Environment and Development

Sustainable Development:

Sustainable development is defined as meeting the needs of the present generation without compromising the needs of future generations. A development process is sustainable if and only if the stock of "overall capital assets" remain constant or rises over time.

The "overal capital assets" include: (i) manufactured capital (machines, factories, infrastructure etc), (ii) human capital (knowledge, skills, experiences etc.), (iii) environmental (natural) capital (quality of air, water, soil etc.).

Among these only human capital does not follow normal depreciation rules. But the other two do. However, the depreciated component of manufactured capital can be regenerated, whereas the damage in case of environmental capital may be irreversible.

GREEN ACCOUNTING:

As we ~~[illegible]~~ do the National Income Accounting, similarly Sustainable National Income accounting also needs to be done. This is called "green accounting".

Sustainable National Income needs to consider the depreciation of stock of both physical capital (DM) and natural capital (DN).

Moreover, for renewable environmental capital the cost of regeneration (R) and for non-renewable environmental capital the cost of averting the damage (A) should be taken into consideration

Such that for environmental capital, the ~~net dep~~ total loss for environment capital becomes: $(D_N + R + A)$

~~So~~. Thus the GREEN NNP :

$$NNP^* = GNP - D_M - (D_N + R + A)$$

We can cite the example of Brandon & Homman (1995), who attempted to measure the annualized values of the environmental damage in India and estimated a loss of 4.5% of GDP, (ie. $D_N + R + A = 4.5\%$).

They followed the methodology to assess environmental damages through:

i) Pollution (Urban/Industrial) ⟶ Health Cost
- Air Pollution
- Low quality of drinking water
- Poor sanitation
- Inefficient Solid Waste Management (SWM)
- Degraded Marine environment

ii) Resource Degradation (Rural/Agricultural) ⟶ Productivity Low
- Soil erosion
- Rangeland degradation
- Deforestation
- Tourism.

iii) Ecological Imbalance ⟶
- loss of flora & fauna
- loss of biodiversity

↓

(not considered in the loss for India by Brandon & Hammann)

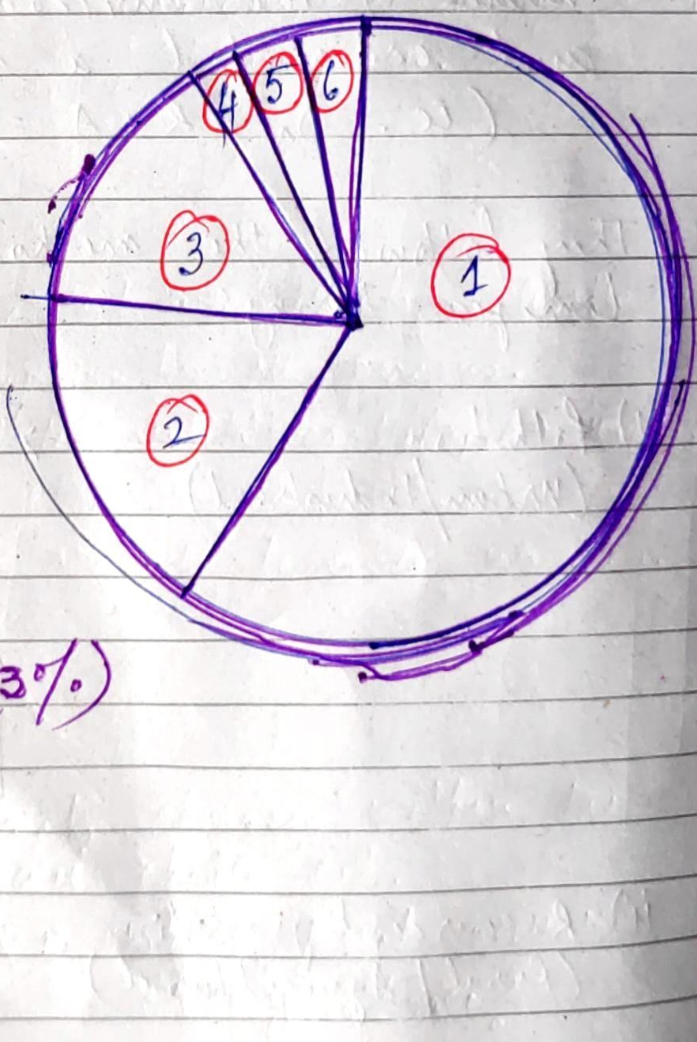
In this paper, to ascertain the health cost, incremental morbidity due to environmental damage is estimated and the "Cost of illness" is calculated to assess the social cost of this morbidity.

For productivity loss direct market based valuation was possible.

Final Assessment :

Loss of GNP due to:

1. Water Pollution (59%)
2. Soil Degradation (20%)
3. Air pollution (14%)
4. Deforestation (2%)
5. Rangeland Degradation (3%)
6. Tourism (2%).



Common Property Resources (CPR):

CPR is open access public good like grazing land, common water body, forest land etc. For CPR, the social cost of participation is much higher than the private cost of participation, generating externalities and leading to over exploitation. If this process continues for a long time, the CPR gets depleted. → This is called the "Tragedy of Commons".

The problem is illustrated by the following example:

Let us consider a CPR lake where the fishermen undertakes fishing activities. Suppose there are total K no. of fishing boats, such that $K = \sum_{i=1}^{n} k_i$, where n is the no. of fishermen and k_i is the no. of boats of the ith fisherman.

Now, the total catch of fish $Q = F(K)$ and the competitive price of a boat is $p = F'(K) = \frac{dQ}{dK} = MP_K$.

It is assumed that fish density is uniform across the lake, and thus each boat brings the same amount of catch.

Now, $K = k_i + K^{-i}$ where k_i = # of boats of the ith fisherman, K^{-i} = total # of boats by all other fishermen.

In taking his decision regarding optimal k_i, the ith fisherman will take K^{-i} as given. Hence his objective fn would be: $\max_{k_i} \left[\frac{k_i}{K} F(K) - p k_i \right]$

FOC: $\frac{K - k_i}{K^2} \cdot F(K) + \frac{k_i}{K} F'(K) = p$.

or, $\frac{K - k_i}{K} \cdot \frac{F(K)}{K} + \frac{k_i}{K} F'(K) = p$.

→ Under symmetric Nash eqlm. $\frac{k_i}{K} = \frac{1}{n} \Rightarrow \frac{K - k_i}{K} = \left(\frac{n-1}{n}\right)$

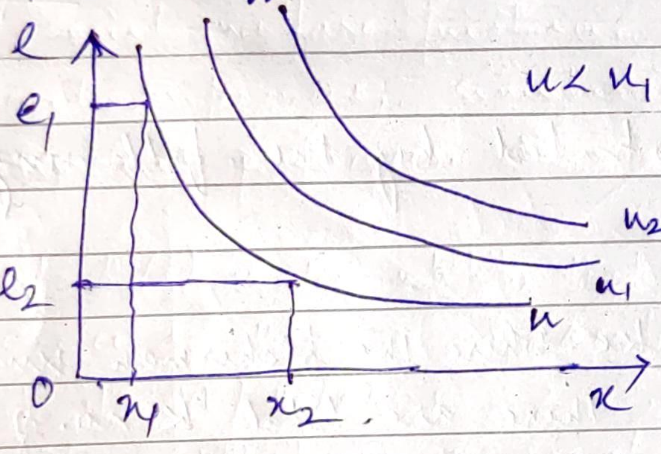
$\therefore p = \frac{1}{n} F'(K) + \frac{(n-1)}{n} \frac{F(K)}{K}$ and as $n \to \infty$, $p \to \frac{F(K)}{K} = AP$.

⇒ Instead of MP, p equals AP ⇒ over exploitation.

Before any further analysis we take a recap of market economy & welfare economics.

I (I) Let x be a good & e be environment, $u = u_i(x, e)$ defines the utility fn. with clean environment fetching positive utility : i) Health benefits, ii) Use value, iii) Existence value, iv) Altruism & v) Productivity value.

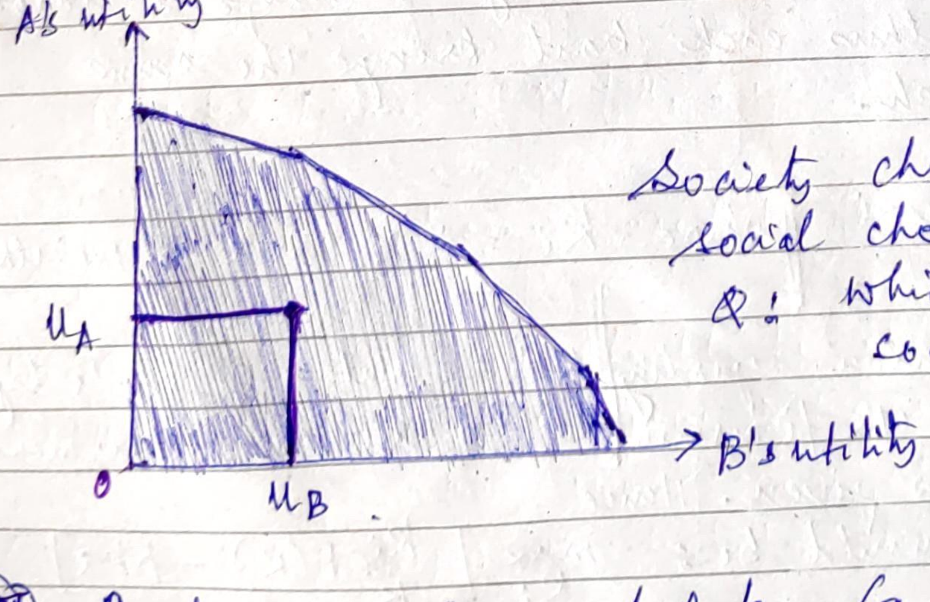
(A) The Indifference Curves: with $u = u(x, e)$.



→ Substitutability between environment & commodity consumption.

(B) Social Choice Set : The choice set are all feasible allocations. The allocation defines consumption for all persons. $x = x_1, x_2, \ldots$ with associated utilities $u_1(x_1, e), u_2(x_2, e), \ldots\ldots$

Then the Social Choice set are all feasible utilities.



Society chooses within the social choice set.

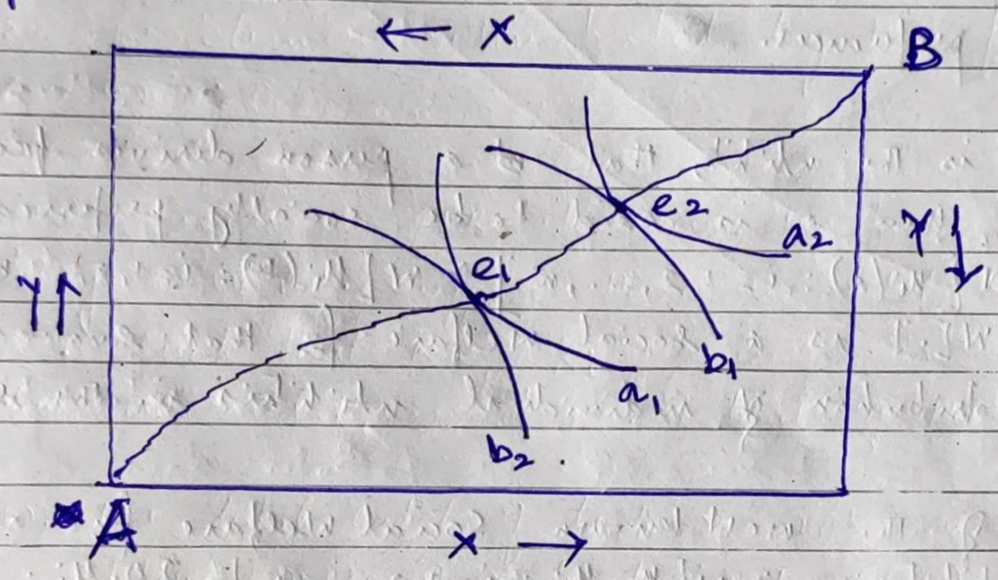
Q: which point will the society choose?

(II) **Pareto optimality** : Let $b = (x, e)$ and $b^i = (x^i, e^i)$.

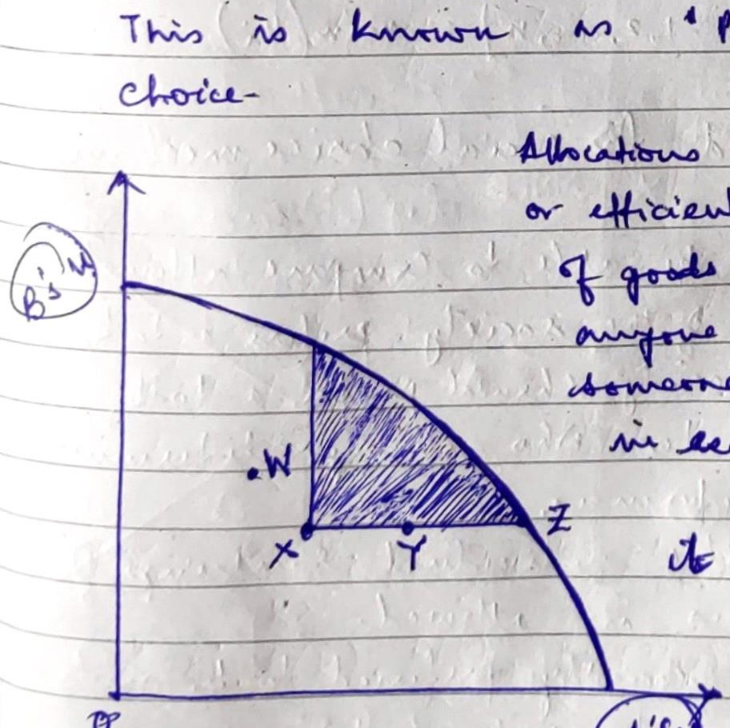
Then b^i is PARETO PREFERRED to b if, for every individual i, $u_i(b^i) \geq u_i(b)$ with $u_j(a^i) > u_j(a)$ at least for one individual j.

Recap:

Considering achieving efficiency (in exchange of goods) in a two-person economy; we illustrate the Edgeworth Box: any point on the plane represents an allocation of two goods between two individuals. The allocations along the CONTRACT CURVE are Pareto optimal. For any given endowment (ie initial allocation), efficiency can be achieved along an array of points – the CONTRACT CURVE – where indifference curves of two individuals are tangent to each other.



For the society as a whole, if all happen to prefer some alternative over all other alternatives, way may conclude that the society as a whole prefers that alternative. This is known as 'PARETO CRITERION for social choice.



Allocations on Pareto fontier are Pareto optimal or efficient. Pareto optimality implies an allocation of goods at which it is impossible to make anyone better off, without making someone worse off. Pareto frontier is, in essence, the contract curve.

An allocation is inefficient if it is interior to Pareto frontier. In such case, Pareto improvement is possible. Pareto improvement means an action that harms no one, and benefits at least one individual.

As described in the graph, W, X and Y allocations are inefficient. Z is an efficient allocation. Y, though inefficient, is Pareto improvement over X. All allocations in the shaded region are Pareto improvement over X.

Social Welfare functions & Impossibility Theorem:

A social welfare function is a way of representing social preferences, similar to utility functions for individual preferences.

If $u_i(a)$ is the utility that a person derives from choice a, then a is said to be socially preferred to b if $W[u_i(a) : i = 1, 2, \ldots, n] > W[u_i(b) : i = 1, 2, \ldots, n]$, where $W[\cdot]$ is a social welfare fn that summarizes the distribution of individual utilities in the society.

Some of the well known social welfare fns are:

(i) Utilitarian : $W[u_i : i = 1, 2, \ldots, n] = \sum_i \theta_i u_i$; $\theta_i \geq 0$, $\sum_i \theta_i = 1$.

(ii) Egalitarian : $W[u_i : i = 1, 2, \ldots, n] = \sum_i u_i - \lambda \sum_i [u_i - \min(u_i)]$

(iii) Rawlsian : $W[u_i : i = 1, 2, \ldots, n] = \min(u_i)$

The assumptions needed for social choice mechanism to work:

(i) Completeness : we should be able to compare alternatives

(ii) Unanimity : If everyone of the society prefers a to b, then the society should prefer a to b.

(iii) Nondictatorship : No dictator who always determines others' preferences.

(iv) Universality : any possible individual rankings of alternatives is allowed.

(v) Transitivity : If a is socially preferred to b, and if b is socially preferred to c, then a should be socially preferred to c.

(vi) **Independence of Irrelevant Alternatives**: Social preference between two alternatives should only depend on people's preferences for these two; regardless of their preferences for any other alternatives.

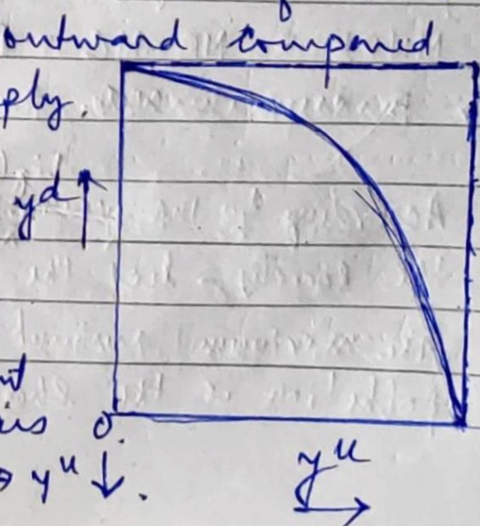
For any profile $\langle R_1, R_2, \ldots, R_n \rangle$ and $\langle R_1^*, R_2^*, \ldots, R_n^* \rangle$ in the domain of F and any $x, y \in X$; if for all $i \in N$ R_i's ranking between x and y coincides with R_i^*'s ranking between x and y, then xRy if and only if xR^*y. [R is the social preference relation].

Arrow's Impossibility Theorem: No rule can satisfy all the six assumptions that can convert individual preferences into social preference ordering.

Externality and Market Failure

Competitive eqlm does not always yield the socially optimum price-quantity combination. The reasons for this could be linked with concepts of externality, common property and public goods.

EXTERNALITY: In unregulated markets, firms costs do not typically account for environmental damages (eg. pollution) – usually associated with prodn process. The market supply is not the same as the socially optimum supply because of externalities. The supply curve is shifted outward compared to the socially optimum supply.



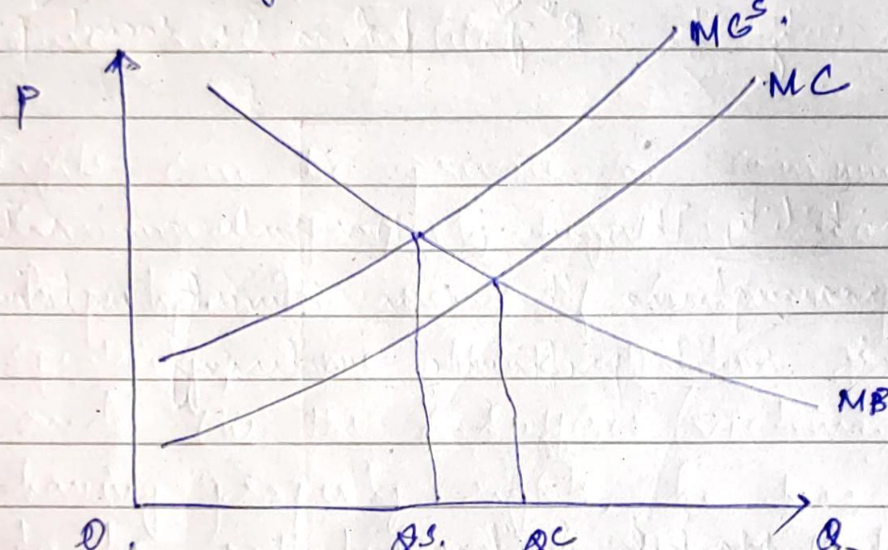
Considering two firms located near a river: One steel factory (upstream), dumping wastes into river & another resort using river for recreational purposes. The steel output (y^d) & resort o/p (y^u) are independent of each other. In presence of externalities y^u will be affected by y^d. As $y^d \uparrow \rightarrow y^u \downarrow$.

A way to resolve the issue of externality is to make it part of producer's cost fn.
~~The social cost (cost)~~.

We introduce here marginal social cost MC^S as sum of Marginal cost and marginal external cost, as:

$$MC^S = MC + MC^E \text{ (or MEC)}$$

For negative externality : $MC^S > MC$.
for positive " " : $MC^S < MC$.



MB : Marginal Benefit

→ example of negative externality

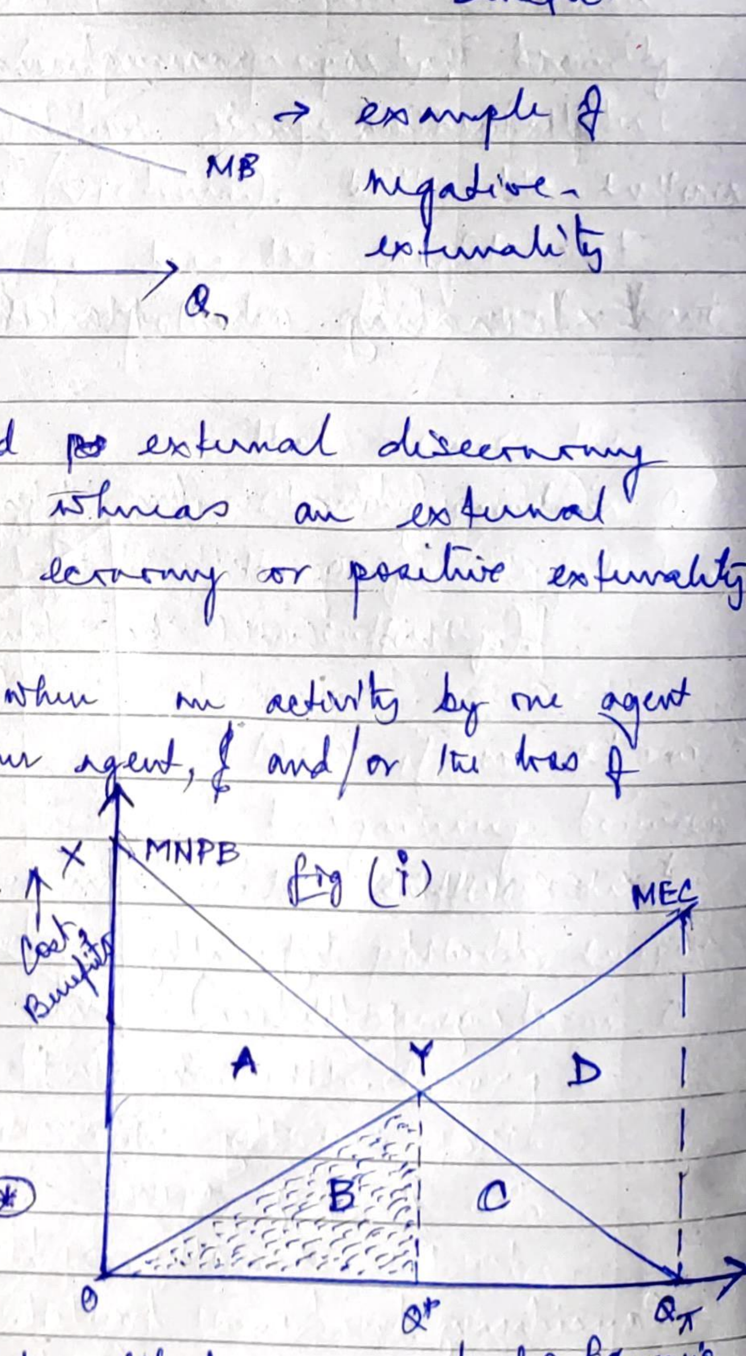
An external cost is called external diseconomy or negative externality, whereas an external benefit is called external economy or positive externality.

An external loss can happen when an activity by one agent causes loss of welfare for another agent, & and/or the loss of welfare is uncompensated.

Marginal Net Private Benefit (MNPB) is the difference between marginal revenue and marginal cost. For a competitive industry $P = MR$, Hence,

$$MNPB = MR - MC = P - MC$$

$\Rightarrow$ $P - MC = MNPB$ ——(i) ⊛



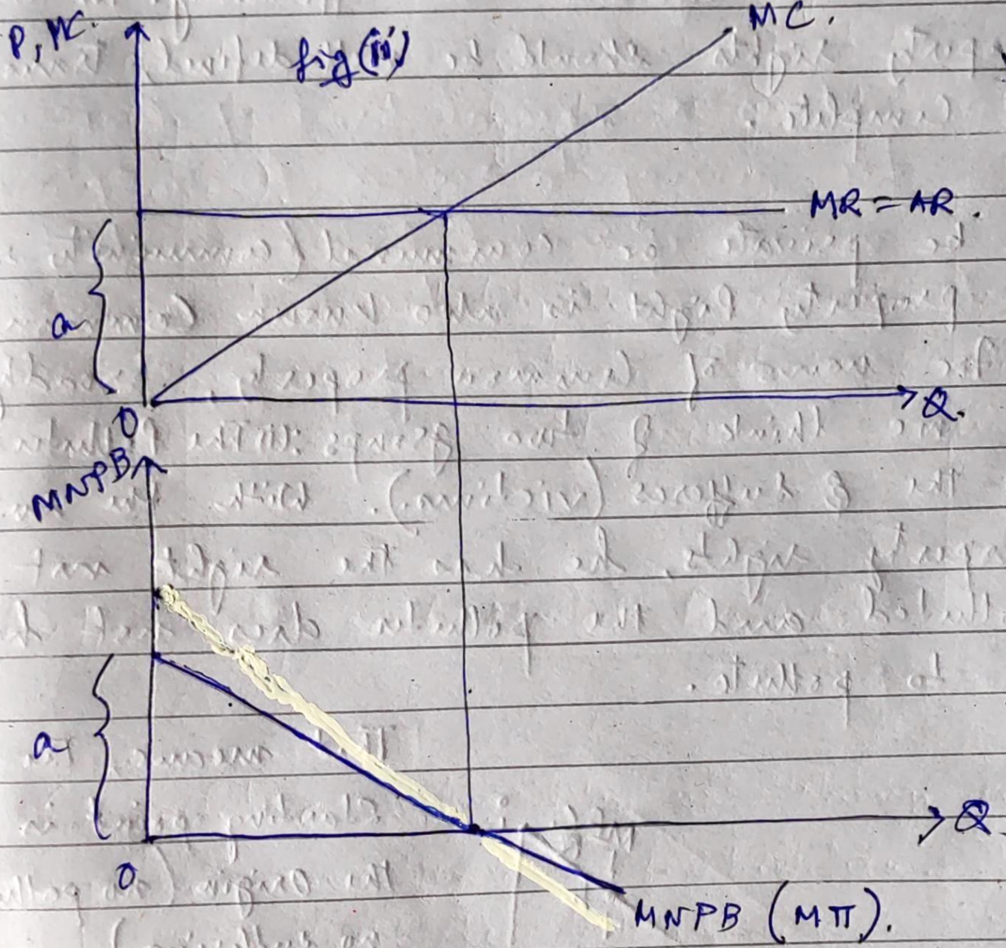
According to the fig (i), (the sum of benefits to the society - less the sum of costs) is maximised at Q^*.
The maximum amount being AOXY. The corresponding optimal of pollution is the shaded area AOQY (also called optimal level of externality).

Formally, at Q^*: $MNPB = MC^E$ ... (ii)

Combining (i) & (ii): we get: $P - MC = MC^E$ (MEC)
$\Rightarrow P = MC + MC^E$ (MEC).

Thus at Q^*: $MNPB = MC^E$; $P = MC^S$.

(*) fig (ii)



From (i):
$MNPB = P - MC$, under the conditions of competitive mkt.

MNPB curve is the marginal profit curve MΠ.

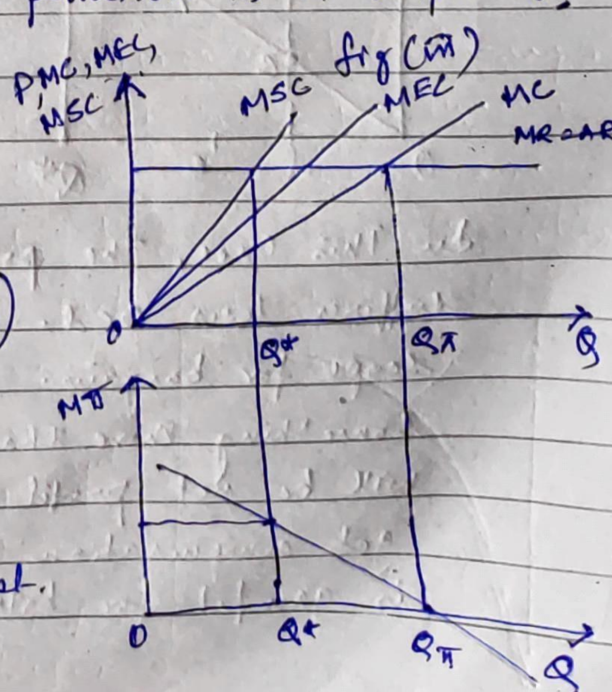
Now, as in fig (i), the MEC represents the value of additional damage by pollution (external diseconomy) due to output Q. MEC rises with Q. The optimum level of pollution is at output Q^*.

The net social benefit is:
= area (A+B+C) - area (B+C+D)
= area A (A) - area D

Optimum level of pollution (at Q^*)
= Area B. (optimum level of externality)

At Q^*, MNPB = MEC
& MNPB = P - MC
$\Rightarrow$ P - MC = MEC
$\Rightarrow$ P = MC + MEC
$\Rightarrow$ P = MC^S (MSC), the marginal social cost.

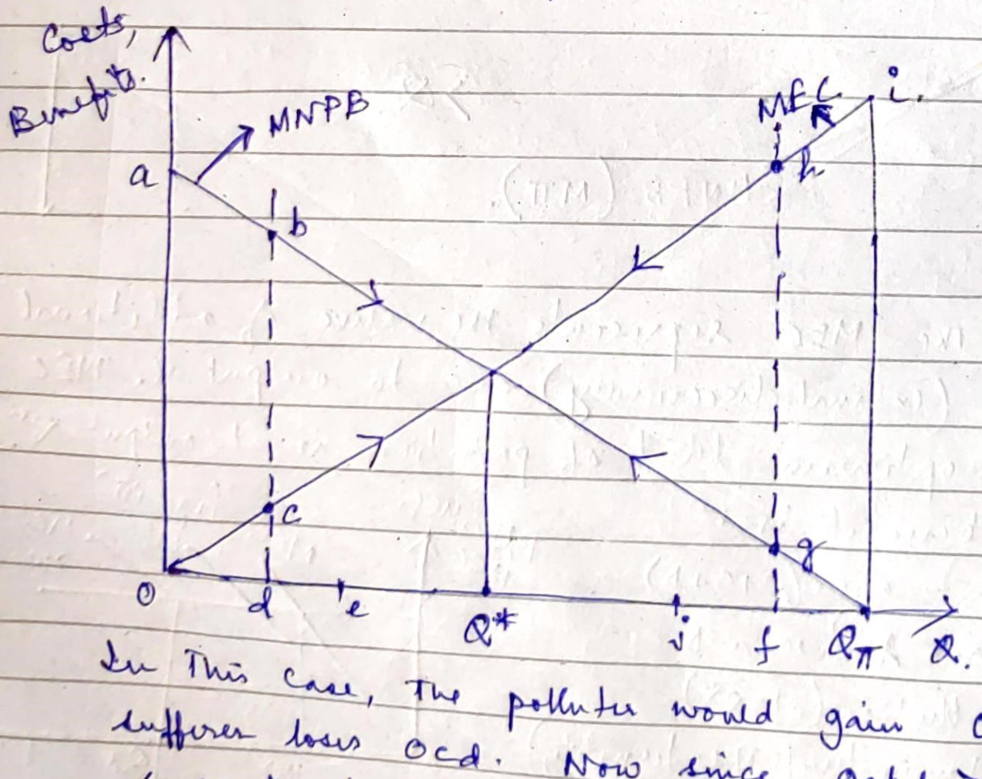
fig (iii)



PROPERTY RIGHTS & COASE THEOREM

With environmental goods, one of the main causes of market failure is non-excludability. A way to ~~tackl~~ tackle this issue is by establishing property rights. Institutional intervention can make goods excludable and allow market work efficiently. For this to work, property rights should be well-defined, transferable, secure and complete.

Rights can be private or communal (community right). Communal property Right is also known Common Property. For users of Common property, broadly speaking, we think of two groups: (i) The Polluters and (ii) the sufferers (victims). With the sufferer having property rights, he has the right not to be polluted and the polluter does not have the right to pollute.



That means, The starting point is O, the Origin (no pollution, no suffering).

Now, if we allow bargaining between the sufferer and the polluter, suppose to move from O to d.

In This case, The polluter would gain Oabd and The sufferer loses Ocd. Now since Oabd > Ocd → there is scope for bargain. The polluter can offer the sufferer something more than Ocd and less Than Oabd. There will be net profit for the polluter and the sufferer get compensation more than the loss. ~~Thus~~ Thus d is gainful for both, Than O. d is Pareto efficient over O.

Thus any movement from 0 upto Q^* is Pareto improvement. Similarly any movement from Q_π towards Q^* (upto Q^*) is Pareto improvement. Thus, with property rights belonging to the sufferer the natural tendency will be to move towards Q^*, the social optimum.

Note: Movement from Q_π to Q^* will be with the premise that the polluter has the property right.

The summary is:

Regardless of who holds the property rights, there is an automatic tendency to approach the social optimum. This finding is known as 'Coase' Theorem.

Coase theorem states that efficiency (social optimal equilibrium) can be achieved in the presence of an externality, regardless of the initial assignment of property rights, under the assumptions of:

- perfect information
- profit-maximizing producers/ utility maximizing consumers
- price-taking economic agents
- costless enforcement of rights
- no income or wealth effects
- no transaction costs.

If Coase theorem is correct, we have no need for government regulation of externality, for the market will take care of itself.

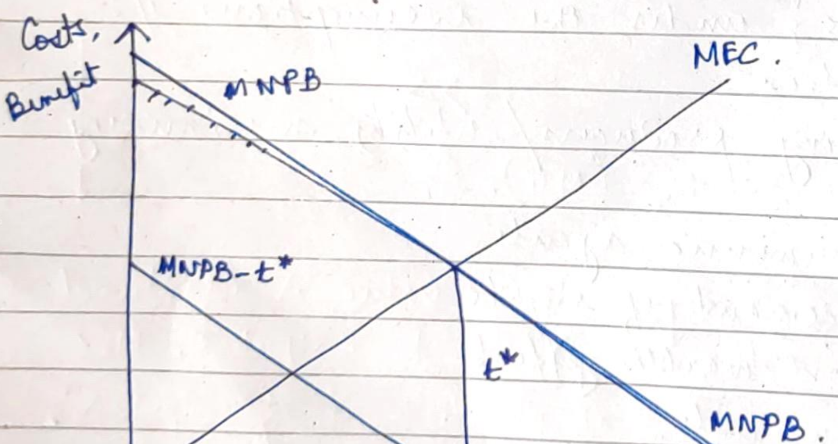
ENVIRONMENTAL REGULATION

There may be various types of regulation:
i) Perspective regulation — Command & Control.
ii) Incentive based regulation →
  ↳ Marketable permits
  ↳ Emission fees — Pigouvian tax.

Here we focus on Pigovian taxes:

<u>Pigovian taxes</u>: It is a special kind of emission fee aiming to restore Pareto optimum in case of market failure. In fact, a Pigovian tax is an emission fee that is exactly equal to the marginal damage caused by pollution when evaluated at the optimal level of pollution.

The optimal Pigovian tax is equal to Marginal External Cost (MEC) at optimum.



If a tax is imposed on each unit of polluting Q, and make tax equal to t^*, such tax would shift down MNPB to (MNPB − t^*). ∵ t^* has to be paid on each unit of Q so that MNPB reduces by t^*. Polluter maximises his private net benefits given the tax at Q^*. t^* is the optimal tax. It is equal to the MEC at optimum.

Mathematically:

Net Social Benefit (NSB) = $P(Q) - C(Q) - EC(Q)$; [EC: External cost]

$\therefore \frac{\partial NSB}{\partial Q} = P - \frac{\partial C}{\partial Q} - \frac{\partial EC}{\partial Q} = 0.$

$\Rightarrow P - \frac{\partial C}{\partial Q} + \frac{\partial EC}{\partial Q} = \frac{\partial SC}{\partial Q}$ [SC: social cost]

or, $P - \frac{\partial C}{\partial Q} = \frac{\partial EC}{\partial Q}$

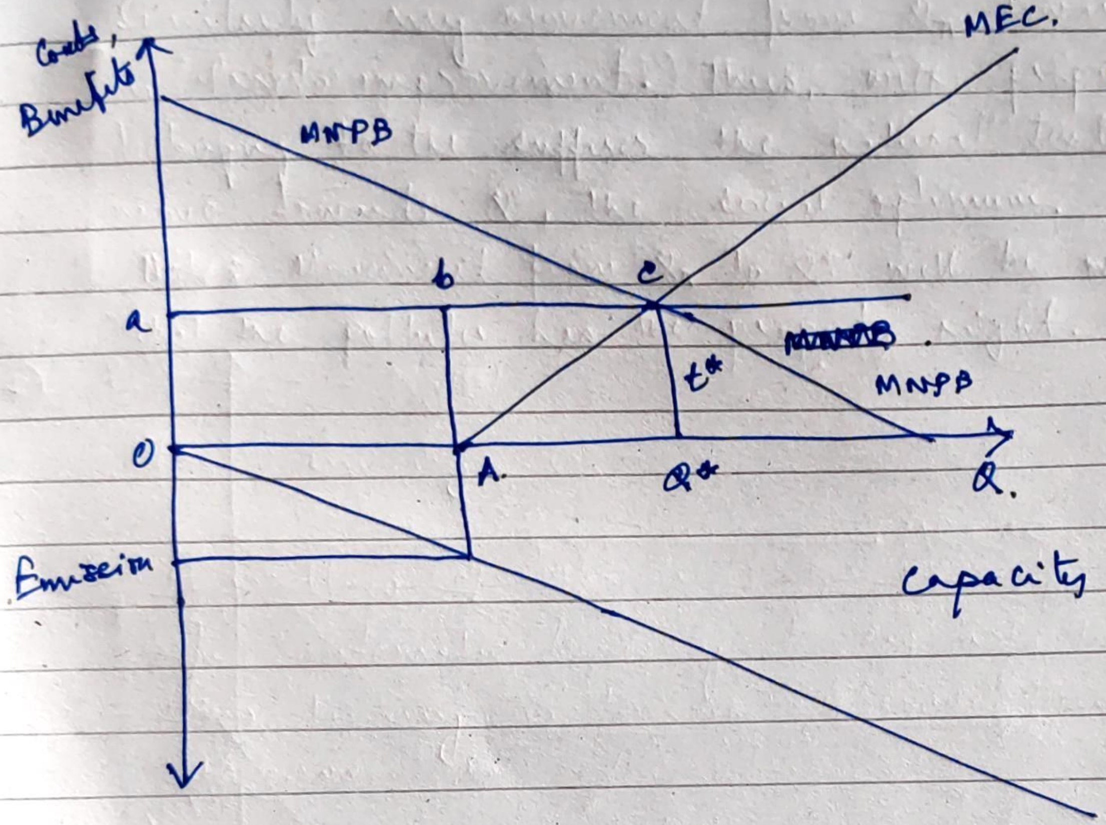
or, $\frac{\partial NPB}{\partial Q} = \frac{\partial EC}{\partial Q}$ [NPB: Net Private Benefit]

Now, t^* being the MEC, we can write. $t^* = \frac{\partial EC}{\partial Q}$

$\Rightarrow P - \frac{\partial C}{\partial Q} = t^*$

or, $P = \frac{\partial C}{\partial Q} + t^*$

With assimilative capacity of environment (suppose upto Q_1):



After Q_1, The environment assimilates the waste. MEC begins to rise from A, the level of activity corresponding to the assimilative capacity of the environment.