3. Efficiency, property right, market failure and the Environment

3.1 Efficiency, discounting and intergenerational equity

1. **Efficiency**

⇒ Efficiency: Maximization of Total Net Benefit

- An allocation of resources is said to be efficient If the net benefit from the use of resources is maximized by that allocation.
- If it is not possible to reallocate resources to make one or more persons better off without making at least one other person worse off →the allocation is at Pareto optimality
- Conversely, an allocation is inefficient if it is possible to reallocate resources that can lead to improvement in someone's position without worsening the position of anyone else → lack of Pareto optimality
- A gain by one or more persons without anyone else loosing is known as a **Pareto improvement.**

2. Static versus dynamic efficiency

I) Static efficiency

⇒ **Static allocation of resources:**

→ Refers to allocations of resources in a single time period.

→ Time is not an important consideration in static allocation of resources.

→ The assumption is that the allocation in one period does not affect allocations in the next period or the periods thereafter.

⇒ **Static efficiency:**

→ The chief normative criterion for choosing among various allocations when time is not an important consideration.

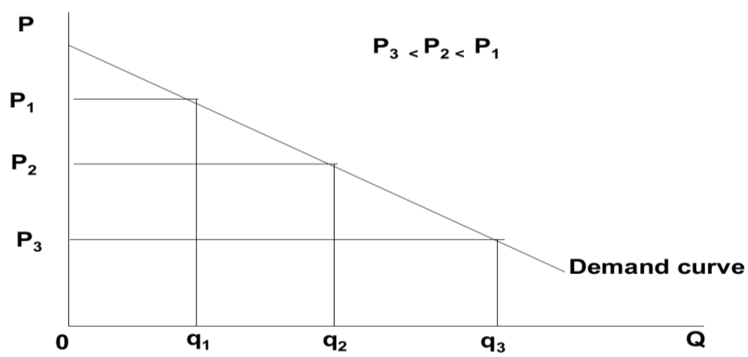
→ An allocation satisfies the static efficiency criterion if it maximizes the net benefits from all possible uses of the resource.

Net benefit (NB) = Total benefit (TB) - Total cost (TC)

How do we measure benefits and costs?

Measuring benefits

- Benefits can be derived from the (market) demand curve.
- Demand curves measure the amount of a particular good people/consumers would be willing to buy at various prices.



- Demand curves are down sloping reflecting the inverse relationship between price and quantity demand.
- Consumers buy less of a commodity (or environmental service) the higher is its price.
- That is, diminishing willingness-to-pay leads to a downward sloping

Marginal and total benefit

Marginal benefit

- For each quantity purchased, the corresponding point on the demand curve represents the price (P) or the marginal willingness to pay (MWTP) people/consumers are willing to pay for the last unit of the good.
- MWTP is the concept used to define marginal benefit (MB).

i.e. P = MWTP = MB

→ The MB/MWTP for q_1^{th} units is the price of q_1 units, P_1.

→ The MB/MWTP for q_2^{th} units is the price of q_2 units, P_2.

→ The MB/MWTP for q_3^{th} units is the price of q_3 units, P_3.

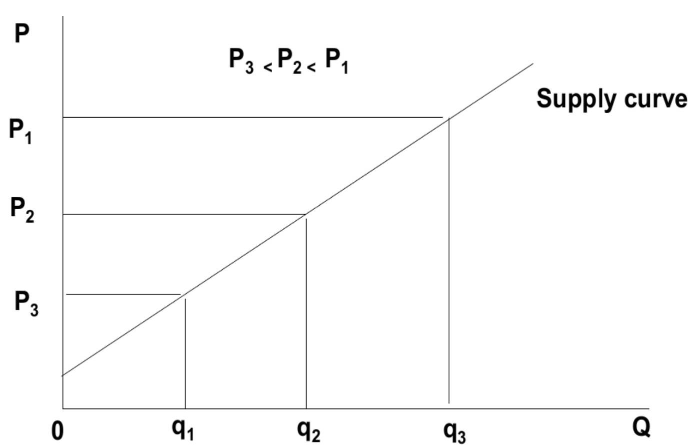
- Thus, the height of the demand curve measures marginal benefit (MB).

<u>Total benefit</u>

- Total willingness to pay (TWTP) is equal to the area under the demand curve from the origin to the allocation of interest.
- TWTP is the concept used to define total benefits (TB), i.e., TWTP = TB
  - → TWTP/TB for q_1 units is the area under the demand curve between zero and q_1 units.
  - → TWTP/TB for q_2 units is the area under the demand curve between zero and q_2 units.
  - → TWTP/TB for q_3 units is the area under the demand curve between zero and q_3 units.
- Thus, the area under the demand curve measures total benefit (TB)

Measuring costs

- Measuring costs involves logic similar to measuring total benefits.
- Costs can be derived from the (market) supply curve.
- Supply curves measure the amount of a particular good people/producers would be willing to supply at various prices.



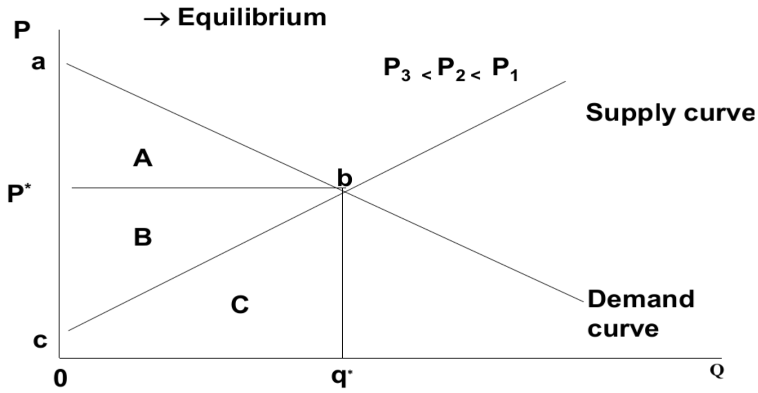
- In purely competitive markets, the supply curve is identical to the marginal opportunity cost curve.
- The marginal opportunity cost curve defines the additional cost of producing the last unit.
- The law of diminishing returns (increasing costs) leads to an upward supply curve.

Marginal and total cost

- For each quantity supplied, the corresponding point on the supply curve represents the marginal cost (MC) of the last unit of the good.
- In purely competitive markets, price is equal to MC, i.e., P = MC.
  - → The MC of q_1^{th} units is the price of q_1 units, P_3
  - → The MC of q_2^{th} units is the price of q_2 units, P_2.
  - → The MC of q_3^{th} units is the price of q_3 units, P_1.
- Thus, the height of the supply curve measures marginal cost (MC).
- Total cost (TC) is simply the sum of the marginal costs.
- Geometrically, total costs are equal to the area under the supply curve from the origin to the allocation of interest.
  - → The TC of producing q1units of the good is the area under the supply curve between zero and q1 units.
  - → The TC of producing q2units of the good is the area under the supply curve between zero and q2 units.
  - → The TC of producing q3units of the good is the area under the supply curve between zero and q3 units.
- Thus, the area under the supply curve measures total cost (TC)
- Geometrically, the total cost of producing q3units of the good is the area under the marginal cost curve (supply curve) from zero to q3 units, i.e. the shaded area in the figure.
  - ⇒ In a perfectly competitive market:

→ All consumers face a common market price, and adjust their consumption until their marginal utility (marginal benefit = MB) is equal to that price.

→ Each firm faces the same fixed market price, and adjusts its output so that its marginal cost (MC) of production equals that price. So we have: P=MC=MB



- In purely competitive markets, static efficiency is obtained at the point of equilibrium (the intersection of D and S), i.e., point b in the figure.
  - ❖ Equilibrium price = P* ; Equilibrium quantity = q*

Total benefit (TB):

⇒ Total consumers' willingness to pay for q* units of the good

⇒ The area below the demand curve between zero and q*units of the good

⇒ Area 0abq*= A + B + C

Total cost (TC):

⇒ The area below the supply curve between zero and q*units of the good

⇒ Area 0cbq*= C

⇒ Total benefit (TB) is greater than total cost (TC):

⇒ Net benefit (NB) = TB – TC = 0abq*(A + B + C) - 0cbq*(C) = acb (A + B)

- The market equilibrium quantity or allocation (q*) is efficient, i.e., maximizes net benefit.
- Any position to the left or to the right of the equilibrium results in a lower net benefit.
- That is, an allocation other than the equilibrium allocation is inefficient.
- In other words, it is not possible to increase the net benefit by producing more or less than q*units of the good.

Thus, static efficiency is achieved (net benefits are maximized) when the marginal benefits (MB) from an allocation equal the marginal costs (MC), i.e. **MB =MC or P = MC.**

Note that P = MB = MWTP.

⇒ **Who gets the net benefit?**

→ It is shared between consumers and producers

→ Consumers' share of the net benefit = consumers' surplus

→ Producers' share of the net benefit = producers' surplus

- **Consumer Surplus:** Total benefit minus cost of purchasing the good, or the area under the demand curve and above the price line.

→ Total benefit (TB) at q* level of output= Area 0abq*= A + B + C

→ Cost of purchasing q* level of output = Area 0P*bq*= B + C

→ Consumers surplus = 0abq*- 0P*bq*= P*ab, or = (A + B + C) - (B + C) = area A

- **Producer Surplus:** Revenue minus Total Cost, or the area under the price line and above the supply curve.

→ Revenue at q* level of output= Area 0P*bq*= B + C

→ Total cost of q* level of output = Area 0cbq*= C

→ Producers' surplus = 0P*bq*- 0cbq*= cP*b, or= (B + C) - (C) = area B

- Thus, NB = Consumers' surplus + Producers' surplus
- Efficient allocations are Pareto optimal.

- An allocation is said to be Pareto optimal if no reallocation of resources could benefit any person without lowering the net benefits for at least one other person.
- Since net benefits are maximized by an efficient allocation, it is not possible to increase the net benefit by rearranging the allocation.
- In other words, reallocation of resources cannot lead to Pareto improvement, i.e., it is not possible to make one or more persons better off without making at least one other person worse off.

Dynamic (intertemporal) efficiency

- Dynamic (intertemporal) allocation of resources: refers to allocations of resources overtime
- Static efficiency criterion (i.e. P = MC or MB = MC) is very useful for comparing resource allocations when time is not an important factor.
- However, in many cases resource allocation involves decision making over time.
- Decisions made now have implications for the consumption and production possibilities available in the future.
- When time is involved and decisions are interdependent over time, the decisions are dynamic in nature (and more complex). Example: a hypothetical demand schedule for oil.

Price per barrel $	Quantity demanded barrels	MC of extraction $
8.00	0	2
7.60	1	2
6.00	5	2
5.60	6	2
5.20	7	2
4.80	8	2
4.40	9	2
4.00	10	2
3.60	11	2
2.00	15	2
0.00	20	2

Example: a hypothetical demand schedule for oil.
Assumptions:
- -There are only 20 barrels of oil in stock
- -The marginal cost of extraction (MCE) of oil is constant: $2 per barrel, for all levels of oil extraction

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Static solution:

- Static efficiency criterion: Extract that quantity of oil for which P=MEC. (Note that MC is replaced by MEC, the marginal extraction cost).
- The efficient level of oil extraction would be 15 barrels.
- If we heed to the static solution, 15 barrels should be extracted this period, leaving only 5 barrels for the future. (There is no enough stock to allow extraction of 15 barrels each period.)
- Is this a good allocation over time? Static models wouldn't tell us. We need a dynamic model to work this out.

⇒ **Now, assume that:**

  → The 20 barrels of oil in stock can be used in two time periods: Period 0 (now) and Period 1 (future).

  → The problem: allocating the fixed stock/supply of the oil between the two years.

  → In period 0, if 15 barrels were extracted, price would be $2 per barrel.

  → However, in period 1 the price would shoot to $6, because there are only 5 barrels available.

  → Oil is scarcer in period 1. An allocation this period affects the net benefit (profitability) in the next period.

  → An efficient/optimal allocation over time should, therefore, maximize the sum of the net benefits (profits) in the two periods (more precisely the sum of the present value of the profits in two periods), given a total stock of 20 barrels.

- How can we make choices in a dynamic decision problem, where benefits and costs occur at different points in time?
- Time is an important factor in dynamic analysis. Incorporating time into the analysis requires thinking not only about the magnitude of benefits and costs, but also about timing.

- In order to incorporate timing, the decision rule must provide a way to compare the net benefit received in one period with the net benefit received in another. The concept that allows this comparison is called present value.

Discounting

- Discounting is finding present value. Present value explicitly incorporates the time value of money.
- Is a benefit of $100 received, this period the same as a benefit of $100 received a year later? (Do you have any time preference?)
- Birr 100 today invested at 10% interest yields Birr 110 a year from now (the Birr 100 principal plus Birr 10 interest).
- The present value of Birr 110 received one year from now is, therefore, Birr 100.PV = 110/(1+r) = 110/(1+0.10) = 110/(1.1) = 100. Because, given Birr 100 now, you can turn it into Birr 110 a year from now by investing it at 10% interest.

⇒ Given an annual interest rate of 10%, $110 received a year from now is only worth $100 today. Therefore, we have to discount future receipts or expenditures to compare them with current receipts or expenditures.

The discounting formula:

- The present value of a one-time net benefit B received n years from now is: $pv[B_n] = \frac{B_n}{(1+r)^n}$
- The present value of a stream of net benefits {B0, …,Bn}received over a period of n years is computed as $PV[B_0,,,,,,B_n] = \sum_{i=0}^{n} \frac{B_i}{(1+r)^i}$
- Where **r** is the appropriate interest rate and B_i is the amount of net benefits received **i** years from now.
- **Note: B0** is the amount of net benefits received immediately. The process of calculating the present value is called **discounting**, and the rate **r** is referred to as the **discount rate**

- Discounting is a central concept in natural resource economics. Itis a mechanism used to compare streams of net benefits generated by alternative allocations of resources over time.
    - ✓ Example: Assuming the interest rate is 10%:
    - ✓ What is the present value (PV) of Birr 100 received immediately (now)?

      $PV_0 = P_0/(1+r)^0 = 100/1 = 100$
    - ✓ What is the present value (PV) of Birr 100 received a year from now?

      $PV_1 = P_1/(1+r)^1 = 100/(1.1)^1 = 90.91$
    - ✓ The PV of Birr 100 received two years from now:

      $PV_2 = P_2/(1+r)^2 = 100/(1.1)^2 = 82.64$
    - ✓ The PV of Birr 100 received three years from now:

      $PV_3 = P_3/(1+r)^3 = 100/(1.1)^3 = 75.13$
    - ✓ PV of Birr 1000 received 5 years later at discount rate of 10%: r=10%, n=5 years, FV=$1000.

      $PV = 1000/(1.1)^5 = 620.92$

    - ✓ The present value of B dollars delivered 10 years from now at rannual rate of interest:

      $PV(B) = B/(1+r)^{10}$

Dynamic Efficiency

- The criterion used to find an efficient allocation when time is involved is called dynamic efficiency.
- An allocation of resources across n time periods satisfies the dynamic efficiency criterion if it maximizes the present value of net benefits that could be received from all the possible ways of allocating those resources over the n periods.

- Dynamic efficiency assumes that society's objective is to balance the current and subsequent uses of the resources by maximizing the present value of the net benefit derived from the use of the resource
- Example: Consider a simple model to define an efficient allocation of a depletable (nonrenewable) resource.

Assumptions:

- The resource can be used in **n** time periods
- The marginal cost of extracting the resource is constant: **C** per unit.
- There is a fixed supply of the resource to allocate between the n periods: total supply is **Q** units.
- The demand for the resource is linear and constant over time: It is given by **Pt= a – bqt**

How do we determine the dynamic efficient allocation?

⇒ According to the dynamic efficiency criterion, the efficient allocation is the one that maximizes the present value of the net benefit. The present value of the net benefit for the n years is simply the sum of the present values in each of the n years.

⇒ The inverse demand equation in year t: **Pt= a – bqt**

⇒ The total cost of extracting any amount qt**:** **TCt= Cqt**

⇒ Total supply of the resource: $\boldsymbol{Q = \sum_{t=1}^{n} q_t}$

Total Benefit:

- Area below the demand curve from zero to the allocation of interest (qt)
- Proceed by integration (the reverse of differentiation)

$$TB_t = \int_0^{q_t} (a - bq_t)dq \quad = aq_t - \frac{b}{2}q_t^2 + d$$

Where d is a constant term

⇒ Net Benefit= **NBt=TBt -TC**== $aq_t - \frac{b}{2}q_t^2 + d - Cq_t$

⇒ Present value of NBt: $pv(NB_t) = \frac{aq_t - \frac{b}{2}q_t^2 + d - Cq_t}{(1+r)^t}$

- Efficient dynamic allocation is one that maximizes the present value of net benefits over time. The sum of the present value of net benefits over time is given by:

$$\sum_{t=1}^{n} \frac{aq_t - \frac{b}{2}q_t^2 + d - Cq_t}{(1+r)^t}$$

→ **Maximize the sum of the present value of net benefits over time**.

- Let Z = the sum of the present value of net benefits over time.

$$MaxZ = \sum_{t=1}^{n} \frac{aq_t - \frac{b}{2}q_t^2 + d - Cq_t}{(1+r)^t}$$

- Subject to a constraint: Supply constraint: $\sum_{t=1}^{n} q_t = Q$
- Applying the Lagrange method:

$$L = \sum_{t=1}^{n} \frac{aq_t - \frac{b}{2}q_t^2 + d - Cq_t}{(1+r)^t} + \lambda\left(Q - \sum_{t=1}^{n} q_t\right)$$

First order conditions (FOCs):

$$\frac{\partial L}{\partial q_t} = \frac{a - bq_t - c}{(1+r)^t} - \lambda = 0$$

$$\frac{\partial L}{\partial \lambda} = Q - \sum_{t=0}^{n} q_t = 0$$

- The FOCs yield solutions for prices, quantities and λs for the n periods.

3.2 Property Rights

- Property right refers to a bundle of entitlements defining the owner's rights, privileges, and limitations for use of the resource.
- Property rights can be vested with individuals, a group or the state.

→ **Efficient property right structure**

- An efficient (well-defined) property rights structure has four main characteristics:
  – **Universality / comprehensive**
  – Exclusivity,
  – **Transferability**
  – Enforceability

→ ***Universality / comprehensive***

- All resources are either privately or collectively owned and all entitlements are defined, well known and enforced.
- Ownership is an essential precondition to trade or exchange

→ **Exclusivity**

- All benefits and costs from use of a resource accrue to the owner, and only to the owner, either directly or indirectly by sale to others. This applies to both private and common property resources. Others should not have competing rights to the same resource.

→ **Transferability**

- All property rights should be transferable from one owner to another in a voluntary exchange
- Transferable by way of lease, sale or bequest.

→ **Enforceability**

- Property rights should be secure from involuntary seizure or encroachment by others.
- There must be trust on the legal system to protect property rights
- An owner of a resource with a well-defined property right has a powerful incentive to use that resource efficiently, since a decline in the value of the resource represents a personal loss

Market failure

- In a perfectly competitive market,
  - → Market allocations and efficient allocations coincide so that net benefit is maximized.

– i.e., Market equilibrium is efficient

- A perfectly competitive market has the following properties:

i. Well-defined property rights

- There are well-defined and enforceable property rights that define the ownership of resources, goods, and services so that buyers and sellers can exchange these assets freely.

ii. No externalities exist

- The action of one agent (a producer or consumer) does not cause any external effect (benefit or cost) on parties external to the transactions.

iii. All agents are price-takers.

- There are many producers and consumers. Producers and consumers are small relative to the market and thus cannot influence prices. Instead, they maximize profits or utility taking market price as given.

IV. Information is symmetric between buyers and sellers.

- Producers and consumers have full knowledge of the prices, quality, availability and location of goods and services.

Transaction costs are zero

- Transaction costs include:
  - ✓ Information costs
  - ✓ Contacting costs
  - ✓ Enforcement costs

- If these conditions were to exist, a market allocation of resources would be an efficient allocation (i.e. Pareto optimal).
- In practice, some of the conditions for perfectly competitive market are not satisfied.
  - In such cases, the economy will be characterized by market failure and markets will not allocate resources efficiently.

➢ **Market failure-** An inefficient allocation of resources produced by a market economy when one or more of the conditions for a perfectly competitive market is not met.

3.3 Externalities

- An externality exists whenever the welfare of some agent, either a firm or a household, depends directly, not only on his or her activities, but also on activities under the control of some other agent as well.
- Externalities may be related to production or consumption activities.
  - **Production externalities** occur when the production decision of one agent affect the production possibilities of another agent.
  - **Consumption externalities** occur when the consumption decision of one agent affect the utility of another agent.

- There are two types of externalities:
- Externalities (external effects) may be beneficial or adverse.

i) An external economy (external benefit, positive externality)

- ✓ Exists when the activities of one agent make another agent better off.
- ✓ Example: - Vaccination against an infectious disease.
  - Bee keeping and apple field (pollination of blossom)

ii) External diseconomies (external cost, negative externality)

- ✓ Exists when the activity of one agent makes another agent worse off.
- ✓ Example: - Noise pollution from radio playing in a park
  – A factory polluting river with a fishery downstream

Externalities:

- ♣ Occur in an unintended way.
- ♣ Violate the exclusivity characteristic of an efficient property right structure.
- ♣ Are not transmitted accurately through a market
- ♣ Those who benefit from positive externalities do not pay for them

- ♣ The producers of negative externalities make no compensation to the affected party.

The Consequence of Externalities

- Economists make a distinction between private costs and external costs.
- Private costs are borne by someone involved in the transaction.
- External costs are borne by someone not involved in the transaction.

The same distinction is made between private and external benefits.

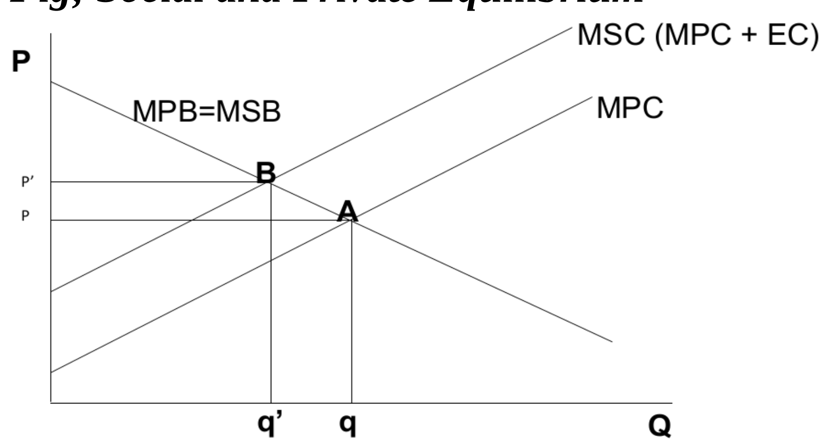
→ **Social costs = private costs + external costs**

→ **Social benefits = private benefits + external benefits**

(i) External diseconomies

- Suppose a steel mill and a resort hotel are located by a river.
- The steel firm uses the river as a receptacle for its waste, while the hotel uses it to attract customers seeking water recreation.
- The steel firm doesn't bear the cost of reduced business at the hotel resulting from the waste it dumps into the river.
- Since the firm doesn't take into account the external cost in its decision-making, it is expected to dump too much waste into the river. Hence, an efficient allocation of the resource (the river) would not be attained

Fig; Social and Private Equilibrium



- MPB – Marginal private benefit
- MPS – Marginal social benefit
- MPC – Marginal private costs
- MSC – Marginal social cost
- EC - External cost
- q – privately optimal level of activity (production)
- q'- socially optimal level of activity (production)

- The demand for steel is shown by **MPB=MSB**.
- The supply of the product (excluding the external cost) is given by **MPC**
- In the presence of negative externality:– **MSC > MPC** (the difference is MEC - marginal external cost)
- The privately optimal level of output exceeds the socially optimal one (i.e. q > q')

Conclusion:

- The output (of the product that generates external benefit) is too low
- The price of the product that generates external benefit is too high

Pecuniary externalities

- arise when the external effect is transmitted through higher prices.
- Suppose that a new firm moves into an area and drives up the rental price of land.
- That increase creates a negative effect on all those paying rent and, therefore, is an external diseconomy.
- This pecuniary diseconomy, however, does not cause a market failure because the resulting higher rents are reflecting the scarcity of land.
- The land market provides a feedback mechanism.

- The pollution example is not a pecuniary externality because the effect is not transmitted through prices.
- That is, prices do not adjust to reflect the increasing waste load.
- The scarcity of the water resource is not signaled to the steel firm.
- An essential feedback mechanism that is present for pecuniary externalities is not present for the pollution case

3.4 Public goods

- A public good is a good or service whose consumption is non- rival (indivisible) and non-excludable

→ **Non-rivalry in consumption**

- Consumption is said to be non-rival (indivisible)when one person's consumption does not diminish the amount available to others.
- This characteristic of a public good implies joint consumption possibilities, i.e. a public good can be consumed by several individuals simultaneously without diminishing the value of consumption to any one of the individuals.

→ **Non-excludability in consumption**

  - Consumption is said to be non-excludable when an individual cannot be prevented/excluded from consuming the good or service whether or not the individual pays for it.
  - This characteristic of a public good implies high exclusion costs, i.e. it is very costly to prevent an individual from consuming a public good even when the individual fails to pay for it.
  - Thus, once it is provided, a public good is accessible to all.

Examples of public good include:

– Fresh air

– A public park

– Charming landscape (a beautiful view)

– National defense

Can the market provide the efficiently level of public goods?

- No! The market provision of public goods tends to be inefficient.
- Inefficiency results because each person is able to become a free rider.
- Due to the consumption indivisibility (non-rivalry) and non-excludability properties of public good, individuals have the incentive to free ride, or to not pay for the benefits they receive from consuming the public good.
- With a free-rider problem, private firms cannot earn sufficient revenues from selling the public good to induce them to produce the efficient (socially optimal) level of the public good.
- Thus, markets often undersupply public goods.

Improperly Designed Property Rights Systems

- Private property is not the only possible way of defining entitlements to resource use. Other property rights regimes include:

  – State-property regimes

  – Common-property regimes

  – Open access resources (Res nullius)

State-property regimes

- State property is a regime in which the government owns and controls the property.
- It exists not only in former communist countries but also to varying degrees in all countries of the world.

- For example, parks and forests are frequently owned and managed by the government in capitalist as well as socialist countries.
- Efficiency and sustainability problems can arise in state-property regimes since the incentives of bureaucrats who implement and/or make the rules for resource use may diverge from collective interests.

Common-property regimes

- Common property refers to property owned in common rather than privately.
- Property right is held by a specified group of co-owners and excludes those not in the group.
- The group of owners jointly own and manage the property.
- Thus, common property is a property rights regime in which the rights of access, withdrawal, management and exclusion are held in common by a group of owners.
- Rights to use common – property resources may be formal, protected by specific legal rules involving the use of the resource (e.g., specific share agreements in certain fisheries).
- Common property rights may also be informal, protected by tradition and custom (e.g. in some agrarian communities' customary procedures govern the use and management of pasture lands).
- Common- property resources may possibly be allocated efficiently
    - → if the group of owners are small and can set up a system of rules, and
    - → if there is social sanctions against breaking rules by any one of them.
- On the other hand, common-property resources are allocated inefficiently

→ if there is no well-defined system of rules governing the use of the resources or if the number of owners is large.

→ Even if the group of owners is small and can set up a system of rules, every one of them has the incentive to break the rules unless there are social sanctions against it.

- Moreover, population pressure and the infusion of outsiders raise the demand for common-property resources and undermine collective decision making significantly that the rules became unenforceable, producing overexploitation of the resource.

Open access resources (Res nullius)

- Open access property is a property rights regime in which no entity holds recognized access, withdrawal, management, exclusion, or alienation rights to a resource.
- Open access thus represents lack of property rights or ownership of any kind.
- Open access property resource can be exploited on a **first-come, first-served basis**, because no individual or group has the legal power to restrict access.
- Rival but non-excludable resources are considered as open access or common pool resources.

  – Examples: unregulated fisheries or grazing lands

  - In the presence of open access, markets cannot by themselves allocate resources efficiently.
  - In the presence of sufficient demand, open (unrestricted) access causes resources to be overexploited.
  - Unlimited access destroys the incentive to conserve.

- An individual exploiting an open-access resource would not have any incentive to conserve because benefits derived from restraint (conservation) would, to some extent, be exploited by others.
- Open access to resources thus promotes an inefficient allocation.

Tragedy of the commons

- Open access leads to the most serious problems in natural resource use popularly known as the "tragedy of the commons".
- Hardin (1968) presented an argument that suggests that overexploitation of a resource shared by many parties is inevitable.
- This argument is termed 'the tragedy of the commons' and it states that each individual with access to a commonly shared (open access) resource will try to maximize his own gain from the resource, and management of the resource to maximize long-term yield will not be possible.
- Every individual harvesting an open-access resource does not take into account the cost he imposes (in terms of reduced productivity of the resource) on others (the community) who are also harvesting the resource.
- The cost of individual behavior is borne by the whole community, but the benefits accrue to individuals.
- Every individual will thus try to take as much resource as possible, and the resource will be exhausted (destroyed).
- Such an outcome is referred to as the "**tragedy of the commons**".

Example: Buffalo hunting

- Consider a buffalo harvesting (hunting) activity in a certain park/village.
- The total revenue or benefit (TR/TB) and total cost (TC) of the hunting activity are depicted in Figure 1(a).

- The related average revenue (AR), marginal revenue (MR), average cost (AC) and marginal cost (MC) of the hunting activity are also shown in Figure 1(b).
- Two different levels of harvest effort (E1 and E2) are shown in the Figure, where harvest effort refers to the time and effort expended by hunters to harvest (hunt) buffalo.

Figure 1 (a): Buffalo harvesting - Relationship between TR and TC

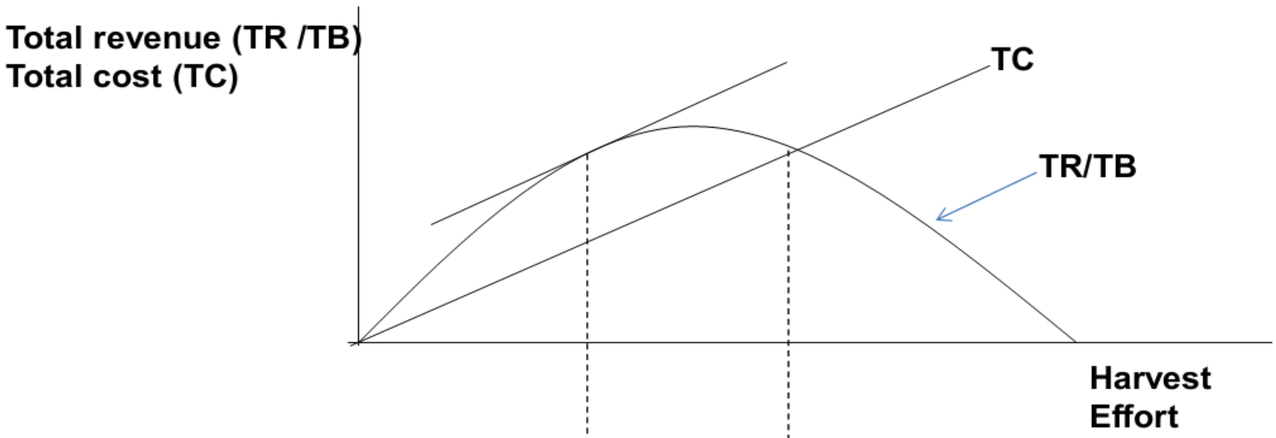
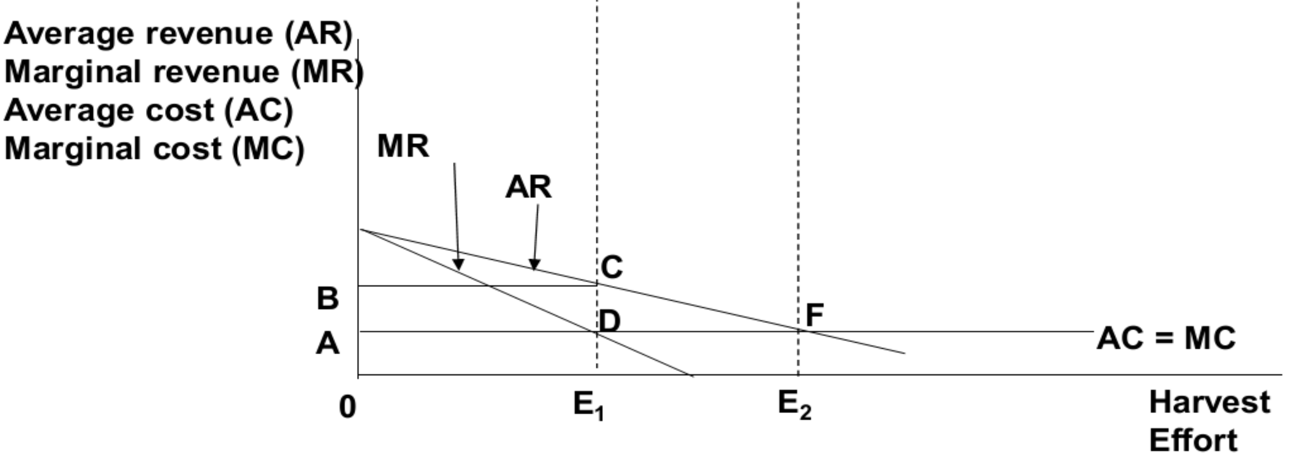


Figure 1 (b): Buffalo harvesting: Relationship between AR, MR, AC, and MC



- The efficient level of hunting activity (effort) is E1.
- E1is the level of effort where the marginal benefit (marginal revenue) curve crosses the marginal cost curve.

- At this level of harvest/hunting the marginal benefits would equal the constant marginal cost implying that net benefits would be maximized.
- Owner/owners with exclusive right would apply this level of effort (E1) and earn scarcity rent (TR-TC) from the resource
- Under open access (with all hunters having unrestricted access to the buffalo) the resulting allocation would not be efficient.
- Open-access hunters without exclusive rights would exploit the resource until their total benefit equaled total cost, implying a level of effort equal to E2.
- At this level of effort, over exploitation of the herd occurs and the scarcity rent dissipates
- No individual hunter would have an incentive to protect scarcity rent by restricting hunting effort.
- Since individual hunters cannot appropriate the scarcity rent, they ignore it.
- Two characteristics of open-access allocation:
    1. In the presence of sufficient demand, open/unrestricted access will cause resources to be overexploited and
    2. The scarcity rent is dissipated; no one appropriates the rent, so it is lost