extraction, distribution and treatment
- The cost should also include the externality effects, e.g.,
  use of water → pollution → cost to downstream users
  externality
  use of water for irrigation →salinity→lost agriculture
  → water mining → loss of water for future generations
- Definition
  - Externality is a cost related to providing water service that is external to the supplier of user and is not included in the cost of service

- Externalities
    - Quality of rivers and lakes
    - Competitiveness
    - Loss of agriculture
    - Reduced living standard
    - Loss of wild life
  - But also
    - Crime from the neighboring city to suburbs
    - Loss of property value due to pollution or noise
- Negative externality
  - Producers pay very little or nothing for water and wastewater discharges
- Externality can also be positive
  - Improved water quality → recreational opportunities
→ improved living standard
→ increased property value

Internalization of externality

1. Legislation (Clean Water Act with NPDES permits) e.g., polluters are forced to clean up at their cost
    1. User fees that include the cost of protecting and preserving the resource
    2. Taxes
2. Litigation and public pressure
3. Water and discharge permit markets – pollution load trading (requires some rules and referees)
4. Negotiation/ mediation

For 1-3, a working institutional system with enforcement must be in place, e.g., NPDES
In the absence of internalization and enforcement, the producers, water users and polluters will recognize only private cost and will act accordingly.

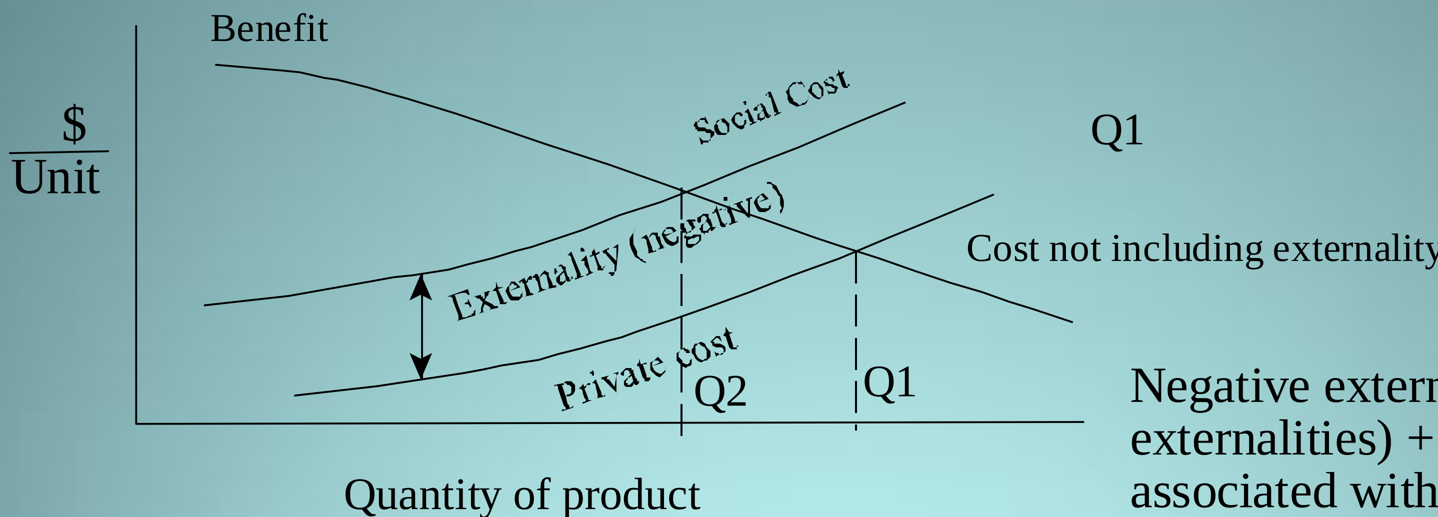
ADDITIONAL EXAMPLES OF EXTERNALITIES

- Chesapeake Bay
  - Water quality, fishing, recreation uses of the bay are degraded because of nutrient (N+P) loads from farms, cities, and industries located often hundreds kilometers upstream
  - Internalization
    - EPA and state regulation require removal of nutrients from effluents. General tax revenues provide subsidies to farmers
- Acid rainfall
  - Acidity of rainfall is increased (pH decreased) by sulfur dioxide and nitric oxide emissions from fossil fuel burning operations (power plants, traffic)
  - Internalization
    - EPA has issued regulations (cap and trade) restricting CO_2 emissions and requiring installation of SO_2 removal technologies. Recent regulations enacted by EPA require significant increase of miles/gallon on automobiles which will reduce NO_x.

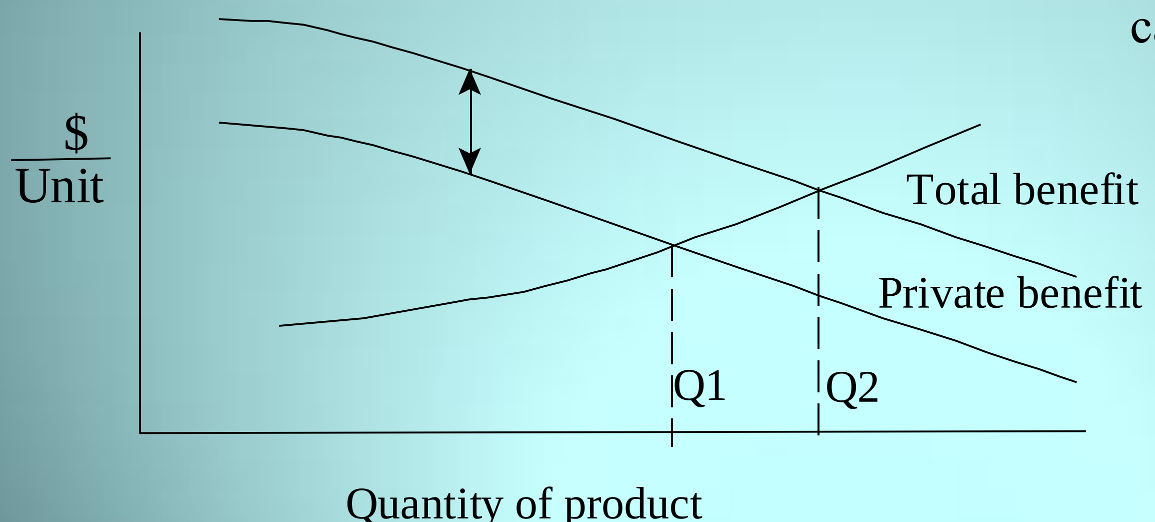
Externality can also be positive

Improved water quality → Recreational opportunities

→ Improved living standard

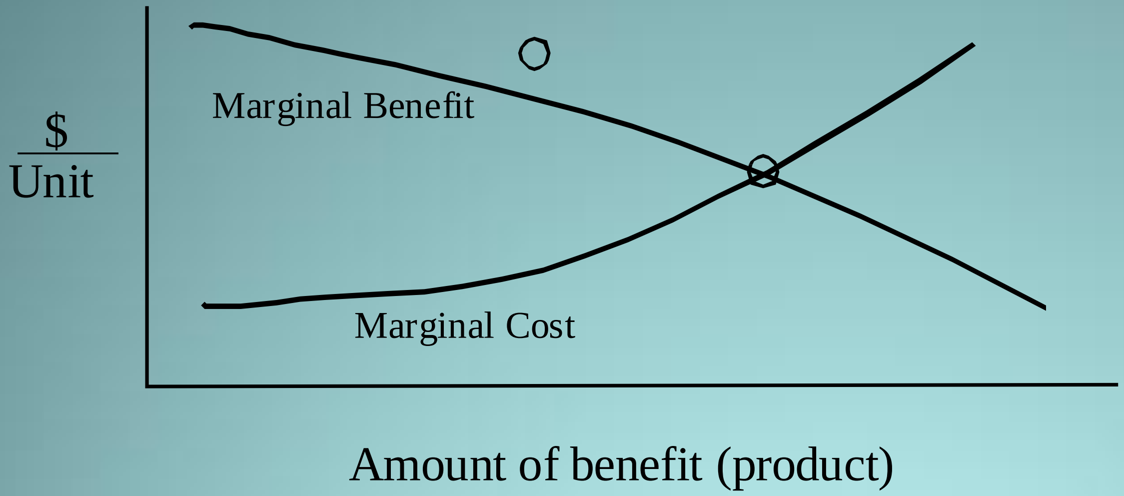


Negative externality (☝ of externalities) + private cost associated with production is called "social cost"

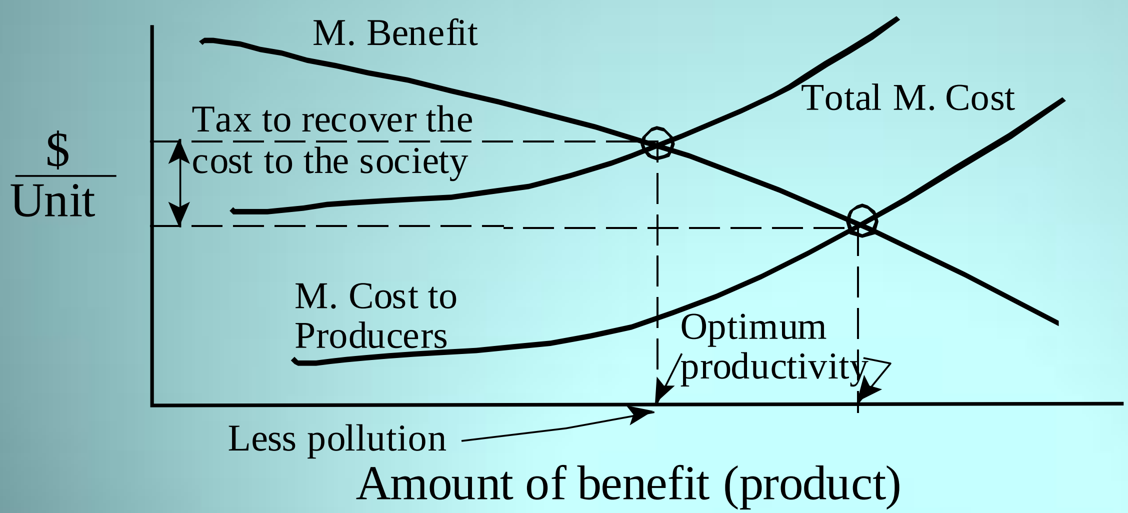


Positive externality can beincluded into benefits

DEMAND AND COST CURVE



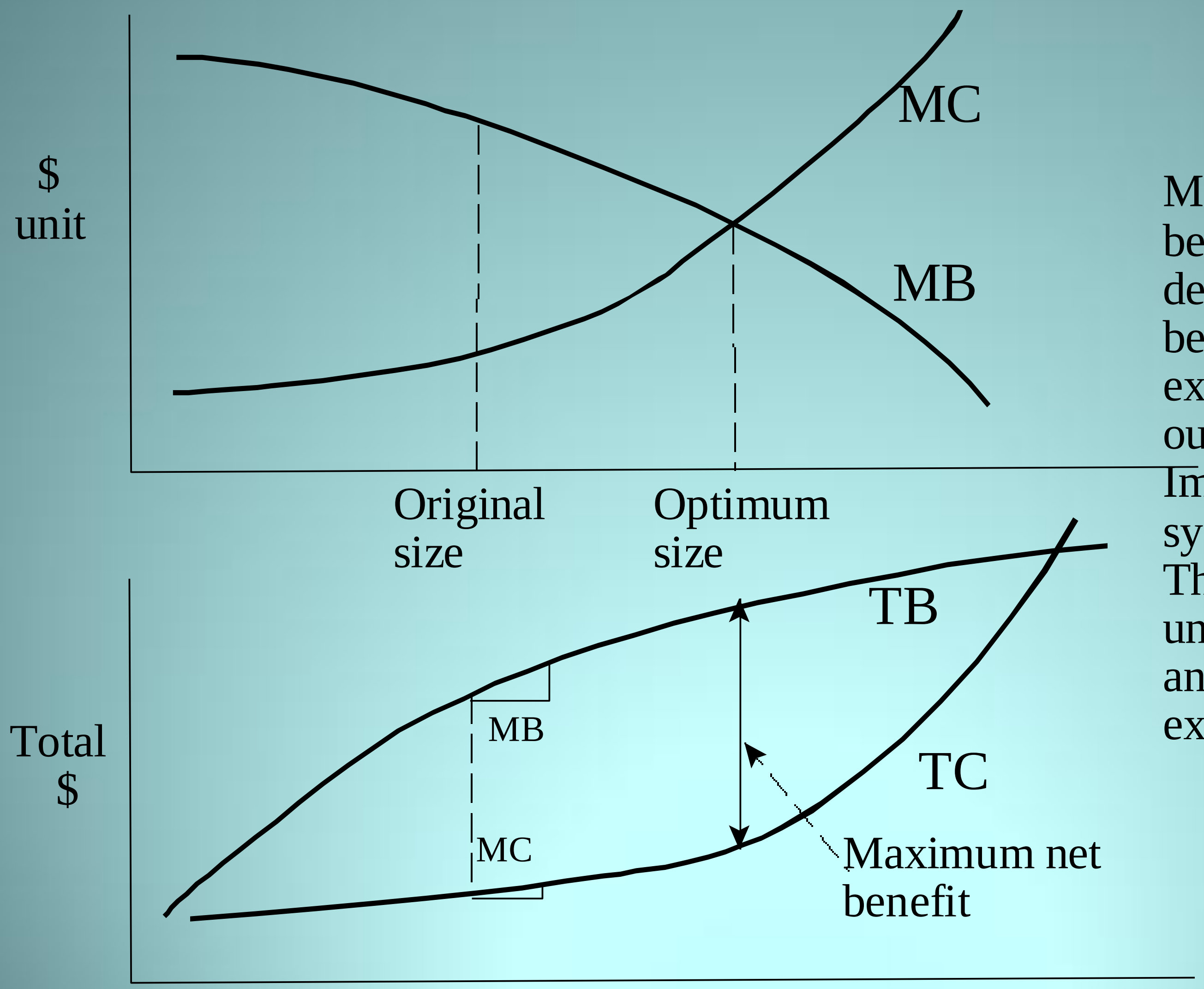
The benefit or cost expressed per unit of output is called <u>marginal benefit or cost</u>



Cost to the society

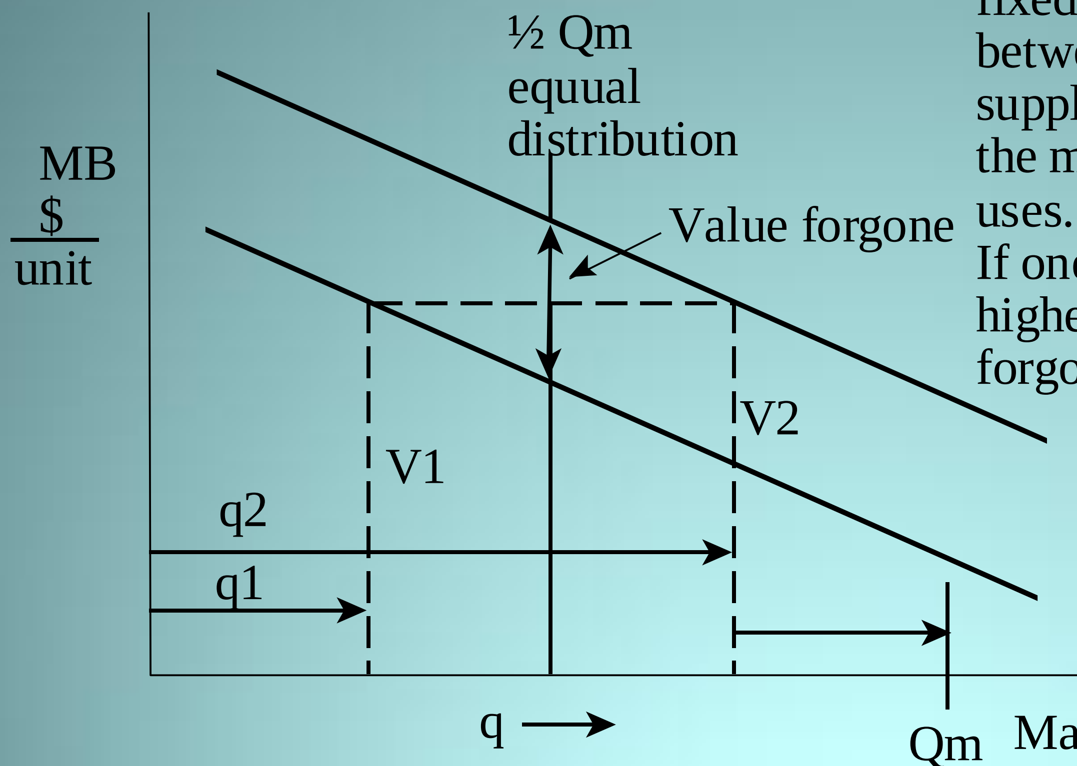
~pollution
~schools
~ infrastructure
~ police, etc.

OPTIMUM SIZE OF A PROJECT



Marginal cost and benefit (value) are defined as a cost or benefit assigned to one extra unit of the output.
Imagine that the system is enlarging. Then MB and MC are unit values of benefits and cost for the first extra unit of output.

ALLOCATION OF MULTIPLE USES



Max q = Qm

If the quantity of available water is fixed then the optimum allocation between two different uses (e.g., water supply and irrigation) is reached when the marginal value is the sam for all uses.

If one marginal value of one pruduct is higher than the difference is the value forgone = opportunity cost.

As V2 is increased V1 is pushed out

q1 + q2 = Qm

Total revenue 1 $= 2\int_0^{½ Qm} MV1\,dq = R1$

Total revenue 2 $= \int_0^{q1} MV1\,dq + \int_0^{q2} V2\,d2 = R2$ R2 > R1

Marginal pricing

- Economists representing users will establish a price based on the marginal cost and ask private utilities whether they would be willing to operate and install the service at that or smaller price. Competitive bidding.
- Because of the problems and tax advantages – many utilities are public (government) agencies.
- Trend is towards privatization
- Marginal pricing will require metering. This is best suited for regions where price of water (pollution removal) is elastic.
- Water surplus regions (inelastic prices) can often get by without metering water or sewage.
- If prices become elastic (higher metering may be required in water surplus regions).

Requirements vs. Demand Function

- “Requirements”
  - Engineers (planners) make a forecast of future demands and design facilities that will meet these demands at least cost
  - Generally, little analysis is made what the beneficiaries should pay, price is simply
    Price = cost of the project + cost of borrowing (+ small profit which is regulated)
  - Managers are assuming that the price will remain constant.
  - Such estimates drive the demand high. Often this leads to inefficient and inequitable solution and ultimately to waste and shortages.

- Demand/supply approach – marginal pricing
  - Price should be set equal to the long term incremental cost of supplying water (water services) from the newest project that would be needed to enlarge the capacity (e.g., in Southwest US and Florida it would be desalination)
  - NEWater will not be cheaper than the "recent" water. For example, City of El Paso (TX) uses water from freshwater aquifer and river. When the resources became exhausted they had to build reverse osmosis desalination of brackish deep groundwater. The price of water should be then based on the cost of desalinated water.
  - This approach may lead to optimal multiple use.
  - Another example, A suburb is using cheap groundwater but is expanding and has to purchase treated water from Chicago that is pumped long distance.

- PROBLEMS
  - In arid southwest, agricultural and urban users relied mostly on cheaper groundwater and surface sources. The new source is expensive desalination and/or long distance transfers (e.g., Arizona Water Projects, California Canal)
    - These sources have very high marginal cost which will wipe out agricultural users.
    - Bad solution- government subsidies for water
  - Marginal pricing is not widely used but it is becoming common in areas with shortages.

Role of Regulation

- Utilities providing water (e.g., Mass Water Resources Authority) are “natural” monopolies.
- They can be fully public (e.g., City) or private for profit (e.g., companies providing natural gas, water companies such as Veolia, Suez, etc.)
- Some public utilities use private operators (e.g., Milwaukee Metropolitan Sewerage district hired United Water).
- Monopolies must be regulated and a have a public oversight otherwise their operation would results in unfair overpricing (e.g., privatized watershed companies in UK)

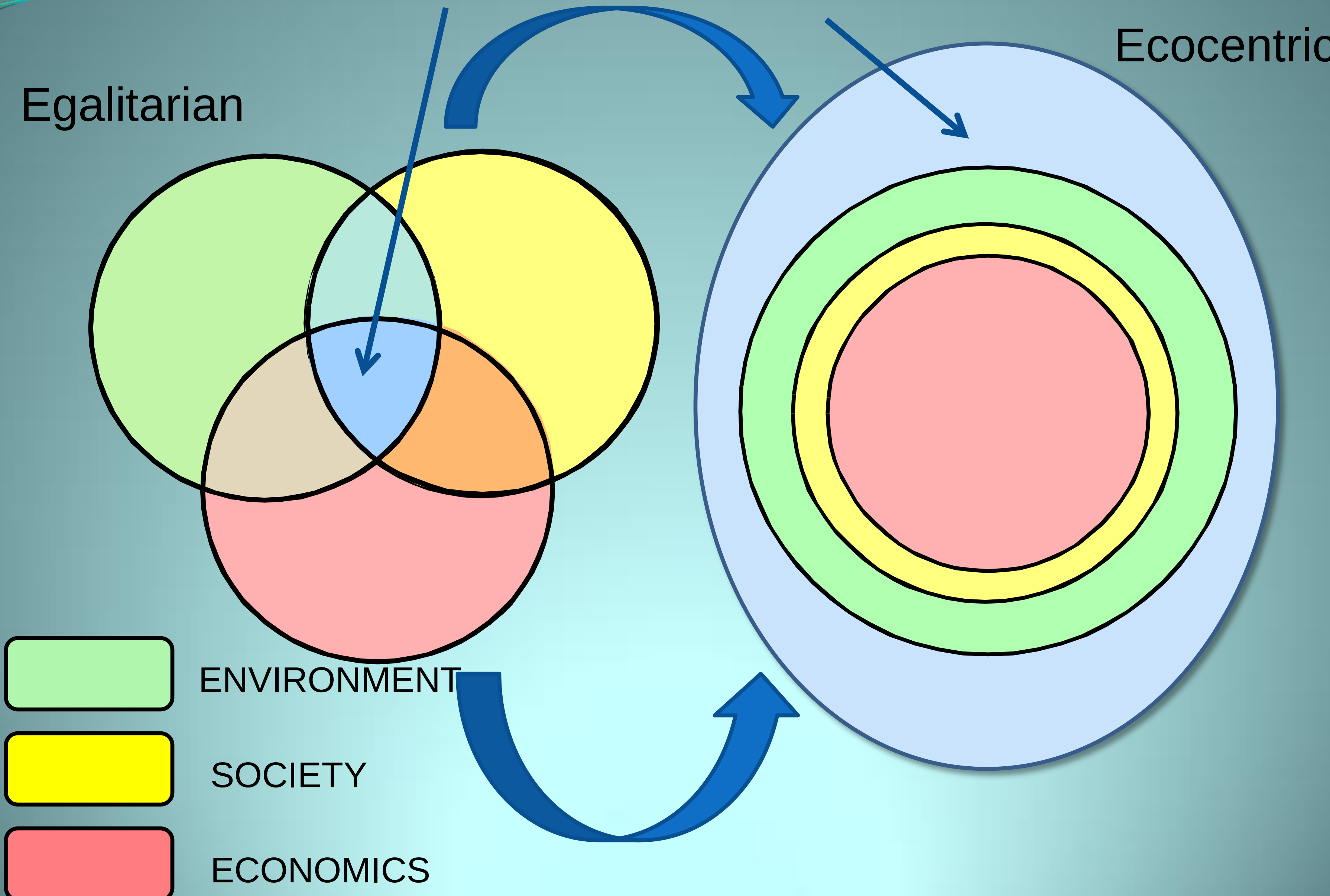
- In a market situation where consumers could have a choice, monopolies are sometimes broken down by legal actions (US Steel, ATT)
- Private utilities (e.g., suppliers of electricity and water) are usually allowed to fully recover the cost + small profit (~ 10%)

Triple Bottom line Assessment

Includes all three of

- Environment
  - Water quality and habitat, balanced biota
  - Ecologically functioning landscape
  - Reduced erosion, etc.
- Society
  - GHG emissions (global self – preservation), net zero
  - Recreation, housing
  - Improved public health
- Economy
  - Employment
  - Green infrastructure
  - Water conservation

Sustainability



Impact of construction

- Construction uses 50% of all worldwide resources
- 25% of all harvested wood
- Mining. Harvesting, drilling, quarrying raw materials pollutes environment
- Transporting material to their point of use and converting them into buildings and construction products further pollutes the environment and has a large water and energy footprint
- After construction the buildings and other construction pollute environment, use energy and emit carbon over their lifetime

Good news

- 90% of US consumers would be willing to pay up to 2% over the const to reduce the environmental effects of construction
- Thus environmental performance must balance the economic performance
- Life time performance can be calculated as its Present Value

Bad news

- Preserving environment and reducing carbon footprint (reducing emissions of GHGs) are economic externalities that are often not included in economic analyses and do not have at first look economic value
- Economic value of intangible externalities is obtained by surveys of Willingness to pay of the population and cannot be typically established for individual buildings or eben subdivisions

Life line assessment

- The life line triple bottom assessment looks not just on the construction cost but on the cost over the entire life line of the project
- It includes also social and other costs such as carbon footprint (global warming)
- It includes all stage of the life line of the project
  - Raw materials
  - Manufacturing
  - Transportation
  - Installation
  - Waste management and recycling

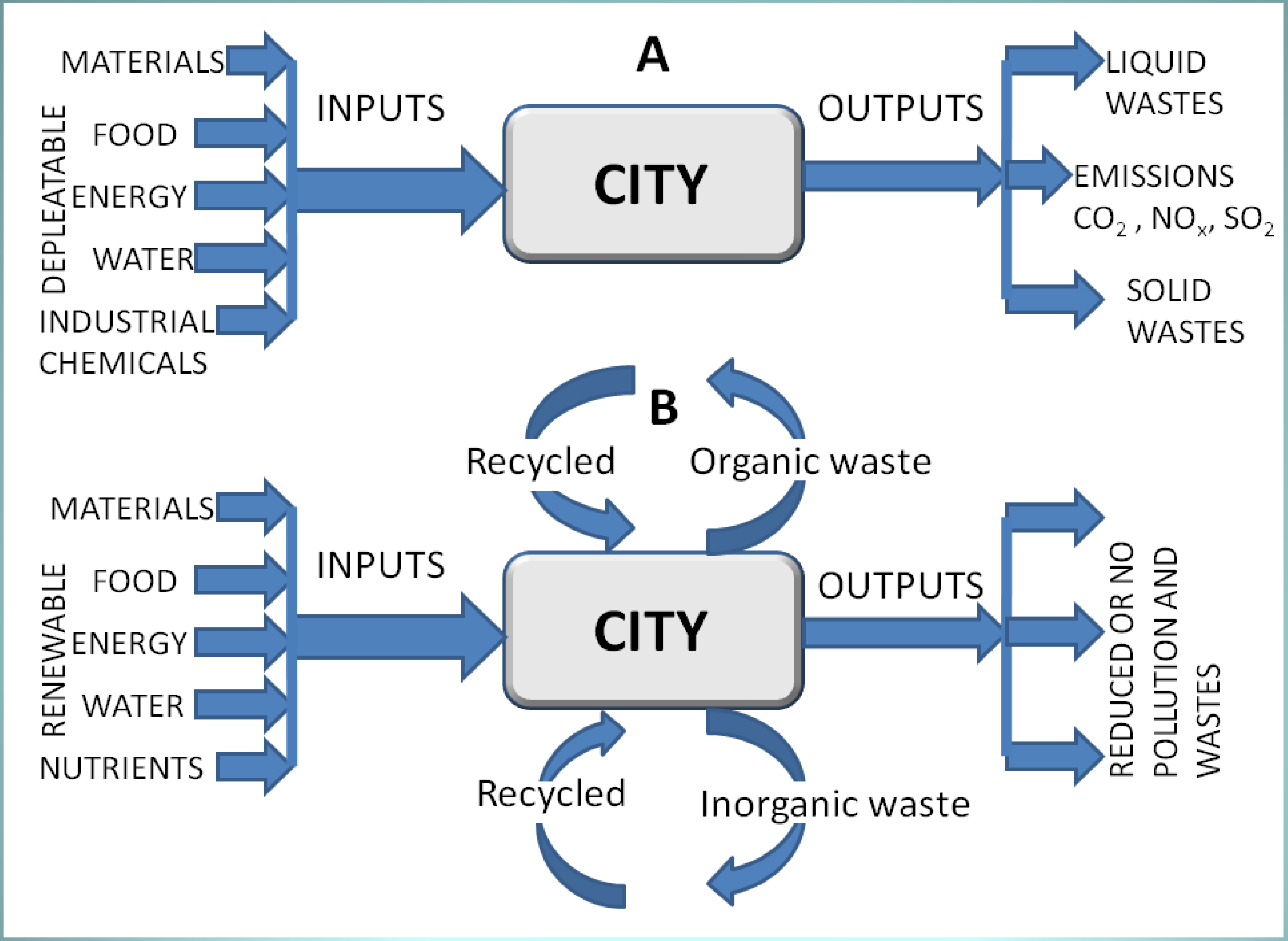
LCA Methodology

1. *Goal and scope definition* spells out the purpose of the study and its breadth and depth
2. *Inventory analysis and flows* quantifies the environmental inputs and outputs associated with a product over its entire life cycle
3. *Impact assessment on environment and society*
    1. *For example, carbon emissions is a flow which has a global impact*
4. *Interpretation step*

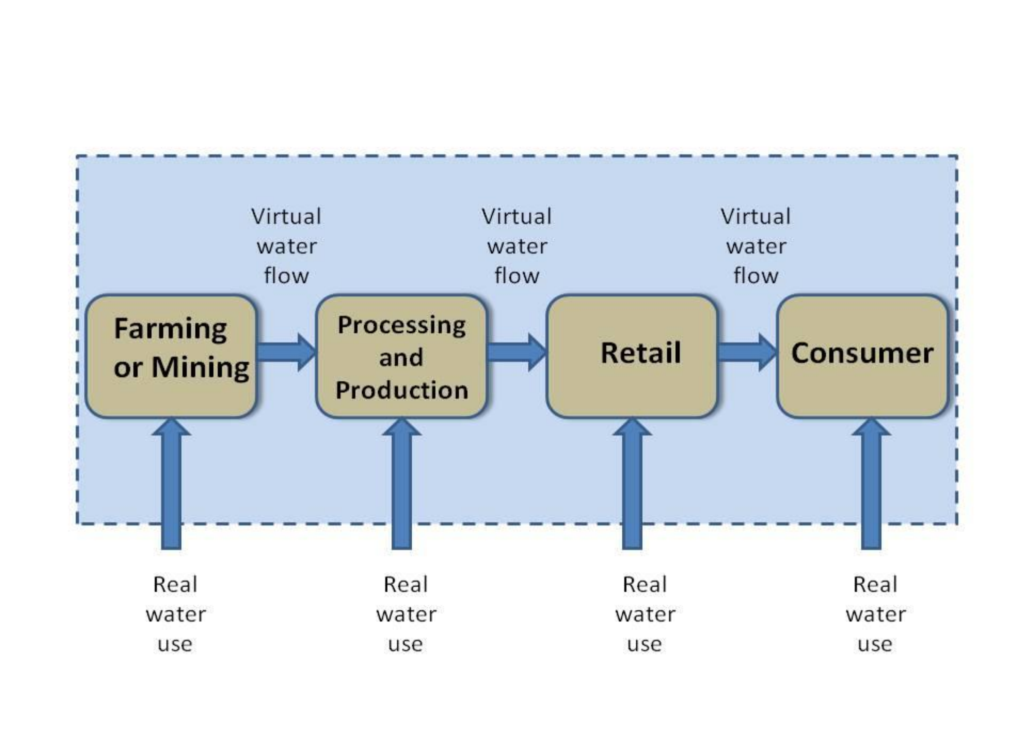
Footprints

- *The ecological footprint* is a measure of the use of bio-productive space (e.g., hectares of land needed to support life in the cities
  - A North American city – 4.8 ha/person
  - India - 1.3 ha/person
  - Available productive land on the earth -- 1.6 ha/[person
- *The carbon footprint* is a measure of the impact that human activities have on the environment in terms of the amount of GHG emissions measured in units of carbon dioxide.
  - US cities average 8 tons CO_2/capita-year
  - Barcelona 3.4 tons CO_2/capita-year
  - Megalopolis of the developing world -- < 1 ton/capita -day
  - Sustainable < 4 tons/capita-day
- *The water footprint* measures the total water use on site and also virtual water

Linear and cyclic systems
Urban Metabolism



Virtual water



In the US

- Water use per person is about 560 litres/cap-day
- Virtual water use is about 1900 litres/capita-day

- Virtual water is transferred in goods and materials from area of production to the area of use.