BASUDEV GODABARI DEGREE COLLEGE, KESAIBAHAL

BLENDED LEARNING STUDY MATERIALS

UNIT-II

DEPARTMENT :-ECONOMICS

SUBJECT :-Environmental Economics

SEMESTER :-6th Semester

CONTENT

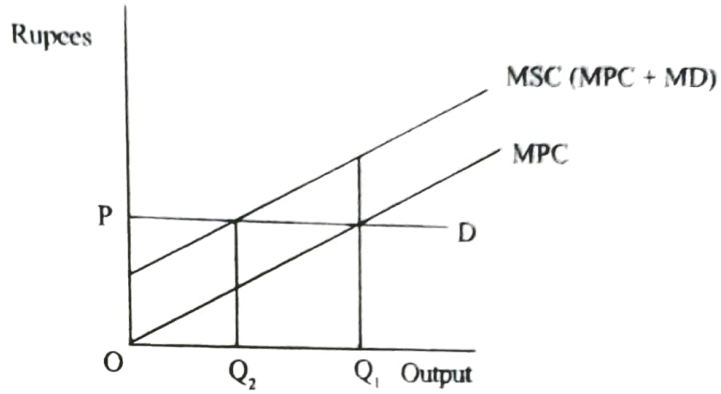
CHAPTER 5

EXTERNALITIES AND MARKET FAILURE

Whenever some project is undertaken to produce a commodity or service there arises a benefit in the form of that particular good or service. In addition, some additional benefits or costs too may emerge along with the good or service. That is called an externality. It is termed as positive externality when it's a benefit and negative externality when it's a cost or harm. That externality may be negative when it causes harm. Construction of highway provides transportation facility that is the direct benefit. But over and above that, it also creates opportunities for some to open hotels by its side for truckers and earn some income, which is positive externality. On the other hand, it also destroys the forest coverage of the area, which is a negative externality. The technical definition of an externality as given by Kolstad is "An externality exists when the consumption or production choice of one person or firm enters the utility or production function of another entity without that entity's permission or compensation." The flower garden of a person would benefit the apiary in the neighbourhood as it would become a source of honey collection by the bees. Similarly a sponge iron factory would increase the cost of a laundry in the neighbourhood, due to more dirt and smoke. The apiary owner cannot be excluded from the benefit if he doesn't pay for it, neither can the laundry owner avoid the pollution or get compensation from the sponge iron factory as a price for suffering the pollution. Here market mechanism will not operate due to non excludability. Here one person's action gives a benefit to imposes a cost on another person and market is not there to mediate between them and arrange for payment for benefit or compensation for damage. This results in loss of efficiency and thus the result is not Pareto optimal.

In the absence of any mechanism to force the firm causing pollution to pay compensation to the victim, there is a possibility of overproduction; the quantity produced is more than what

is efficient for the society. Conversely, there being no market mechanism to ensure payment to the firm which causes positive externality, there is possibility of underproduction, the resultant quantity being less than what is efficient for the society. Following diagram depicts the case of negative externality such as pollution.

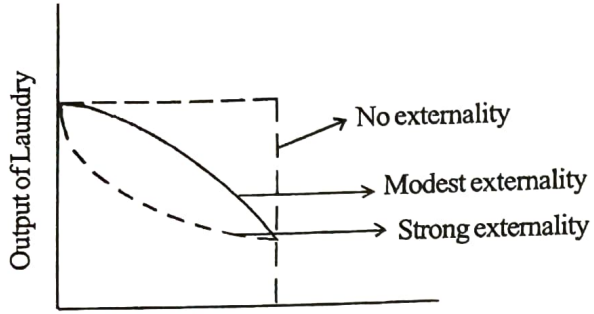


(Figure 5.1)

Overproduction due to netative environmental externality

Quantity of output has been represented on X axis and price on Y axis. Demand curve faced by the competitive firm is horizontal, as is in case of a competitive market. Here MPC represents marginal private cost, the cost curve actually faced by the firm; also the supply curve of the firm. MSC (marginal social cost) represents the cost curve if the firm has to pay compensation to the extent of the damage caused. MSC is MPC +MD (marginal damage). The dotted line represents the difference between MSC and MPC, i.e.MD. As we see the amount of good produced is q_1 if no compensation is paid. But when compensation is paid, cost becomes equal to society's marginal cost and lesser amount q_2 is produced. Hence there is over production, when there is negative externality, and loss of efficiency.

Externality maybe viewed from the point of view of production or consumption. A production externality occurs when one firm's production enters another firm's production function without its permission or compensation. The example of sponge iron factory and laundry shows production externality. The smoke from sponge iron factory is making the clothes dirtier and laundry's cost is rising.



(Figure 5.2)

Output of Sponge Iron Production Externality

With output of the two producers on the two axes, both would be able to produce their optimum output independently as depicted by the dotted line making the square when there is no externality. When there is modest externality, the combination of outputs would be depicted by the concave curve, where laundry output declines but slowly as sponge iron production increases and along with it smoke and dirt also increase. The dotted convex line indicates strong externality and the fall in output of the laundry would be fast as sponge iron production and hence pollution increases. Thus total output for the society decreases as negative externality increases.

A consumption externality occurs when consumers suffer loss of utility by the action of some firm or individual. A person getting disturbed because of a neighbour's practice of playing the music system loudly is an example of consumption externality. Another type of consumption externality would arise when a tannery dumps its wastage in the river, which people use for swimming. When pollution of the water increases, it reduces the utility of the consumers as they have to reduce swimming.

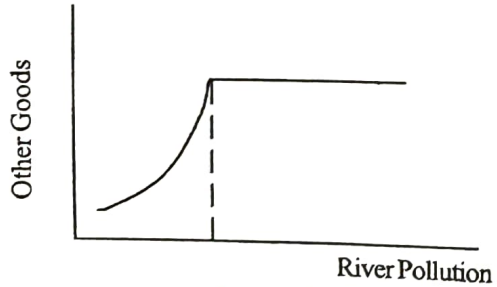


Figure 5.3

Consumption Externality

We may depict the indifference curve of consumers with river pollution on x axis and other goods on the y axis (figure 5.3). The consumer is combining different quantities of the goods with swimming to attain some level of utility. Since more pollution means less swimming, they have to buy more of other goods to compensate the loss in utility due to less swimming and keep the level of utility constant on an indifference curve. So here the indifference curves would be upward sloping and convex as with every increase in pollution the loss of swimming would rise fast. (In chapter 2 the indifference curve described is downward sloping and convex as that is the case where both axes represent goods, but here x axis represents a bad). There is a kink in the indifference curve at point p_h, because at this point river has become so polluted that swimming is given up by people. So after this pollution has no effect on utility and the indifference curve becomes flat.

In these cases, the generator of the externality is deciding the amount of pollution indirectly while deciding the amount of output to be produced, but it is ignoring the impact on others, and market mechanism does not come to any help in solving the problem.

Sometimes externality may be transferred over space, to another location, or over time to another generation. Whenever industries release the waste in water streams, it goes downstream along with the flow and causes harm downstream. By raising the chimney a factory could send air pollution to distant regions away from the locality where it is situated. Emissions from factories in the US getting drifted by air and causing acid rain in Canada is another example of how pollution is transferred over space. The radioactive wastes from nuclear power plants that we are storing underground so called securely, in fact are not so secure. We are simply transferring the risk to the future generation. In the book Small is Beautiful E F Schumacher has quoted from a report on the Control of Pollution in 1972 in Britain which says "....we are consciously and deliberately accumulating a toxic substance on the off- chance that it may be possible to get rid of it at some later date. We are committing future generations to tackle a problem which we do not know how to handle."

Thus environmental pollution and degeneration is a negative externality and hence market mechanism is of little help to provide a solution. Hence alternative methods must be tried to tackle the menace.

CHAPTER 6

PROPERTY RIGHTS

Property Right is the right to possess, use and dispose of things. It's distinct from mere possession, since possession implies just the physical holding of something. It is a right of a person or group or any entity to acquire, to keep, to use valuable things, and they are usually called the owner. The right also provides the owner the prerogative to sell, let, donate or otherwise dispose of the thing in the manner the owner desires. This right also includes the right of succession. Property rights are considered well defined if they satisfy some important characteristics, as mentioned below –

(i) *Comprehensively Assigned*- All assets or resources must be owned privately or collectively, and this fact must be known to one and all and the right must be enforced effectively.

(ii) *Exclusive*- All benefits and costs from the use of a resource should accrue to the owner exclusively, either directly or by sale to others. This should be the case in case of privately owned as well as collectively owned resources.

(iii) *Transferrable*- All property rights must be transferrable from one owner to another a voluntary exchange. It provides the incentive of conservation to the owner.

(iv) *Secure*- The right must be secure from forcible seizure or encroachment by other people, firms or the govt. This way improvement and preservation of a resource is promoted.

Property rights may be classified into four types as follows

- Private Property Rights: The right is possessed by individuals and business enterprises, and the owner is recognised legally
- Common Property Rights: The right is held by an exclusive group
- State Property Rights: The right of ownership belongs to the State or Government

- Open Access: No specific right is given to anyone and the resource is open to all. Fishing in the sea is an example of open access resource.

Property right is essential for the functioning of the market. Without this right no one can be sure of owning a commodity and use it according to choice without fear of losing it. Hence no one in fact would be willing to buy and without any property right there cannot be any supplier either. Hence no market can function.

It is common knowledge that the market fails to conserve environmental resources, and its cause is incomplete markets. The cause of incomplete market is again the incapability of the system to establish property rights due to high costs. The failure of the market to produce efficient control of pollution is because no one can be excluded from suffering from the pollution say from inhaling polluted air on selective basis. Sometimes such market failures may result from certain steps or actions of the government. A suitable example is the case of the local governments who lower environmental standards to attract industry and jobs to the regions or in the absence of strict environmental regulations when provincial governments provide fiscal incentives to attract industries, where concentration of industries increases pollution.

Environmental resources such as forests provide a range of market and non-market goods. Timber, medicinal herbs, honey, fuel wood and various fruits, leaves and flowers are market goods. Non market goods include a range of eco system services, bio diversity reserves and carbon sequestration. These benefits accrue invariably to one and all; no one can be selectively excluded. Due to the vast range of non market benefits associated with forests, an owner won't be able to enjoy the entire benefit exclusively, nor be able to prevent others from enjoying these benefits. Thus in the voluntary exchange process the price would be too low as compared to the ideal and efficient value to the society. Thus property right cannot be complete and the market valuation would be inefficient. This is the reason why, many countries in the world keep a significant portion of or whole of forested area under state ownership. This allows the governments to resolve the trade off between maximising profit from timber production and maintaining the public good value of the forest.

CPR is another aspect of property rights with respect to environmental resources. This has been in existence since a considerably long time in the history of human civilisation. This is an alternative method devised by the society to deal with market failure in the absence of proper individual property rights. In case of CPR the property right is collective, where an

exclusive group has well defined claim on the resource, the resource has the characteristics of indivisibility (that of a public good), and its use is subtractive in nature. Common grazing grounds around villages, village panchayat land, tank, unclassed forest land where villagers have access are few examples of CPR. Here the particular group in question can have exclusive rights on the use of resource and access, but not ownership right. But access is denied to persons who are not members of the group. The group frames rules regarding use of the resource and benefit sharing. There must also be an institution within the group to enforce these rules and regulation. Such modified type of property rights seem to work well and serve the purpose of conservation of the resource, when the group size is small. When the size of the group expands and becomes too big governance becomes a problem and the resource is depleted gradually. Such a situation is termed as 'tragedy of commons'. The concept was developed by evolutionary biologist Garret Hardin in 1968.

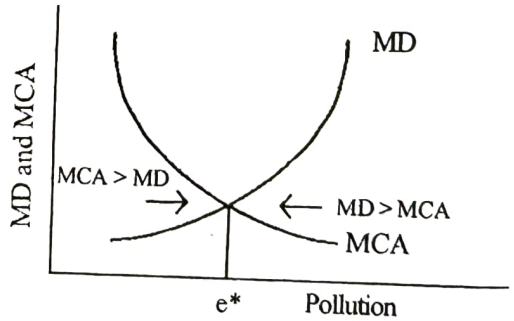
In case of **pollution** which is an environmental bad, the principal cause of market failure is again property rights. In the effort towards finding a solution, the first problem which is encountered is whose right should be admitted- the polluter's or the victim's? Conventional view would emphasize that the polluter is doing the wrong, hence right of clean air (which can be treated as a property right of the individual) should be admitted. However, if we give up the argument of right and wrong and agree that the victim could also be blamed for being next to the polluter, then scenario would change. Now property right can be assigned to the polluter, so that the right to pollute is now admitted. Describing such a situation, there is a famous theorem named after economist Coase "the Coasian bargaining theorem" (elaborated later in this chapter). If property right is given by the government to the polluter, now right to pollute becomes a property which has value and can be traded. So that the victim bargains with the polluter and pays to the polluter to reduce pollution,& thus in a way the polluter sells the property it owns. If right is accorded to the victim, then the victim has the property right (the right to clean air). Now the polluter would bargain and pay the victim to induce him to sell the property. In either of the case an efficient solution is arrived at as would be done in a perfect market. Thus assigning property right helps solve the problem of pollution in the market principle style. However such simplistic solutions hardly work when there are large number of polluters and still larger number of victims, where transaction costs also become too high. The inability or unwillingness to assign proper property rights justifies the government's action of intervention. Governments intervene by making adoption of pollution control technologies mandatory for

industries, imposing fines, taxes, and bans or in some cases providing subsidies for pollution reducing technologies.

Thus property rights are essential for functioning of the market and efficient allocation of resources. But in case of environmental resources, property rights are very difficult or impossible to define. Hence several alternative institutional arrangements are attempted for preservation of the resources or regulation of pollution.

Coase Theorem

Inability of the system to define property rights results in inefficient allocation in the society and in case of pollution it results in the generation of too much of pollution. Ronald Coase in 1960 in his Nobel prize winning paper argued that if zero transaction cost exists, then giving property right of the nonmarket good to one of the parties by removing institutional constraints that prohibit defining property rights would prompt the two sides to enter into a bargain and bring about the efficient amount or socially optimum amount of the good. And the final result would not be affected by which party is bestowed the initial right. Transaction costs are costs associated with the process of trading, such as finding someone to trade with, of negotiating and concluding the deal, then taking approval from the regulator etc. Transaction cost is the amount spent for making a transaction possible, over and above the exchange price of the good. For example, buying a car involves payment for sales tax, registration charges, and insurance payments etc. in addition to the price of the car. Now when there are two parties such as a polluter and a victim, when property right is assigned to either the victim (the right to clean air), or to the polluter (right to polluter), it would result in optimal control of the externality. The theorem could be explained better with the help of the following figure.



(Figure 6.1)

Efficient Solution through bargaining

The amount of pollution is represented along the x axis. Along the y axis are represented the marginal cost of abatement to the polluter and also the marginal damage (MD) suffered by the victim. When the polluting firm has to take abatement action to reduce pollution its additional cost of abatement would go on increasing. The more the abatement, the less will be the pollution and higher would be the marginal cost of abatement. At higher level of pollution marginal cost of abatement would be low as the effort of abatement is low. So the MCA curve of the polluter plotted with emission on the horizontal axis would be a falling one. As pollution goes on increasing the cost or the damage suffered by the victim goes on increasing. When the pollution level is low, the damage suffered increases moderately for an extra unit of emission, but as pollution level increases, the additional damage or marginal damage suffered by the victim increases faster. As per the marginal principle, the optimum amount of pollution for the society is the one where marginal benefit and marginal damage coincide. According to Coase theorem if property right is assigned to either of the two parties then costless bargaining between the two parties would take place and it would lead to the ideal amount of pollution being generated as at e^*. Now let us consider the scenario where the victim has right to clean air or atmosphere. Then the victim would desire the pollution lvel to be as low as possible, or even zero. So the polluter has to bargain with the victim to allow him to pollute. To the left of e^* the marginal cost of abatement to the polluter is more than the damage suffered by the victim. Offer of anything more than the damage would make the victim accept a little bit of more pollution. Similarly the polluter would be willing to pay anything less than the marginal cost of abatement to get permission for some more pollution (which it is generating as a side effect of its production activity). The maximum amount the firm would be willing and able to pay is the distance between the two curves. Hence the process of bribing by the firm would continue till the point where MCA becomes equal to MD. After that it won't be paying for the firm to bribe the victim. If the right to pollute is assigned to the firm, then the firm would try to take pollution level to that which suits him best. In that case the victim will have to bribe the firm to reduce pollution. The polluter would accept anything more than the MCA (marginal cost of abatement) to undertake pollution abatement and the victim would offer anything less than the damage suffered for reducing pollution. To the right of e^* MD of the victim is more than the MCA of the firm. The maximum amount the victim would be willing to pay would be the difference between the two curves. Hence the process of bribing by the victim and in response the firm taking pollution control measures would continue till the intersection point

between the two curves is reached and pollution level reaches e^*. Thus we see that whoever gets the property right, bargaining takes place and the socially optimal pollution level is achieved.

There are real life instances of successful working of a solution through bargaining process. As depicted in Kolstad, (2010) in Santa Maria, California, when with the growth of township, houses moved closer to a feedlot or cattle fattening facility, residents became wary of the pungent smell. In the mid 1990s, the City Council took a decision and then taxed the citizens around that area and paid the revenue amount to the feedlot to stop operation. Here victims paid to reach efficient outcome. There are also examples with polluters pay principle leading to efficient outcome. In Kolstad we also find mention of another example ehere the polluter paid to get a solution. Gavin Power Plant, a coal based plant in Ohio was adjacent to a town Chesire. There was tussle with the residents due to the pollution generated by the plant. Finally the plant bought the whole town after negotiation and the people moved to another place. Thus in select cases Coase method works.

Problems

Coase theorem can offer a solution in checking externalities when they are on a small scale or are local in nature. On a larger scale and with many players a number of difficulties arise, which make reaching a solution next to impossible.

With too many generators of pollution or victims it becomes difficult to define property rights. It is so especially in case of externalities such as pollution of a river or the air. However formation of association of victims may help to solve this issue of property rights. But there are other problems too.

Transaction cost is never zero. One can hardly find a situation when transaction cost is zero. As we saw in the figure, the amount one party is prepared to pay to the other having property right, has to be less than or equal to the difference between the two curves. If transaction cost enters then it may raise the payable amount to more than the difference. Then transaction cannot take place.

With hundreds of polluting firms and thousands of victims, striking a bargain requires consensus on both sides. Before striking a deal participants on each side must agree with one another, about the conditions or the amount of compensation, or the division of the gain among them. This could be too hard to achieve.

Free riding may be another problem. When the victims are in large number some of them may try to free ride. Some of them may pretend to not to mind the pollution, and hence would not be willing to pay. Now rest of the victims together have to contribute to pay the polluter. The division of cost among the rest may be such that it would exceed their expected gain. Hence bargaining cannot take place.

Though Coase argues that who is given the right initially does not matter, it actually does. When rights are established by the legal system, it is important that it should go to the party which has greatest willingness to pay for those rights.

In case of environmental resources it becomes difficult to define property rights as it belongs to future generations too. As a solution we may think of the Government to act as the representative of future generation, issue a debt and pay on their behalf. Debt repayment would take place in future and hence it would be tantamount to payment by the future generation. But such a solution does not come under Coase theorem.

An analysis of Coase theorem gives some important messages regarding policy formulation. One is that if an efficient solution is desired then payment by victims should also be acceptable against the popular ethical principle that polluter should pay. Secondly, transaction cost matters, and hence while delineating the legal property rights of the parties, the objective should be to minimise transaction costs. For example if too much paper work or too many regulations, or red tapism are involved, then it would increase transaction costs.

QUESTIONS

1. Describe the meaning and significance of property rights.
2. Describe the concept of property right and examine its significance with respect to environmental resources.
3. Critically appraise the bargaining theorem of Coase.
4. With large number of players the solution offered by Coase to minimise negative externalities becomes unattainable- Discuss.

□□□

CHAPTER 7

ENVIRONMENTAL POLICY

Since the onset of industrial revolution in the late 18th century, the world economy has strided forward with compounding growth of output and ever higher standard of living. Market forces with their function of efficient allocation of resources have made the progress smooth. But close on its shadow, has followed the problem of environmental degradation, and market forces have failed to help solve this problem. The reason being the nature of publicness of environmental goods and bods, Now the world is facing environmental problems in the form of pollution of air, water and soil, loss of bio-diversity, global warming, climate change and so on, & they are emerging as a threat to the very survival of the earth. Since market can not offer a solution, we have to look elsewhere for a solution. The alternative which comes to mind instantly is policy intervention by a social regulator & more precisely the Government. Government has broad policy tools – Command and Control (CAC) and market based instruments (MBI).

Command and Control

Pollution is a bad and it is desirable to reduce its production. In its endeavor to achieve this objective society may take the help of Command and Control measure. Here the government tries to induce the agent responsible for pollution to take required action so that achievement of the desired objective becomes possible. The government would specify steps to be taken by the perpetrators. However this would be a difficult task. Because the government first has to decide what could be considered the socially desirable level of pollution. Secondly the action which the polluter would have to take would definitely reduce his benefit; hence there would be resistance from polluter's side. It would increase the difficulty for the government, when it tries to control the action of the polluter.

Three branches of the government namely the legislators, the regulator, and the judiciary become instrumental in executing the command and control measure. Regulations are passed

by the legislature which the regulator has to implement, and the judiciary interferes in the work of the regulator whenever there is necessity. The Parliament in India is the body which passes law. That law is then implemented by the regulator the Ministry of Environment, Forests and Climate Change (MoEFCC). The provincial courts and the Supreme Court do the required work of the judiciary.

The regulatory authority would specify the course of action to be taken by the polluter. The regulatory authority may specify the use or installation of specific equipment, for example a scrubber or a electrostatic precipitator when the objective is to check air pollution. Sometimes the quantity of pollution may also be specified by the regulating authority, and the polluter has to keep within that limit. These measures are combined with fines and penalties in case there is non compliance. Sometimes repeated non compliance may lead to temporary shut down or even withdrawal of license of operation in extreme cases.

Monitoring would be an essential part of CAC to ensure compliance. Advantages of CAC are that there would be greater certainty regarding how much pollution would result after the measure is implemented. Secondly in emergency situations such as harmful gas leakage in case of some accident in any industry, ommand and control measures would come to he!p as economic measures need time for implementation. Monitoring too is simple, since it would simply involve, inspecting if the particular devices that too of specified quality has been installed or not.

But it has a major disadvantage because the choice of the firm would be restricted as the measure to be adopted is specified for the firm & is not chosen by it. Secondly, equalisation of marginal cost among several polluters (the efficiency criterion) can not be ensured. Hence the outcome would be economically less efficient than the economic measures, Thirdly, there will be no incentive for the firm to find better ways to control pollution, so there is no incentive & scope for innovation.

Economic Incentives or MBIs (Market Based Instruments)

This sort of arrangement tries to achieve pollution reduction target by providing economic incentives for pollution reduction or by increasing the cost for flouting environmental standards.

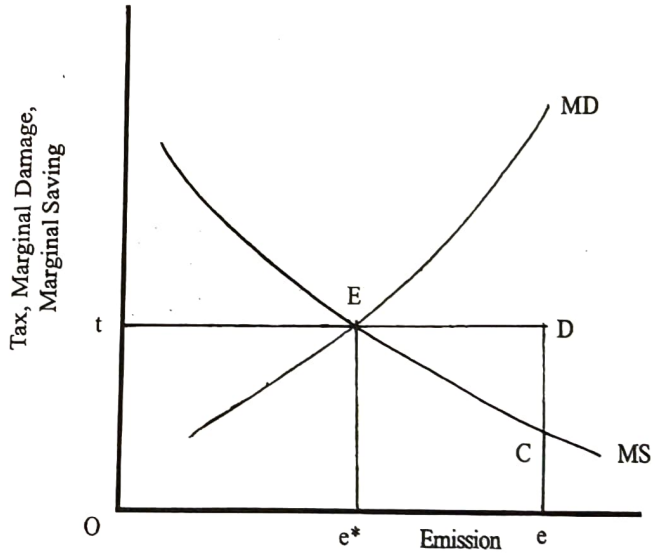
Incentives raise the cost of non compliance, but simultaneously provide flexibility to firms to find the least-cost pollution control startegy. Pigovian fees and tradeable permits are two such MBIs of pollution control.

Pigovian Fees

When a price is charged for pollution, a firm is motivated to cut back on pollution. Economist A.C. Pigon, in the early part of 20th century had suggested placing a price on pollution, to check it. It is known as Pigovian fee.

As defined by Kolstad, "A Pigovian fee is emission fee exacutly equal to the aggregate marginal damage caused by the emissions, when evaluated at the efficient level of pollution.

Efficient level of pollution would be that where the marginal damage suffered by the victim (s) is equal to the marginal benefit (that is the marginal saving or the cost not incurred) to the polluting firm (s).



(Figure 7.1) Pigovian Fees

In the figure Emission is shown on *x* anix and marginal damage, marginal saving & tax on the y axis. MS, is the saving to the firm at the margin for emitting pollution. If it cuts back on pollution, the firm has to spend these amounts or incur marginal abatement cost. That amount is saved & hence MS is actually the negative of marginal cost for particular level of emission. As emission goes on increasing, the marginal saving declines. More emission means, low pollution control effort & hence low marginal cost. Thus the MS is low at high level of emission. Marginal damage suffered by the society is described by the curve MD. As emission or

pollution goes on increasing the damage automatically increases. According to marginal principle, the optimum pollution level for a society is one, where MS & MD match. Now suppose the firms are generating e amount of emission as a by product of their production activity. If ot amount of tax is imposed, then, emission would be cut down to e*. If ot is the tax per unit of pollution then, the total tax paid for e amount of pollution would be otDe. But if, emission is cut down to e*, the total spending of the firm (s) would be otEe* (total tax for e* pollution) + abatement cost Ecee*. When we add up the marginal units, we arrive at total, & thus the area under the marginal saving curve between ee* would represent the total reduction in saving due to polluting or the total cost incurred to check pollution. Thus we see that the firm(s) would save an amount equivalent to the area EDC. So it pays for the firm to cut down an emission to e* level, when a tax of ot per unit of pollution is imposed. Thus optimum level of pollution is achieved through Pigovian tax.

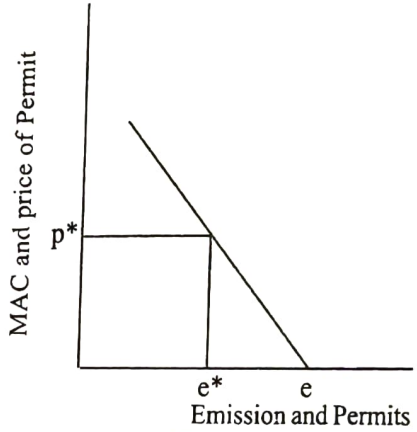
However, when we come to practical implmentation of Pigouvian fees, we would e meet with some fundamental dificulties. It concerns chiefly the estimation of marginal damage and information on abatement cost of the firm. In mostt of the cases pollution affects large number of people as it happens in case of air and water pollution where millions of people are affected. Thus the society's marginal damage is the sum of marginal damage suffered by all people. Hence information needs to be collected on a very large scale. So also information regarding the abatement cost functions of the firms needs to be collected from a large number of firms. Thus it is possible that the cost of collection of information on such a huge scale may be exhorbitantly high and designing & implementing a Pigovian fee may not be economically feasible at all.

TRADABLE PERMITS

Tradable permits or better known as tradable pollution permit (TPP) system is a form of environmental regulation which operates through allocation of property rights to the generators of pollution in the form of pollution permits. The origin of the concept of TPP dates back to two writings in the late 1900s– One by T Crocker in 1966 and the other by J.H.Dales in 1996.

It is a form of quantitative regulation of premission. Suppose the emissions of pollution in a region is 2000 tonnes per anncum and the Government decides to bring it down to 1000 tonnes. So the difference of 1000 tonnes of emission would be allowed. The simplest way

under TPP is to make one thousand permits of 1 tonne each and distibute it among the polluters, so that one has the property right of as many tonnes of pollution, as the units of permit she holds. Here of course there are two methods which may be followed for handing over the permits. One is **grand fathering** system, in which, the permits are simply given away. The second is **auctioning**, where the permits are auctioned at a price. Next step is that firms are allowed to trade in the permits. When trading takes place, the price of the permits is determined in the market. The demand curve for the permits would have link with the marginal cost of abatement of the firms. In fact the MAC curve would serve as the demand curve.

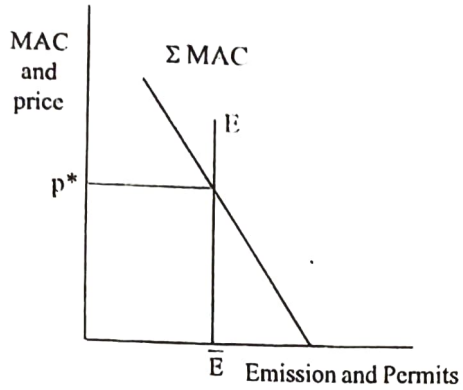


(Figure 7.2)

Demand Curve of Tradable Permits

The polluting firm's production decisions, determine the emission level it would generate. If the emission generation is more than the permitted amount, then it has to buy permits. If the price of permit is more than MAC, then the firm would take to abatement and not buy permits. If the price of permit is more than MAC, then the firm would take to abatement and not buy permits. If permit price is cheaper, then buying permit & causing pollution would give more net benefit to the firm. In the figure 6.2, thhe firm would be buying e* amount of emission permits.

Under perfect competion, the price of the permits would be determined by the intersection of total market demand and total supply. Total supply is fixed, equal to the amount of emission and number of permits given by the regulatory authority. But the market demand curve is the summation of MAC curves of all firms operating in that region. We may write the aggregate demand as $\sum_{i=1}^{n} MACi$ if number of firms in the region is n.



(Figure 7.3)
Determination of equilibrium price of permits

In figure 7.3, the total emission decided by the Govt is $\bar{E}$, & hence the supply is fixed there & the total supply curve is the vertical line $\bar{E}E$. The market demand curve is the aggregation of MAC's & is reprerented by the line ΣMAC. The intersection of these two curves determines the market price P*. No firm can influence the price, so each one of them makes adjustment so that MACi = P*, for each firm (l.....n). Thus $MAC_1 = MAC_2 = ...$ = P*. the price of the tradable permit

Three scenarios emergy here, involving situations, where e_p-permit given to a firm is o(no permit), is less than its emission level or more than its emission level. The three diagrams in figure 7.4, depict the three situations.

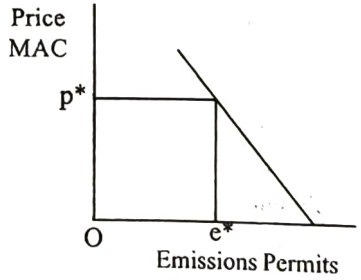


Figure 7.4(i)

In the three figures e_p representy pollution permits and e*, the permits, the firm wants to hold ideally given the price p*. In (*i*) no permit is given to the firm. So it buys all the permits it wants to hold represented by the square area between oe*.

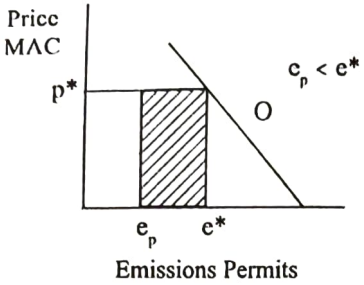


Figure 7.4(ii)

In part (ii), the firm wants to hold e* amount of permit but is given e_p which is less. Hence it is purchasing the rest amount represented by the shaded rectangle.

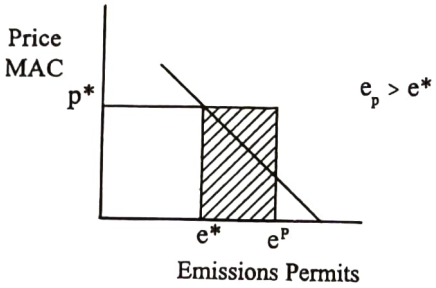


Figure 7.4(iii)
Buying and selling of Permits

In part (iii), the permit held by the firm ep is more than the amount it wants to hold e*. So the firm sells the amount of permit represented by the shaded rrectangle between e^P & e*.

Systems of Trading

There are various systems of trading with TPP. The simplest is emissions permit system (EPs), where units of permits are denominated in units of pollutants emitted, as in the example we used above, 1 tonne of the pollutant =1 unti of permit. In case of uniformly spread pollutions, EPS system of trading 1:1 works. This means, a firm can emit 1 tonne of the pollutant if it buys 1 permit form another firm. Similarly if a firm sells one 1 permit, it must reduce pollution by 1 tonne.

But for non uniformly mixed pollutants, such trading may increase the total impact of pollution. Here, impact is taken into account, rather than source alone. If a firm A is situated

in an already heavily polluted area & B in an area with less pollution, then if A buys 1 unit form B & emits one extra unit, when B reduces 1 unit of pollution, the overall impact would increase. Hence 1:1 trading should not be undertaken here. Rather interms of impact A should buy say 2 or 3 units of permits from B to increase only only 1 unit of pollution. This keeps the overall impact of total permitted pollution, at the desired level. Such a system of unequal trading (not 1:1) is called ambient permit system (APS).

Another system of trading is known as pollution offset system, where while trading traders are required to not to violate the ambient quality target at each receptor point. However, when the quality of enviornment set for a particular receptor point is higher than the actual, then there is a chance that total pollution amount would increase & become more than the target. Hence to take care of this limitation another system which is suggested is **non-degradation offset** system. This system allow trading and imposes extra condition that the total emission should not increase as a result of trade. Another variant to this system is also suggested, which is called **modified pollution offset** system. According to this system trading is allowed as long as neither the pre-trade quality, nor the target level, whichever is minimum, is not violated.

Problems

The TPP system is more appealing theorectically as in practical implementation several problems may arise. The price of the permit p* would be ideal and would offer efficent least cost solution, if there is perfect information on the part of every trader. But perfect information regarding supply price & the willingnes to pay on the part of the two parties is very rare to be realised.

Secondly trading yields efficient solution, when transaction cost is absent. But when there are several polluters (say m nos) & several receptor points (n nos), then there can be upto m×n markets. It would be a complex web & trading in such a situation would involve high transaction cost.

In addition, there is the problem of moral hazard too. The regulatory authority would have fixed, certain no of receptor points at particular places. The firms may change the location pattern of emissions, so that the places where their emissions concentrate shall not coincide with the ones fixed by the authority. Hence pollution would increase, & trading would be avoided. One solution to this problem is to increase the number of receptor points sufficiently.

If these points are very close, the possibility of cheating by avoiding receptor points would be minimised. But with n (the number of receptors) increased, the number of markets m×n would go up even higher and transaction cost would rise further. Thus result of trading would be inefficient.

Market Based Instruments and Developing Economies

Market Based instruments intervene with the help of market forces to control pollution or improve the environment. It creates a situation so that it becomes expensive for the polluter to continue with pollution. Sometimes monetary incentives such as subsidy may be provided to induce the right action on the part of the polluter. However for a proper working of these monetary policy instruments, a precondition is that market in the economy must be functioning perfectly. Perfectly competitive market structure is a feature of developed economies.

But a developing economy has a market structure which is far from perfect. There is a sizeable non-monetized rural sector in such economies. Lack of information and initiative on the part of the economic agents, as well as lack of mobility of factors of production are major hurdles on the path of establishment of a perfect market system. Hence prices prevailing in the market are not the efficient one. Introduction of some market based instruments may distort the price further which may reduce welfare of the society. The financial market too is underdeveloped in these countries. Implementation of the MBI is contingent upon a sound financial system. Large unemployment existing in these countries forces a large section of the poor to get livelihood directly from the environment.

Moreover these economies have very low level of national income as well as per capita income. Hence governments pursue a growth oriented policy, and they fail to give enough attention to environmental concerns. Hence many policy initiatives may already be in clash with environmental well being. Moreover the majority of the industrial units in these countries happen to be small and marginal units. The technology needed to control pollution is definitely modern and expensive. Hence the theoretical argument that MBI induces industries to adopt cost effective pollution control technology does not hold ground. With a limited market and tough competitive condition in the globalised world, when these small industrial units are operating with marginal profit already, it would be naïve to expect them to get induced by MBI to adopt modern pollution control technology. On the other hand the MBI such as Pigovian Fee may raise the price, leading to fall in demand and so market size. The firm in such a case

would have to reduce output which in turn would lead to unemployment. A developing country already under the pressure of unemployment cannot afford further unemployment.

Pollution permits too won't lead to desirable outcome in the developing countries. Pollution permits issued to industries results in ideal amount of pollution at least cost only when the firms trade and exchange these permits in a perfect market setting. When perfectly competitive markets don't exist for normally traded goods in these economies, it would be too much to expect perfectly competitive market for tradable pollution permits.

So if market based instruments are applied in a developing economy it cannot generate the desirable inducement. However a developing country may adopt MBI gradually when the economy matures and market conditions move towards an ideal one.

QUESTIONS

1. State the needs for an environmental policy and explain the command and control measure of environmental policy.
2. What is efficient level of pollution? Can Pigouvian tax achieve this level ?
3. Elucidate, how the tradable pollution permits would provide least cost solution to pollution control.
4. Do you think MBIs of Pollution control would be effective in developing countries ? Give reason.

CHAPTER 10

THE ECONOMICS OF CLIMATE CHANGE

Climate change is a much discussed phenomenon at every intellectual, political and economic sphere in the world today. This phenomenon occurs due to emission of huge amount of green house gases such as carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), ozone and chlorofluorocarbon (CFC) etc. The concentration of these gases in the atmosphere reduces re- radiation of heat back into the space. Thus heat gets trapped in earth's atmosphere and causes warming. This phenomenon of green house gas emission and global warming is also referred to as climate change. Continuously ongoing scientific studies are pointing to anthropogenic factors as cause of climate change. Especially the CO_2 and its equivalent gases resulting from industrial activities, vehicular emissions, deforestation and even agricultural activities are the primary causes of accumulation of these GHG gases in the atmosphere. As a result extreme climate events such as hurricane, typhoon, cyclones etc have become very frequent. Monsoon is becoming more and more erratic. The Inter Governmental Panel on Climate Change (IPCC) in its latest assessment report ASR 5 released in 2014 projects that The Arctic Ocean is now going to be ice-free during the summer by mid-century under a high emissions scenario, whereas in ASR 4 in 2007 it had predicted this event at the end of the 21st century. The ASR 5 also makes various serious revelations. The report estimates that warming has been to the extent of 0.85 degrees Celsius (1.5 degrees Fahrenheit) since 1880 with the fastest rate of warming in the Arctic. Its projections are that the sea level rise is likely to be to the extent of 0.26-0.55 meters (10-22 inches) by 2100 under a low emissions scenario and 0.52-0.98 meters (20-39 inches) under the high emissions scenario. The report further gives an estimated greenhouse gas emissions budget of 840Gt of carbon for the world to have a 50 percent chance of staying below 2^0 C of warming by 2100. But the worrying fact is that more than half of that (over 531 $GtCO_2$) has already been emitted. Moreover at current emission rates (around 10 $GtCO_2$ per year), we will use up our carbon budget in just 30 years.

Global climate change has profound impact on ecosystem functioning, biodiversity, agricultural productivity, and human health, and that in turn puts the wellbeing of humans as well as all living beings on the earth in jeopardy. The impacts are exhibited in various forms such as increasing morbidity and mortality in tropical regions, erratic monsoon and resultant

loss of agricultural production and productivity, rising food insecurity and poverty, increasingly more frequent extreme weather events such as hurricanes increasing scarcity of fresh water and so on. There may be some benefits to cold regions like lesser incidence of cold wave related deaths, cost and energy saving due to lesser heating requirement. However due to heavy population concentration in tropical regions the costs would far outweigh the benefits to the world as a whole.

Various measures have been devised to face the challenge and they may be grouped under two heads – Preventive and Adaptive. Preventive Measures include steps like shifting to low carbon or non fossil fuel manufacturing and creation of carbon sinks through preservation of forests and aforestation.

Adoptive measures require construction of dikes and seawalls as protection against rising sea level and extreme weather events such as floods and hurricanes, relocating people away from low-lying coastal areas, mobilizing manpower as well as financial and material resources for climate related disaster management, and also changing agricultural practices such as introduction of drought resistant varieties of crops and take other suitable measures to face changing weather conditions and so on.

The economics of climate change is all about finding ways to avert mitigate or adapt to the adversity by drawing from economic theoretical framework and empirical findings and designing policies on their basis in this regard. This process has been initiated since the 1960s and it has played a key role in the formulation and implementation of a range of climate change policies at the domestic and international levels. As a result, the carbon taxes, emission trading systems , performance standards, and technology promoting programs adopted at national and international level and a slew of all such related measures have evolved overtime to tackle the menace of climate change.

The Economic Perspective

From the perspective of Economics climate change like any other environmental issue; is a **negative externality**. The emission of green house gases cause harm to others with no provision or mechanism for the perpetrator to pay for it, and to compensate the victim. Another aspect is that it represents a case of overuse of a **common property resource**. Earth's atmosphere belongs commonly to everyone and all of us together use it for emitting GHG. The atmosphere is a global common and it is being overused. Moreover wherever the GHG is emitted, everyone is affected by its impact and hence it is public in nature - it's a **public bad**. When it comes to taking measures for mitigation, there is the problem of **free riding**, as every country gets benefit of mitigation, whoever makes the effort. To quote British economist Nicolas Stern "climate change is the greatest and widest-ranging **market failure** ever seen, presenting a unique challenge for economics."

The standard solutions offered by economic theory in a perfect competition set up to internalize the externality range from Pigovian fees to Coasean bargaining theorem to tradable permits. The government imposes Pigovian Fees according to the marginal social cost, Coasian bargaining strategy works when the govt allocates property rights either to the polluter or the victim and prompts them to bargain, and tradable permits in pollution provides least cost solution to control pollution when the govt allocates permits in units of pollution to the firms, and they trade in the permits while reducing pollution in an efficient manner. Over and above that the state may resort to command and control measure even. However all these tools have been formulated in the condition of perfect competition and certainty regarding the impact of pollution, which the victims suffer. At international level other policy options have gradually evolved such as transfer of technology and performance standards.

The standard theoretical tools discussed above, if applied to climate change would not provide much of a solution, the reason being some peculiarities of climate change which makes it a lot different from other pollution problems occurring in different countries.

The Peculiarities and complications

Climate change is a negative environmental externality of an entirely different kind. The reasons being that its impact has a very long time scale extending far into the future, there is also a great deal of uncertainties because exact prediction of the impacts is impossible, the issue has international scope , and the benefits and costs are extremely unevenly distributed across space and time. An analysis of the problem and the probable solutions bring to notice; various peculiarities and complications involved which are discussed below.

Firstly with respect to **duration of time and certainty** of impact climate change exhibits some peculiarities. The greenhouse gases remain in the atmosphere for a very long period of time, hence the impact extends to the future generation too. Effort for mitigation would yield result a long time after it has been taken and hence large part of benefit goes to the future generations again. Scientists say the green house gases take a long time even a century or more to dissipate, if drastic measures to cut the emission is taken. The cost needed for transition into non fossil fuel from fossil based fuels would involve substantial transition cost to be borne by the present generation. But the benefit of reduced CO_2 would accrue to the future generation. Moreover the benefits to accrue in future are uncertain or unknown in terms of magnitude and probability. The uncertainty increases further with positive and negative feedback effect. If some impact of the rising temperature becomes a cause for further rise in temperature it is called positive feedback effect. For example global warming leads to melting of snow in the arctic and melting ice uncovers darker land or ocean beneath, which then absorbs more sunlight, causing more heating and more global warming.

Secondly, various problems come up when a valuation of the **costs and benefits** of climate change is attempted. Because of the long term considerations involved, there'll be need for using a discount rate for valuation of costs and benefits. Here the cost is the cost incurred on abatement measures, which has to be compared with the cost of probable damages which could arise due to the projected increase in carbon emissions. Here the benefit is the estimated cost of the avoided damage. There are problems such as estimating the cost of bio diversity loss. It is impossible to judge the extent and value of the loss of bio diversity, but some probable estimates are attempted always.

Thirdly, since the costs and benefits extend into future economists make use of a **discount rate** while estimating the cost or benefit. The ideology behind such practice is that human beings value present more than the future. Hence future costs and benefits have lower money value as compared to present or they have a discounted value. The formula used is as follows

$$Present\ Value\ (X) = X / (1 + r)^n$$

where r represents the discount rate and n the number of years. On the left side of the equation is the discounted present value of the amount X. The choice of proper discount rate poses a lot of problem. The more the discount rate, the less will be the future value and the less will be the imperativeness of taking action. But one thing is obvious that without policy intervention, carbon emissions can be expected to continue to rise as predicted by scientists on the basis of various climate models. Repercussions are likely to be very severe in future, but even the present generation has started feeling the heat already. Thus immediate and aggressive policy actions by the world community are imperative for initial stabilization and subsequent reduction in total CO2 emissions in the future. The problems and implicit value judgments associated with discounting add to the complications. Thus economists need to take a judicious approach and be guided by considerations which include ecological as well as economic costs and benefits. Giving greater weight to long-term ecological effects, the Stern Review uses a low discount rate of 1.4% to balance present and future costs.

Fourthly, the issue of fixing responsibility too leads to certain complications. Given the fact that developed countries are responsible for the problem so far, justice calls for action to be taken by them only, sparing the developing countries to pursue their objectives of growth and poverty removal. That means future emissions would come chiefly from these developing countries. This way the problem would exacerbate in future. Thus a middle path solution is called for. Technology transfer is one such scheme mulled by international community today.

Fifthly, another issue needs urgent attention along with issue of mitigation and that is **adaptation**, steps that need to be taken to reduce the impact of climate change. The impact of past emission is already making its presence felt. But the issue here is that the impact is felt and would be increasingly felt with more severity by the poor nations of today, though they

don't have any role in causing it. Hence the issue of development assistance becomes another matter to be considered at international level. These countries deserve development assistance in general and also assistance for development of infrastructure, drought resistant crop varieties and other areas in particular.

Finally we encounter the issue of **jurisdiction** when it comes to application of economic tools. In cases of externalities such as water or air pollution, the Government can use tools like tax or allocation of tradable permits to internalize the externalities. The polluter is legally bound to comply, otherwise faces punitive action. But given its international nature, jurisdictions are not defined for impacts of climate change, but there is no such sovereign international authority that could compel a country to take proper action.

Given such anomalies, normal economic tools will be of little help. Hence there is need for international cooperation and coordination among countries, which are highly diverse in terms of income and standard of living, extent of industrialization, demographic characteristics like size, composition, and educational attainment level and so on. These differences again define the capacity of a country to bear the transition cost, and the degree of its vulnerability to climate extremities.

International Cooperation

One thing is obvious that without policy intervention, carbon emissions can be expected to continue to rise as predicted by scientists on the basis of various climate models. Thus immediate and aggressive policy actions by the world community are imperative for initial stabilization and subsequent reduction in total CO_2 emissions in the future. There are various estimates regarding the extent of economic cost of climate change. The most widely discussed among the estimates is that by the Stern Review Committee Report in 2006. On the basis of formal economic models, the Review committee estimated that if the world didn't take any action, the overall costs and risks of climate change would be equivalent to losing at least 5% of global GDP each year, for all time to come. But the report said, in case a wider range of risks and impacts was taken into account, the estimates of damage could rise to 20% of GDP or more. In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.

And the IPCC report of 1996 highlighted the inequality aspect and stated that a 2.5°C temperature increase would result in a loss of 1.0 to 1.5% of GDP in developed countries but a 2–9% loss of GDP in developing countries. Stern too gives an estimate with weights applied on the basis of inequality. Stern estimates that, without the effects of inequity, the costs of business as usual (not taking any action) scenario will be 11-14% of global GDP. However attaching more weight to the impacts on the world's poor gives a cost estimate of 20% of global GDP.

There are hosts of studies based on various economic models which make different estimations regarding the anticipated loss. Despite variations in the range of estimates, all the studies point to one outcome- a grim future. Hence taking action is the only option open to the world community. International economic cooperation has to come up taking into consideration all the difficulties such as issues of negative externality, free riding, long time horizon and uncertainty of the impact, inequality, climate justice etc.

The basic game theoretical solution to a game involving free rider issue calls for the promotion of a collaborative solution. A real effective solution would be a collective global approach consisting of clear long – term international agreements, that would facilitate proper functioning of the market and the entrepreneurs. But such agreements are not easy to arrive at; they need a proper understanding of the consequences by each one of the countries, and their individual responsibilities as per the agreement. Designing a proper incentive structure would be another requirement for a successful collaboration.

International Cooperation in Practice

The history of international cooperation to face the challenge of climate change began with the Stockholm Conference on Human Environment in 1972. It is in this conference that the United Nations Environment Program (UNEP) was set up to generate political will and prepare action plan in a systematic manner. The need for scientific analysis and research gave rise o the formulation of Intergovernmental Panel on Climate Change in 1988 by UNEP and World Meteorological organization (WMO). Out of a series of conventions and conferences a few merit special mention. One of them is the Montreal Protocol, which was signed by the US and 24 other industrialized nations in 1989 to freeze the emission of nitrogen oxide which causes acid rain and also reduce and subsequently stop using ozone depleting substances such as CFC. However developing countries such as India and China were spared from the commitment for 10 years. It is highly appreciated as the most successful treaty. In the Copenhagen Summit in 1992 the time limit to phase out CFC and tetrachloride was advanced to 1996.

The United Nations Conference on Environment and Development better known as the Rio conference at Rio de Janeiro in 1992 prepared a framework for climate change negotiation named the United Nations framework Convention on Climate Change (UNFCCC). Since then the signatories of the treaty, the 181 countries meet every year in conferences called Conference of Parties (COP) to discuss issues related to climate change and find solutions.

One of the most important COPs was the third one at Kyoto in 1997. From the beginning the main thrust has been on green house gas emissions. In Kyoto emission targets

were set for developed countries, called Annex I countries and it was binding under international law. US did not ratify the treaty as India and China were let free to continue with their emission levels. Due to technicalities it could come into force only in 2005. But introduction of two important economic tools in policy action make the protocol even more special. They are trading of Emission Permits, Clean Development Mechanism (CDM) and Joint Implementation. The trading of emissions permits is to take place among nations that are bound by specific targets. Thus one nation unable to meet its target could purchase permits from another nation that reduces its emissions below its requirements. The European Union has set up a carbon trading system which went into effect in 2005, though it met with some problems and the process has been refined to make it a success. The introduction of **clean development mechanism**, enables industrial nations to obtain carbon credit for financing emission-reducing or emission-avoiding projects in developing nations not bound to specific emissions targets, including China and India. CDM is to the advantage of both set of countries developed as well as developing. And **joint implementation**, whereby an industrial nation receives credit for financing emission-reducing projects in other countries bound to emissions targets, mainly in transitional countries such as Russia and Lithuania. In Doha Agreement, 2012 (the 16th COP), Kyoto Protocol was amended as the commitment period agreed to in Kyoto came to an end. The second commitment period spreads over 2013 to 2020. The Cancun COP in 2010 too took a very important decision of establishing a Green Climate Fund with contribution from developed countries. The purpose of the fund is to devise a mechanism for funding projects and progrmmes of climate amelioration in developing country, and thus address the issue of equity and justice raised by developing countries. In the summit developed countries submitted their economy wide emission targets and developing countries submitted their Nationally Appropriate Mitigation Action (NAMAS), to be implemented subject to financial and technical support. The latest among the COPs was held at Paris in December 2015. Countries have agreed to make all efforts to hold global temperature below 1.5° Celsius to 2° Celsius.

Thus international cooperation has progressed steadily overtime to face the challenge of climate change. Free rider problem and clash of interests have put hurdles on the path of attainment of equilibrium in a game theoretical situation. It is natural that every country would try to maximize its own gain and they choose strategies accordingly. Given the situation of interests clash, free riding, absence of an enforcement mechanism etc. a perfect solution can hardly be expected at international level. Still gradually more and more people all around the world have started understanding the seriousness of the problem and hence the imperativeness of joint effort. Thus proper use of economic tools and more importantly a move in the direction of global cooperation is the right answer to the problem of the menace of climate change.

Question.

NO

1 - Discuss how pollution act as Externality?

2 - Discuss the concept of optimal pollution.

3 - What do you mean by property right? Discuss how it will provide incentive for Economic-Development of a city.

4 - Write short Notes

a - Coase Theorems

b - Pigovian Taxation

c - Subsidies

5 - What do you mean by climate change? Discuss the causes of climate change.