EUROPEAN ACADEMIC RESEARCH
Vol. V, Issue 4/ July 2017

ISSN 2286-4822
www.euacademic.org

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Collective Action and Climate Change

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INTRODUCTION

The global rise in the average temperature (global warming) is the biggest threat to the Earth today. These greenhouse gases (GHGs) namely carbon dioxide, chlorofluorocarbons and methane are the biggest contributors to this climate change problem (Nordhaus, 1991). Global warming or the climate change has further adverse effects on the economies world-wide due to its economic nature. The economics of climate change can be witnessed through various aspects. For instance, climate change has a direct impact on the production of various goods and services (mainly, agrarian commodities and forest-timber products). Geographical alterations like rise in sea levels and natural disasters like floods and cyclones often lead to loss of lives and property destructions in the affected regions. Degradation of ecosystems and biodiversity caused by the climatic change has led to adverse effects on human well-being and has made them worse off. Likewise, extreme health effects (e.g. morbidity due to high temperature) arise from such a rising temperature and extreme weather events. Even then countries all over the world have problems reaching a consensus on controlling green-house gas (GHG) generation. This situation is similar to a 'dilemma'. An economic argument by Hsu (2011) is that reduction of GHG emissions today to control climate change issues would mean that the present generation will have to transfer their potential wealth to the forthcoming generations who will be even wealthier since the world economy will continue growing wealthier, like it has for centuries. In this literature review we look at; (a) the challenges faced in collection action to solve the problem of climate change, (b) how climate change problems can be solved using various game theoretical models, (c) and how collective actions have been used at global national and local levels.

COLLECTIVE ACTION, GHG EMISSION REDUCTION AND CHALLENGES

Collective Action refers to set ups where individual decision making on a cost involving action is made individually, but the outcomes conjointly affect everyone involved in such a decision making. To achieve an outcome that is desired at the societal level i.e. an outcome that provides high proceeds to all the members irrespective of whether they borne the cost in providing the outcome, individual decision making must not aim only to maximise short term material benefits (Lichbach, 1996; Schelling, 1978; Vatn, 2005 as cited in Petersmann, 2012). In the times when climate change is a big threat, it is important for nations across the world to come to an agreement in order to tackle the former.

However, the following are some of the peculiar features of climate change problem proposed by Hsu (2011) which are further the reasons why countries fail to come to an agreement (e.g. Kyoto Protocol) - (a) Non excludable in provision and non-rival in consumption makes GHG reduction a public good; (b) Free-rider effects of mitigation - “In the form of avoiding costly mitigation while allowing others to undertake it, and it may also take the form of avoiding the costs of research and development of new technologies that reduce greenhouse gas emissions”(Hsu, 2011); (c) There exists an ‘uncertainty’ concerning the harms and adaptation costs; (d) Even though the climate change effects are being felt in the present age, furthermost serious effects in all likeliness are expected to occur in the long run (say, 50-200 years from now). This expectation makes all the cost benefit fifty to two hundred years from now, making cost-benefit evaluations remarkably sensitive to the "discount rate". Now there exists an enormous uncertainty as to what shall be the 'best' rate; (e) lastly the fewer actions taken today to control GHG emissions the more expensive it will be in future to take up the same actions. Caplan, Ellis and Silva, (1997) have argued that not like most trans-boundary pollution issues "global warming can create winners".

> "[…] for example, growing seasons are lengthened for some regions as rainfall distribution is altered. This presence of winners compounds the collective action problem, because some nations would be motivated to undo the efforts of others to augment their own gains from warming" (Caplan, Ellis and Silva, 1997).

Olson (2009) termed the problem of GHG reduction as "Global Pure Public Good" since it "provide non-rival and non-excludable benefits to the world at large". Thus, the "conventional theory of collective action" (Brennan, 2009) envisages that no one will of your own free will adjust their behaviour to reduce energy-use and GHG releases; an outside authority is essential to enforce rules that shall change the incentives of the decision makers..

CLIMATE CHANGE PROBLEMS – A PRISONER'S DILEMMA

The individual decisions to solve the problem of climate change can be understood in terms a "non-cooperative" game theory and demonstrated like a prisoner's dilemma game (Speirre, 2016); whereby the players in this case are those accountable for the GHG emissions (nations, institutes, corporations and/or individuals). The strategy set for each has two strategies namely, (a) mitigate by reducing emissions of GHG (b) carry on conducting "business as usual (BAU)".

Figure 1 shows that if both the players (say nations) mitigate their GHG emissions, then both the nations will be gaining in the long run due to the adoption of sustainable growth path. However, if one country mitigates but the other does not cooperate i.e. it continues with the business as usual activities then the country that mitigates early has an economic disadvantage due to the energy preservation efforts and costs, on the other hand, the countries with business as usual activities would be maximizing his benefits by maximizing the industry and output. However in the very long run both the nations and the world as a whole will suffer from high global GHG concentrations.

Figure 1: Strategy Matrix of Two Countries

	Country B Mitigates	Country B BAU
Country A Mitigates	• Both countries benefit from long-term sustainable eco-system services, better human health, diversified and independent economies, as well as an improved sense for justice and the well-being of others I	• Country A: : disadvantaged economically in the short term due to conservation efforts including reduced industry and decreased production • Country B: benefits economically by maximizing industry and production • Over the long-term both countries suffer from heightened GHG concentrations in the atmosphere II
Country A BAU	• Country A: benefits economically in the short-term by maximizing industry and production • Country B: disadvantaged economically in the short term due to conservation efforts including industry and production • Over the long-term both countries suffer from heightened GHG concentrations in the atmosphere III	• Both suffer from environmental and economic degradation in the long-term • Both benefit economically in the near term IV

Source: (Speirre, 2016)

Even though cooperation strategy of both nations mitigating GHG emissions today to reap the benefits in the long run provides higher pay-offs to each player (hence the society as a whole), the Nash equilibrium in such a prisoner's dilemma is clearly when the players are maximizing their individual benefits without accounting for the long run social benefits (quadrant IV). In other words, there are no incentives for players to deviate from a situation of "non-cooperation".

Certain modifications to the above prisoner's dilemma settings can be done to understand the real life scenarios. For instance, if the players are heterogeneous in nature then the fourth quadrant (earlier called the Nash equilibrium) can now be thought of as a scenario where the weaker (or the poorer) country may suffer more from environmental degradation. "While the level of carbon dioxide and other GHGs in the atmosphere may be relatively uniformly distributed at a mega scale, the impacts of climate change differentially affect localities and regions by their geographic location, ecological and economic conditions, prior preparation for extreme events, and past investments" (Ostrom, 2010). For example, relatively warm climate may result in milder winters giving residents of a region some convenience by offsetting cold and severe weather, but on the counterpart, the summers will be relatively hotter but it would also make summers hotter increasing the scale of heat-waves. Say, in the U.S. the degree of weather change determines the reduction in electricity bills due to fall in the heating expenditures in winters which are warmer now more than the increase in expenditure due to more cooling requirements in the hot summers. This may result in positive net annual benefits of billion dollars. However, for many developing countries located in warmer climates than the U.S., a rise in the cooling costs in summers might dominate a fall in the heating expenditures which were nearly non-existent before, will definitely lead to a higher net costs.

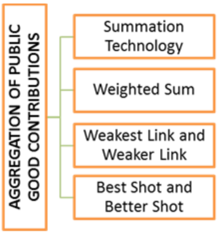
Now if one country mitigates but the other does not cooperate (quadrant II, III) there can be instances of mitigating nations having an impact of providing incentives to other player(s) to increase the GHG emissions. Suppose if Americans reduce consuming fossil fuels resources then due to a fall in demand of these fossil fuels the global prices will fall, however this would enable other nations to increase their consumption of the same, thus transferring the utmost benefits to the countries which do not willingly restrict their emissions. Thus, non-cooperation the on parts of players can not only fail to achieve the desired socially optimal level of public good (here, GHG reductions) but it may further lead to higher inequality among the members if they are already heterogeneous

In order to reach cooperation or a collective action it is important to know how much of the aggregate contribution by the involved members is needed to achieve the desired public good. The next section discusses four aggregation techniques by Sandler (1998).

AGGREGATION OF PUBLIC GOOD CONTRIBUTIONS

The provision of a public good like GHG reduction we need an aggregation method or technique to aggregate all the contributions by the individual members involved to achieve a socially desired level of out outcomes. Sandler (1998) defines technology of public supply aggregation as; "the association between individual contributions and the total quantity of the public good available for consumption is known as the technology of public supply aggregation". Sandler (1998) gave the following four technologies for aggregation of public good contribution;

Figure 2: Aggregation of Public Good contributions



SUMMATION TECHNOLOGY

The summation technology is simply the aggregation of each country's contribution to the public good to get the total level of the good. Therefore, "the contribution of one agent serves as a perfect substitute for that of another — that is, contributions are anonymous in the sense that each unit contributed adds the same at the margin regardless of who gives" (Sandler, 1998). This technology is denoted as-

$$Q = \sum_{i=1}^{n} qi$$

where Q is the total public good (GHG reductions) which is the sum of individual i's contribution qi. This technology can be thought of as the "prisoner's dilemma" since a player *i,* contributes no unit of the good if the benefit minus the cost of providing the good is negative. This decision is irrespective of what other are doing. Thus it is the dominant strategy of players not to contribute if they incur net loss. If everyone were to view the contribution problem in this manner, then the public good would not be provided unless some higher authority (Sandler, 1998).

WEIGHTED SUM TECHNOLOGY

The projection for cooperation in the weighted technology is more "optimistic than the summation technology". This technology has the following denotation for country i

$$Qi = \sum_{j=1}^{n} \alpha ij . qj \text{ , i = 1, 2, 3, 4…., n}$$

where Q is the global public good and Q_i is the share of that public good enjoyed by a country i, q^j is country *j*'s contribution in GHG reduction, α_{ij} is the "share of country j's provision received by country *i*". The point to note here is that if all of the α_{ij} are equal to one, then the cooperation exists and the pure public good is provided results.

However, if the α_{ii} are equal to one and the off diagonals αij are zeros, then the good is similar to a pure private commodity since there exists no positive spill-over effects one nation's contribution on others. "If the s αii dominate this transport matrix, so that the largest non-zero entries lie along the diagonal, then the underlying public good is quite impure with large nation-specific private components being derived from reducing sulphur emissions" (Sandler, 1998). In such a scenario, a transfer of endowments from countries with smaller spill over (α_{ij}) of public good to other nations which have high spill over effects, the overall level of attaining the public good can be improved. Also, redistribution to nations with higher private benefits from public good can also assure higher cooperation and delivery of the resultant good. Furthermore, the weighted sum technique does not certainly suggest a "Prisoner's Dilemma" where the "dominant strategy is not to contribute" (Sandler, 1998). According to Sandler (1998), there are possibilities that there may exist a single nation who may derive adequately huge benefit from providing the public good even if it has to solely provide the whole of the public good. Thus some nations will have a dominant strategy of contributing the good irrespective of what other nation players are doing.

WEAKEST LINK AND WEAKER LINK

In this technology of public supply aggregation according to Sandler (1998) "the contributions of everyone will be more or less similar in the equilibrium". The method of aggregation is to fix the minimum effort level by the members involved. Thus the "weakest link" is the least effort of one nation which decides the overall availability of the good for all other nations. It is represented by;

$$Q = \min\{q1, \dots \dots qn\}$$

Figure 3: Weakest Link

a. Weakest-link

		Player B: *0 units*	*1 unit*	*2 units*
	0 units	* 0, 0	0, −2	0, −4
Player A:	*1 unit*	−2, 0	* 2, 2	2, 0
	2 units	−4, 0	0, 2	* 4, 4

Source: Sandler, 1998

In the figure 3, is assumed that the per unit cost of providing the public good is $2, and each player gets a benefit of $4 with each unit of public good, if and only if it is provided by both the players equally. It is also seen that when all the players are contributing none has an incentive to deviate to 'not contribute' strategy. Also, if no one contributes then there is again no incentive to contribute all by oneself. Thus contributing in the provision of the public good is more binding in this scenario than the summation technology that was analogical to Prisoner's Dilemma (Sandler, 1998). Thus the diagonal entries in the figure 3 represent all the Nash equilibria.

"The least effort has the greatest marginal impact on the level of the public good, followed by the next least effort and so on (Cornes, 1993)" (Sandler, 1998), therefore, the contributions more than the minimum levels add only slightly to the overall global contributions. This is termed as the 'weaker link' game.

Figure 4: Weaker Link Game

b. Weaker-link

		Player B: *0 units*	*1 unit*	*2 units*
	0 units	* 0, 0	* 2, 0	3, −1
Player A:	*1 unit*	* 0, 2	* 2, 2	* 4, 2
	2 units	−1, 3	* 2, 4	* 4, 4

Source: Sandler, 1998

In the weaker link game, there are off diagonal equilibrium possibilities too. Once again, costs per unit are \$2. Suppose that now players get benefits of \$2 if a single unit is provided by just one player. Thus the net benefit of the provider is zero dollars (i.e. benefit of \$2 minus cost of \$2). However the non-contributors get a net benefit of \$2 (i.e. \$2 - \$0). If, however, both players contribute a unit, then each player gets \$4 in return before paying the costs (since now the total units provided are 2 and benefit from each good is \$2). Thus, there exists free ridership problem at the Nash equilibria. For instance, if player 1 provides one unit of the pure public good and player 2 provides none of it, then the payoff are (0,2), where player two gains even without any contribution, and this is a Nash equilibrium as there is no incentives of individual deviations.

Nevertheless, according to Sandler (1998) "such equilibria allow for greater collective action possibilities, because perfect coordination is not required with a weaker-link technology".

BEST SHOT AND BETTER SHOT

"A best-shot technology equates the level of the public good to the largest individual provision level" (Sandler, 1998). Thus the global aggregation can be represented by;

$$Q = \max\{q1, \dots \dots qn\}$$

"Best-shot technologies are related with co-ordination games where one or the other player only needs to act in equilibrium (Farrell, 1987; Sandler, 1992, pp. 41–2)." (Sandler, 1998)

Figure 5: Best Shot Game

Best-Shot Game

		Player B:		
		0 units	*1 unit*	*2 units*
	0 units	0, 0	4, 2	* 7, 3
Player A:	*1 unit*	2, 4	2, 2	5, 3
	2 units	* 3, 7	3, 5	3, 3

Source: Sandler, 1998

On the other hand, “a less strict form of this technology is better-shot”, whereby the greatest marginal increase in the provision of the public good (say, GHG reduction) is through the contribution of the player who had the largest contribution. “Smaller provision efforts can also add to the overall public good supply but by much less than the greatest effort” (Sandler, 1998). Thus a single player who has the highest stake in the final public good provision can act.

In figure 5, suppose that per unit cost of provision of the good is $2, and each player gains $4 if one unit of the good is provided and $7 if two units are provided (before paying the costs). Also, the player gets the benefit irrespective of whether he contributes or not. Thus, the Nash equilibria in figure 5 is when either of A or B provides the entire public good. When player A provides 2 units to the good, he gets a payoff of $3, and player B gets a payoff of $7. Similarly, when player B provides both the units of the public good i.e. suppose it alone reduces its GHG emissions, then his net gain is equal to $3 whereas, player A gets $7. In both these situations the players have no incentive of unilateral deviations. Thus the richest nation can achieve the emission targets unassisted by the poorer countries since the contributions by poorer or weaker nations will add to the final outcome only marginally.

CHALLENGES OF MAINTAINING GLOBAL COMMONS – OSTROM (1999)

Eleanor Ostrom (1999) has proposed numerous factors in favor of maintaining the common pool resources at the local and regional levels, but on the other hand she has stressed upon the challenges of maintain a global common pool resource like ozone layer. According to Ostrom (1999) the enforcement and agreements of rules at the world level is difficult or organize because of "large number of participants", also "an increased cultural diversification can decrease the likelihood of finding shared interests and understandings". Other factors like increasing capitalization, growing population, development of economies and technological advancements act as huge barriers in maintaining the global commons.

One of the most common reasons in reaching an agreement on the GHG reductions by countries is that the governments of strong and the powerful nations resort to "hold out for special privileges" before giving their consents to an agreement. The following section compares the two popular international agreements – The Montreal Protocol and the Kyoto Protocol to understand the reasons for the success and the failure respectively.

COLLECTIVE ACTION - GLOBAL LEVEL

The role of collective action in addressing climate change can be widely witnessed within the international arena. These negotiations are sluggish, politically dynamic and calculative. But even after years of discussion these negotiations are uncertain to deliver the expected results. To understand the fundamentals of collective action in climate change, this literature review compares and analyses a successful climate change agreement (Montreal Protocol) and an unsuccessful one (Kyoto Protocol).

Table 1: Montreal Protocol v/s Kyoto

Basis	Montreal	Kyoto
Objectives	To cut Chlorofluorocarbons (CFC) by half from 1986 levels.	To cut Greenhouse gas emission by 2012 as compared to 1990
Mechanism	Ban on Production and consumption of CFCs and Halons.	Emission Trading system [1] Clean Development Mechanism[2] Joint implementation[3]
Benefits and cost	Benefits ▪ Public health – mainly cancer ▪ Biodiversity Costs ▪ Ease of Substitution between ozone depleting to non-ozone depleting. ▪ Policies to implement the Protocol.	
Pay off	Annexure Table 1	Annexure: Table 2
Results	Success. 195 countries have ratified the protocol Ozone to be fully recovered by 2050 and Polar regions by 2025	Failure
Reason for success/ Failure	• The costs and benefits became favorable as the treaty updated and from leanings over time. • Prevention of trade leakages • Incentives for developing countries to join the treaty.	• Withdrawal of USA • Unfavorable Payoffs. • Trade leakages.
Minimum participation	Needed to be ratified by atleast 11 countries: comprising 66.67% of world CFC consumption.	Needed to be ratified by atleast 55 countries: comprising of at least 55%of world Co2 consumption
Leakage prevention	Yes. Trade barriers between members and non-members.	No.
Free rider deterrence	Yes. Trade restriction and bans on Ozone depleting substances (ODSs) and products containing ODSs.	No.
Quantitative emission limits for developing countries	Yes	No

Source: Environment and Statecraft.

[1] "A carbon trade is an exchange of credits between nations designed to reduce emissions of carbon dioxide".

[2] "The Clean Development Mechanism (CDM) is one of the Flexible Mechanisms defined in the Kyoto Protocol (IPCC, 2007) that provides for emissions reduction projects which generate Certified Emission Reduction units (CERs) which may be traded in emissions trading schemes." (IPCC, 2007)

[3] "Emission reduction projects implemented jointly between Annex I countries (developed countries and transition economies)"

ANALYSIS

The Montreal Protocol was negotiated to prevent the further depletion of ozone layer by the release of Chlorofluorocarbons (CFCs), whereas the Kyoto Protocol was convened to reduce Greenhouse gas emissions to reduce global warming. The means to achieve the objectives in the 2 protocols were different: Montreal advocated a complete ban on production and consumption of Ozone Depletion Substances (ODSs), whereas Kyoto prescribed emission trading system, clean development mechanism and joint implementation. The pay offs of the Montreal were relatively favourable than of Kyoto's and hence, it incentivized other countries to join Montreal protocol.

One of the major reason behind the success of Montreal was that it was ratified by 11 countries which accounted for more than two third of the global CFC consumption, in contrast to Kyoto wherein 55 countries ratified making up 55 % of the GHG emission (After USA withdrew, making up for only 30%). The Kyoto agreement however, was not structured in a manner which incentivized the signatories to cooperate or reduce emission.

- It did not address the issue of trade leakage: Polluting industries could freely migrate from developed to developing countries where the environment standards were low.
- It also did not have a Free rider deterrence mechanism i.e. it did not ban or restrict pollution intensive goods.

ESSENTIALS FOR AN EFFECTIVE INTERNATIONAL TREATY

Trade Leakage

Trade leakage occurs when a pollution intensive industry migrates to a foreign country when the home country ratifies an environment agreement. Trade leakage may be positive and negative.

It may be negative because abatement cost (migration to a foreign country) may increase the price of that particular good in the international market, resulting in consumers to substitute for cleaner good. The Montreal protocol prevented trade leakage by imposing bans on trade of ODSs and products containing these substances between signatories and non-signatories.

One of the measures to address trade leakages is by imposing border adjustment taxes (BTAs). "BTAs are import fees levied by carbon-taxing countries on goods manufactured in non-carbon-taxing countries". However, there are two major problems with BTAs: they are very difficult to compute and they may clash with the trading rules of the world trade organization, incorporating the GATT.

In conclusion, the best option is for everyone to participate then, trade leakage will be zero by definition. The second best option is to impose tariff and differentiated taxes and third best option is neutralize indirectly by punishing non participation.

Trade Linkage

Trade Linkage can hinder as well as aid cooperation i.e. depends on the issue, and the manner in which it is linked. For example, Country A can threaten to cut its supply of oil to country B, if country B does not comply with environment regulations. However linkages can be a hindrance too, if country B threatens country A too, turning the issue to country B's favour. Trade Linkages help participation if global agreements encourage collaboration in R&D and deny non signatories of the products of participation.

Side Payments

"A payment made to a party or parties to induce them to join an agreement." The positive result of side payment is that it incentivizes a non-signatory to ratify an agreement. This helps to sustain a largely superior outcome. However, side payments lower the payoff of the donor countries, which may make them less willing to participate. Further they soften the punishments for free riding.

Model - Transforming the Prisoners' Dilemma Game to N Players Game

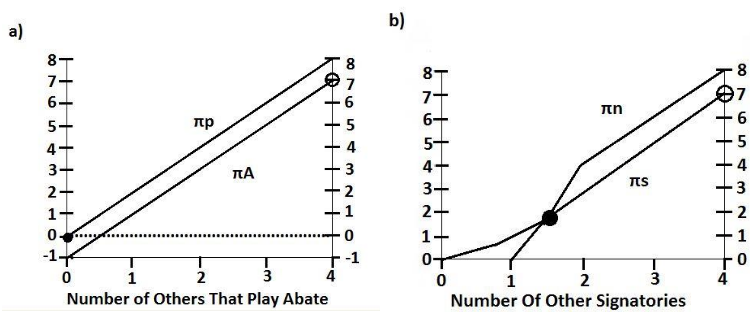
Assumptions (Barrett, 2003):

"1. There are N players, with $N \geq 2$.

2. Let k denote the number of signatories, and let signatories be identified by the subscript s and non-signatories by the subscript n.

3. Payoff function - $\Pi_i = 2(Q_{-i} + q_i) - 3q_i$, where q_i is the i's abatement and Q_{-i} is the aggregate abatement by countries than I; that is, Q_{-i} = summation of q_j. finally let $q_i \in \{0,1\}$.

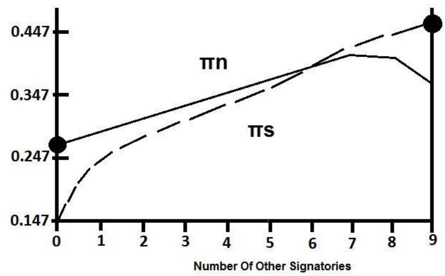
4. Then if i plays Abate it chooses $q_i = 1$. If i plays pollute it chooses $q_i = 0$".



If N is 5, then the game will appear like diagram (a). if there is only one participant/signatory to the treaty, then it would play pollute ($\Pi_s = 0$ if it pollutes, $\Pi_s = -1$ if it abates). But, when there are two or more participants/signatories, then both will get a higher payoff for playing abate: for example if no of signatories is two, then each gets $\Pi_s = 0$ if they play pollute and $\Pi_s = 1$ if they play abate). (see diagram (b))

Linking environment protection to trade;

- o “Environmental agreement may only restrict trade in goods directly linked to the environmental problem.”
- o “That the industry producing these goods is imperfectly competitive.”
- o “Industry output is homogenous”
- o “Firms segment the global market choosing destination – specific output levels.”
- o “Trade between signatories and non-signatories is banned.”



Suppose that non signatories pollute and signatories abate. When the number of countries ratifying the agreement is less, then every country’s dominant strategy is to NOT be a signatory. This is because when participation is low, signatories suffer due to the trade ban. They suffer not only in terms of free ridership, but also loose from gains from trade.

However, when the number of countries ratifying the agreement is huge, then every country’s dominant strategy is to be a signatory. This is because the non-signatories are unable to trade with majority of the countries due to the trade ban.

Therefore, there are two stable equilibria i.e. one in which everyone pollutes, and the other in which everyone abates. Although the best option in welfare terms is for everyone to cooperate, but countries can also move towards a” mutually preferred equilibrium” by adding a minimum participation clause to the agreement, similar to that of

Montreal protocol (see diagram, point at which Π_s and Π_n intersect).

COLLECTIVE ACTION – NATIONAL AND LOCAL LEVELS

"Global solutions" negotiated at a global level, if not backed up by a variety of efforts at national, regional, and local levels, are not guaranteed to work well." (Ostrom, 2010). She deliberates various national level initiatives taken to address the air pollution problems. For instance, in Colorado the law enables local municipalities to give funds for the permitted building developments and also provide funds to the property holders to pay-off any capital investment which was undertaken to reduce the usage of fossil fuels through by repaying over twenty years (Ostron, 2010). "California was one of the first U.S. states to pass major legislation—the Global Warming Solutions Act in 2006. The act requires drastic reductions from major industries including oil and gas refineries and utility plants" (Engel, 2006). "The Regional Greenhouse Gas Initiative (RGGI)" is an initiative by ten North-East and Mid-Atlantic states who planned to cut carbon emissions from the power sector by ten per cent by year 2018 (Rabe, 2004). A meeting held under Governor Charlie Crist in Florida (in July 2007) was concluded with a number of administrative guidelines signed to achieve reduction of GHG emissions with introduction of new construction codes using increased energy efficiency (Ostrom 2010). A study by Matrak (2009) in England, talks about the "new polycentric system- Westmill Co-Op wind farm" which enhances the power generating process devoid of any supplementary GHG emissions. There have been instances where people came forward as groups to get justice; "[…] Citizens of Xiamen organized a 'stroll' to draw attention to the planned citing of the PX plant in the city, deliberately refraining from calling it a protest" Van Rooij (2010). A law suit on air pollution was won by 1721 petitioners in Fujian and the reason by Van Rooij (2010) for such a victory is that "a small group of five representatives was able to coordinate the case and initiate litigation on behalf of all pollution victims."

There is increasing evidence that private cars emit up to 80% of the air pollution in the urban areas. Further, private car congestion leads to loss in valuable man hours; thereby increasing opportunity cost of time. Considering the above problem and desire for a quick solution, many governments in the past have opted to implement the odd even scheme to reduce local air pollution. However, the success of this policy has been mixed. We attempt to analyse an unsuccessful attempt at Beijing and a successful attempt in New Delhi.

The Chinese government rolled out the odd even policy in the wake to clean Beijing's highly toxic air. The immediate effect was that the average speed increased by 27% and the congestion reduced by 21% (Hai et al., 2011; as cited in Barik, 2016). But, people soon started to purchase a second car with a different registration number. Thirty per cent of the new cars purchased were to satisfy the need for the second car (Hai et al., 2011; as cited in Barik, 2016). This rebound effect weakened the policy and turned it to be ineffective. There were however many reasons behind the success of New Delhi's odd even policy. Firstly, it was only rolled in phases of 15 days each. This did not incentivize people to purchase the second car with a different registered vehicle number. Secondly, the government relied on the willingness of people. People chose to willingly cooperate because the government built trust that the policy was fair effective and transparent.

CONCLUSION

Collective Action refers to set ups where individual decision making on a cost involving action is made individually, but the outcomes conjointly affect everyone involved in such a decision making. In the times when climate change is a big threat, it is important for nations across the world to come to an agreement in order to tackle the former. However, the distinctive features like non-excludability in provision and non-rival in consumption makes GHG reduction a public good. Unlike other natural resources like fisheries, forests, etc. the problem of air pollution cannot be solved by privatization of resources as it is impossible to draw boundaries in the atmosphere and also impossible to exclude the receptors or users of the clean air in a region. Similarly, self-governance is not a common instrument to solve climate change issues due to the free riding problem. Regulation is the key to GHG emission reductions which is needed at all levels like global, national, regional and local levels. As proposed by Ostrom (1999), a climate change can be controlled by "polycentric systems" which are a combination of manifold governing authorities at various stages rather than a single unit of regulator at a single stage. Also, to reduce GHG emissions by different players depends on their dominant strategies. For some players a dominant strategy can be to not to provide the public good (clean air) at all, for some players it may be a dominant strategy to provide the clean air partially and sometimes even wholly. The individual contribution depends on the initial endowments, net benefits, and share of the final good received. Global environment negotiations are sluggish, politically dynamic and calculative. An international agreement needs to address issues such as trade leakages, trade linkages and side payments for it to be successful. The best option is for everyone to participate, this will result in highest possible social welfare. The second best option is to impose tariff and differentiated taxes and last option is to neutralize indirectly by punishing non participation.

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APPENDIX

Table 2: Ozone Payoffs

Predicted implications for the US of the Montreal protocol and of a unilateral ozone policy			
	No controls	Montreal Protocol	Unilateral implementation of Montreal by the U.S.
Ozone depletion			
By 2000	1.0	0.8	0.9
By 2050	15.7	1.9	10.3
By 2100	50.0	1.2	49.0
Payoffs to the US(billions of 1985 $ US)			
Benefits		3575	1373
Costs		21	21
Net benefits		3554	1352

Source: Barrett, S. (2003)

Table 3: Selected estimates of global marginal abatement benefit and global CO2 abatement cost ($US per ton C)

Benefit study	Marginal benefit	Cos t study	Marginal cost stabilization	Marginal cost 20% cut
Ayres & walter	30 – 35	Jorgenson-wilcoxen	20	50
Nordhaus	6.8	Edmonds – Reilly	70	160
Cline	7.6 – 154	Manne- Richels	110	240
Peck & Teisberg	12 – 14	Martin - Burniaux	80	170
Fankhauser	22.8	Rutherford	150	260
Maddison	8.25	Cohan - Scheraga	120	330
Source : IPCC				

Source: Barrett, S. (2003)