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Environmental Impact of Some Rural Industrialization Programmes in West Bengal: Need for New Instrument of Environmental Governance

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Section I

1.1. Introduction

In less developed countries large number of people draws their livelihood from natural resources like agricultural land, forest, fallow land and water bodies. Industrialization programme instituted primarily in rural settings would be socially and environmentally sustainable only if its long term and short term benefits to the society is at least as great as its total social cost which include cost due to loss of environmental quality. The potential positive impact of an industrialization programme on culture, social consciousness, health and education of the people along with its economic benefits on employment and income should be valued against the enormous social cost involved with such programmes, particularly when such programmes are developed in a rural area. Apart from cost due to conversion of land from other uses to industrial use, the negative externality of a rural industrialization programme arises due to its impact on environment and quality of resources like agricultural land, forest, grazing land, water bodies, livestock and human health. Emission of solid, gaseous and liquid effluents cause damage to air, soil, water bodies human health, livestock and bio- diversity. The burning of fossil fuel leads to emission of Carbon dioxide, Carbon Mono Oxide, sulfur, and many other harmful particulates. Dumping of solid and liquid waste results in air and water pollution, which is aggravated by discharge of heavy metals and chemicals into water and drainage of liquid effluents. Moreover use of water for industries leads to lowering of ground water level creating scarcity of water, particularly in dry areas. The possible effect of environmental degradation can be listed as: 1) the result of harmful impact of industrial pollution on human bodies is to create health hazard leading to diseases of chronic and permanent nature, sometimes even affecting the health of the new born. There can be long run adverse effect of this in society and economy due to loss of labour productivity reduction in income generating capacity and standard of living of the affected people, deteriorating their social and cultural life, 2) the degradation caused to the ponds, rivers and other water bodies on which farmers depend for irrigation and other purposes, leads to lowering of agricultural productivity, value of crop land and agricultural income which expose them to high risk and uncertainty, 3) The degradation of other common property resources like forest and gazing land has its adverse effect on livestock and livelihood of the people depending on these resources, 4) The over all effect on human life may be enormous bringing about drastic change in the life pattern of rural communities, exposing them to the values and vices of industrial society having long run social and political implications. 5) The effect on ecology and bio diversity creates condition for loss of life support system both for the present and future generations. While there has been lots of theoretical discussion on these issues, efforts to make rigorous evaluation of social cost against benefits of rural industrialization have been few.

The present study is a meager attempt to conduct an investigation into the economic impact of environmental degradation caused by some rural industrialization programme in West Bengal: The objective is to examine the effectiveness of existing regulatory measures, to investigate their limitations and suggest supplementary measures to ensure higher level of enforcement, better compliance and less adverse environmental impact. In this context the potentiality of some supplementary instruments to the existing command and control system of regulations has been explored on the basis of available empirical observations and a simple Game theoretic framework of analysis. The present study therefore has two broad sections apart from this introductory section: Section II deals with estimation of impact of environmental degradation due to industrial pollution, and section III deals with the problem of Governance of environmental protection system and nature of regulations and control for maintaining environmental quality. The polluting industry that has been taken up for assessment of effect of environmental degradation is the Sponge Iron industry. And the areas that have been selected for the study are two rural blocks of Purulia district and one rural block of Bankura district in West Bengal. Before going to take up the analysis we like to present a very brief outline of the status of Research Development in the subject as follows:

1.2. A Brief Outline of the Status of Research and Development in the Subject

Number of studies has been made so far on valuation of environmental and natural resources. Starting from Kenneth Boulding's (1970) 'Economics as science' the idea of valuing environmental quality has developed through a long process of research and development. Arrow and Fisher's (1974) and Fisher and Krutilla's (1985) treatment of the issue of preservation of environmental quality and natural resources are considered as path breaking.

The volume of literature concerned with environmental problems in India is very big starting from M. V. Nadkarni's study on the political economic aspects of preservation, use, degradation and management of natural resources and common property resources in India. M S. Jodha's documentation of the nature of dependence of the rural poor on the common property resources is also a pioneering attempt on the estimation of degradation of natural resources and their possible impact on the lives of rural poor. That common property land resources and its quality have deteriorated through out India is evident from studies made by K. Chopra et. al. (1990). Kadekodi and Perwaiz (1998) observed similar phenomenon in Tamilnadu. The valuation of environmental quality of natural resources have been conducted by James and Murty (1998) (1999), K. Chopra (1998), V. Ratna Reddy (1998), Kadikodi (2001), Marothia (2001) and Sekar (2001), with the use of tools like Hedonic Price, and Contingent Valuation Method.

There are some empirical studies on the impact of environmental degradation on agricultural production but studies on impact of industrial pollution on agricultural production have been few and far between. Pinock (1978) has analysed the effects of different levels of water quality on output and income in irrigated agriculture. The impact of saline water damage in USA Colorado has been analysed by Vincent and Russel (1978); Moore (1978) has also made a similar analysis. Vagirathi Behre and V. Ratna Reddy (2002) have carried out analysis of impact of industrial pollution on agricultural production through deterioration in the quality of irrigation water for a village in Andhra Pradesh in India. Walsh and Warren have conducted estimation of economic cost of health damage due to water pollution for Africa, Latin America and Asia. Such analysis has also been conducted by a number of researchers for USA (1978). Phantumvanit

(1992) has conducted a comparison between the damage cost due to water pollution and the abatement cost of such pollution.

Closely related with the problem of assessment of environmental degradation and their effects are the problems of formulating suitable measures and evolving suitable institutions for effective management of natural resources and halting their degradation. Large volume of literature has grown dealing explicitly with relative effectiveness of different measures under varying circumstances (Murty, 2001). In less developed economies the traditional command and control measures are widely used; the state and the network of administration under it is the institution which is in charge of imposing the measures and monitoring their compliance. The efficiency of this method depends on correct assessment of gain from non compliance and cost of compliance to the polluters, and on correct assessment of the size of fine and penalties on that basis, on the one hand, and efficiency and the commitment of the different pollution control authorities under the state to implement rules and regulations and punish non compliance, on the other. The alternative to this method, market based method of control is a more popular method in developed countries. This method is based on imposition of taxes and subsidies so as to achieve Pareto optimal outcome through operation of market forces via price mechanism. The efficiency of this method also depends on collection of required information to estimate the cost and damage functions for individual agents. An alternative to these instruments, as has been suggested by D. H. Dales (1968), is a system of conducting market operations with tradable pollution rights or pollution permits with a view to achieving specified environment target. The institution taking care of the system being market, the success of the system depends on efficient operation of the market for this instrument. In less developed economies the information costs are prohibitively high and estimation of optimal level of emission, which requires high level of technical efficiency, is very difficult to achieve. It is very problematic to control and manage the environmental problems either by the method of command and control or by the market based method unless an elaborate procedure for estimation of cost and benefit of non-compliance and compliance by the polluters and damage cost is evolved. In the absence of such a system neither the command and control method nor the market-based method may be fully successful in achieving environmental goals. The Coasean method of controlling externalities by assigning property rights to the relevant agents is suggested for managing environmental problems as alternative to the institution, state and the market. However the Cosean method does not appear to be practicable unless the agents involved can form powerful and authoritative coalition to formulate rules and implement them efficiently.

Partha Dasgupta (1999) has elaborately discussed Social Capital as alternative instrument for management of environment and natural resources. Social capital forms the basis on which collective endeavor of people to cooperate for a common cause is built up. This is identified with those features of social organization, which facilitate coordinated action. Thus social capital is identified with trust, norms and networks the existence of which lead people to accept agreement for their mutual benefits and empower them to ensure achievements of certain goals. The norms of reciprocity and network of civic engagement have been considered as two important features of social capital which make it an effective instrument of cooperation among self interested people. Ostrom (1990) Seabright(1993), and Balland and Plattau(1996), have demonstrated, both theoretically and with the help of case studies, the working of cooperative behavior in achieving some common cause. Chopra, Kadekodi and Murti (1990) have examined cooperative solution to the problem of sharing arrangements of benefits from protection of common property resources in India. However, the example of protecting environment from industrial pollution through coordinated action among the stakeholders has not so far occurred in such analysis of collective action.

Section II

2.1. Some Facts About Sponge Iron

Sponge iron is a cheaper substitute for coke which is used as an essential ingredient in the production of steel. Increasing use of sponge iron as an input in the production of steel has led to reduce the dependence on foreign supplies of coke. It is extracted from iron through reduction of iron ore to metallic iron with the use of carbon at temperature below the melting point of carbon;for this the technical name of the product is direct reduced iron (DRI) Blast Furnace technology being dependent on foreign supply of coke, requiring huge investment and long gestation period is slowly going out of practice being replaced by electric furnace as a cheaper technological option which is based on sponge iron. .This combined with global shortage of scrap has led to very fast increase in the growth of sponge iron industry , particularly with the growth in global demand for steel over the past few years. With the de licensing and removal of Iron and Steel Industry from the list of industries reserved for the public sector, production of Sponge iron has received enormous impetus: With the progressive reduction of customs duty for raw materials of iron and steel industry, de regulation of pricing and distribution and hundred percent Foreign Direct Investment being allowed ,huge investment has been made by steel giants like POSCO and Mittal and their domestic counter part like Tata and Jindal both in iron and steel and sponge iron industry. However in spite of all this, fact remains that 60% of the sponge iron producing units are small scale industrial units with very small investment and production capacities. Majority of the production technology is coal based rather than gas based due to high price and non-availability of gas though gas based technology is a cleaner technology. Ninety percent of world's sponge iron production is gas based. Of the remaining ten percent sponge iron production based on coal seventy eight percent is located in India. While initial capital cost of the technology is considerably small, running cost of the units based on coal is also very low compared to its gas-based counterpart. This makes it possible for small investors to enter the field and continue with production maintaining good margin and leads to cumulative growth and concentration of units in a particular area. Central Eastern belt of the country endowed with rich mineral resources, including the states of West Bengal, Orissa, Jharkhandand and Chattisgar are the key regions for the growth of these units. West Bengal being endowed with rich deposits of non–coking coal suited to sponge iron manufacturing, with availability of iron ore in the neighboring state of Orissa, has seen huge increase in the number of mini sponge iron plants in its different districts like Burdwan ,Bankura and Purulia ,in last few years. But most part of the last two districts mentioned suffer from lack of adequate supply of water, which is an essential ingredient of the pollution control technology.

Sponge iron industry in India being mainly coal based is one of the very polluting industries under strict regulations imposed by central pollution control authority, implementation of which rests upon the state pollution control board and different local bodies under it. The sponge iron industries are to comply with certain requirements for maintaining standard with regard to emission of carbon dioxide carbon, monoxide and sulfur. Its emissions contain cadmium, nickel, hexavalent Chromium, Arsenic, manganese and Copper. The heavy metals in this particulate matters are most dangerous. The emission of oxide and sulfur cause quick damage of fruit trees and agricultural harvest. They are also very harmful to human lungs. Not only there are standards set by the Pollution Control Authority to maintain gaseous emission at the minimum level, there are measures instructed by the authority for dealing with solid and liquid effluents and fugitive elements. There are norms set by the authority with regard to disposal and recycling of gaseous, solid and liquid effluents and clear instruction prohibiting use of ground water and specifying the quality of coal and iron ore to be used as raw materials. The quality of iron ore and coal is very important since the rate of dolchar (the harmful solid waste) generation becomes exorbitantly high due to use of inferior quality of coal. Another important aspect is adequate supply of water. Water is important for gas conditioning through cooling which requires 5-6 cubic metre water per hour for each klin of 100 tonne per day. Thus water becomes essential ingredient for pollution control. While non-availability of good quality coal and iron ore intensify the process of generation of pollution enormously, lack of adequate supply of surface water creates huge pressure on ground water, enhancing both private and social cost of pollution control.

2.2. The Study Area

Several visits to Nituriaaa and Saturi blocks of Purulia district and Borjora block of Bankura district make it amply clear that small sponge iron units have sprung up with rampant violation of pollution control measures; the black smoke and black dust filling the atmosphere make it difficult to breath without taking polluting materials into the lungs; the black cover over the rooftop and the leaves indicate the extent of environmental degradation having its extremely adverse impact on the quality of land , forest cover, water , grazing land, biodiversity and human health. This further indicates the extent of probable damage not only on the ecology but also on the economy, in terms of fall in land productivity, loss of standing crops, diseases and death of domestic animals loss of human health and labour productivity, fall in the output of fruits, vegetables and aquatic resources deterioration in the quality of water and fall in the water tables.

The two districts are known as agriculturally backward districts due to lack of irrigation and infrastructure. Rate of industrialization and urbanization is also very low. Large number of people remain in poverty and without gainful employment. The areas mentioned above are characterized by large tracts of dry and fallow land. In Purulia, sponge iron units are concentrated in up land areas within close proximity of hills. People living in small hamlets within very short distances from the sponge iron factories in both Purulia and Bankura mostly depend on agriculture and cattle raising. Water scarcity forms the main problem of livelihood of the people. In summer acute scarcity of water intensifies the problem further. The sponge iron factories have created marginal benefits to a very small section of people by providing some employment. People do not feel it an advantage on the ground that the jobs are extremely hazardous and that the entire projects have led to reduction in agricultural production, lower the water table intensifying the water scarcity and have caused death of animals in large number.

2.3. Our Study

In order to estimate the extent of loss incurred by the people living in surrounding areas we have carried out statistical analysis on the basis of data collected from the household level through field survey. In order to take care of the impact of the combined effects of gaseous and solid emissions as well as spread of particulate wastes we consider it appropriate to estimate the fall in output of agricultural land within different distance ranges from the factories and to estimate the effect of distance from the factory on the fall in production and fall in the number of live stock. By following a method of two-stage stratified random sampling we select 200 households falling under different size classes of holdings, living in Nituria and Saturi blocks of Purulia within .5,1,2 and above 2 KMS of distances from the one or the other of the seven sponge iron factories concentrated in the area. By following the same method of two –stage random sampling we select 50 households falling under different size classes and living within the same four specified distances, from the one or the other of the three sponge iron units concentrated in the Borjora block of Bankura district. For each farmer we take into account different plots of land falling under different distances from the factories. We collect data on different aspects of agricultural production, production of fruits and vegetables and livestock raising before and after the coming of the factories. Since factories have come up within last five years, there has been no problem in getting data relating to the year just before the coming of the factories along with data relating to current year. In this study we have taken into consideration two kinds of impact on the lives of the inhabitants of the locality: 1) Impact on agricultural activities and 2) Impact on Livestock. As reported by the households some of the agricultural lands have gone out of cultivation due to degradation of the soil. Apart from this the land which are still under cultivation have undergone drastic fall in productivity due to loss in soil quality. Secondly due to degradation of gazing land caused by spread of harmful solid waste from the factories, the domestic animals suffer from diarrhea and animals with less sustaining capacity die of the diseases in large numbers. While cows and buffaloes can sustain and live with ill health, goats, lambs and calves can hardly sustain the hazard. The areas have seen drastic fall in goat, lamb and calf population. The goats which once were considered as a important subsidiary source of livelihood of agricultural people have almost been wiped out of the area. We present below the average percentage of fall in agricultural production and percentage fall in livestock in two survey areas according to different land holding size groups and different distances from the factories:

Table-1
Fall In Production For Different Groups Of Households With Different Land-sizes

	PURULIA			BANKURA		
Range of Land (in hectares)	**No. of Households**	**Average Production Fall (in mon)**	**Average Production Fall (%)**	**No. of Households**	**Average Production Fall (in man)**	**Average Production Fall (%)**
o<---<.5	89	23.93	42.25	4	1.25	4.22
0.5---<1	62	30.33	35.61	12	4.08	31.46
1--<2	29	45.79	38.64	7	0.11	10.17
2---<2.5	4	38.75	27.08	1	3	25
2.5---<3	3	90	43.33	1	5	41.66
3and above	1	100	14.28	2	5	38.09
total	188	328.81	33.53	27	3.07	25.10

Table-2
Land Size and Use of Fertilizer

Range of Land(in hectares)	No. of Households	Average per hectare fertilizer use (in kg)
O<---<.5	44	27.52
0.5---<1	26	88.38
1--<2	8	148.62
2---<2.5	4	133.75
2.5---<3	1	75
3 and above	1	165

Table-3
Fall in Production According to Distance

Distance from Factory	Purulia Fall in Production(%)	Bankura Fall in Production(%)
<0.5km	73.52	46.26
0.5<1km	62.14	33.37
1<2km	41.16	26.44
2 and above	29.96	21.54
Average	44.78	30.59

Table-4
Fall in Livestock with the Distances from Factory

PURULIA			BANKURA	
Distances from Factory (in km)	**Average Fall in Livestock**	**%Fall in Livestock**	**Average Fall in Livestock**	**%Fall in Livestock**
0--<0.5	**2.78**	**31.53**	**8**	**71.48**
0.5--1	**1.84**	**30.18**	**7**	**56.66**
1---2	**1.81**	**21.59**	**14.41**	**55.03**

It can be seen that there have been more than 45 percent and 30percent fall in production of paddy in survey areas of Purulia and Bankura districts respectively. However the proportional fall in production have been higher for smaller farmers compared to the bigger ones. This may be due to the fact that big farmers can prevent the fall in production to some extent by using productivity raising new technology, where as small farmers can not do so due to their limited capacity. It is seen that in spite of the fact that there has been huge rise in the use of fertilizer and improved variety of seeds in last five years, the farmers in our survey areas have largely failed to counter the harmful impact of environmental degradation on production and productivity.

Table–3 demonstrates percentage fall in production within different distance ranges from the factories. For each farmer, we have taken into consideration all the different plots of land under his operation falling within different distance ranges from the nearest factories. The table shows that within the distance ranges of 0.5 kilometer of a factory the fall in production has been very high and the extent of fall gradually declines with increase in distance ranges. The variation in proportion of fall in productivity across different distance ranges from the factories clearly indicate the impact of land degradation on agricultural production due to emission of gaseous and solid wastes from the factories.

The percentage fall in the number of livestock due to death caused by diarrhea has also been quite high between the year before and after the factory came into being, indicating the extent of negative impact not only on the well being of the rural households but also on the biodiversity having very great potential long run impact on lives of human being.

In order to examine this more rigorously we have carried out regression analysis using dummy variables to take care of impact of distance parameter:

REGRESSION 1

Fall in Production and Distance from Factory with two Other Independent Variables (Land & Fertilizers)

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + D + \varepsilon$$

Where Y= Fall in production

X_1= Cultivated land in hectare

X_2= Use of fertilizer per hectare

D=1, for less than 1 km. distance

=0, otherwise

ε = Random disturbance term

Regression Statistics	
Multiple R	0.68
R Square	0.46
Adjusted R Square	0.45
Standard Error	19.72
Observations	173.00

ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F*
Regression	3.00	56522.10	18840.70	48.46	0.00
Residual	169.00	65711.67	388.83		
Total	172.00	122233.77			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	47.79	3.24	14.74	0.00
Cultivated land in hectare	12.72	1.99	6.40	0.00
use of fertilizer per hectare	-446.30	38.44	-11.61	0.00
dummy(<1km)	8.09	3.57	2.26	0.02

Correlation between fall in Production, Cultivated Land and Use of Fertilizer Per Hectare

	% fall in pro	Cultivated land in hectare	use of fertilizer per hectare
% fall in pro	1		
Cultivated land in hectare	-0.101	1	
use of fertilizer per hectare	-0.56	0.65	1

We find that there has been significant fall in production even for land beyond the distance of more than 1 KMS. Proportion of fall rises significantly as one moves to distance range of less than 1 Km from the factory. More use of fertilizer leads to less fall in production. Higher size of farms leads to larger fall in production. This last result which indicates big farmers are more affected than the small farmers, is inconsistent with the result that more use of fertilizers leads to less fall in production. This inconsistent result with regard to effect of farm size on extent of fall in production seems to be due to multicollinearity problem as the correlation between farm size and fertilizer use is observed to be very high. We therefore carry out another regression analysis with only farm-size and distance Dummy as the independent variables.

REGRESSION 2

Relationship between fall in Production and farm size, distance from the factory in **Purulia**

$$Y = \beta_0 + \beta_1 X_1 + D + \varepsilon$$

Where Y= Fall in production

X_1= Cultivated land in hectare

D=1, for less than 1 km distance

=0, otherwise

ε = Random disturbance term

Regression Statistics	
Multiple R	0.18
R Square	0.03
Adjusted R Square	0.02
Standard Error	26.36
Observations	173.00

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.00	4113.07	2056.54	2.96	0.05
Residual	170.00	118120.70	694.83		
Total	172.00	122233.77			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	**50.84**	4.32	11.77	0.00
Cultivated land	-2.32	2.01	-1.15	0.25
Dummy(less than 1km)	**9.68**	4.77	2.03	0.04

The results of regression analysis show while there has been very significant fall in production between the two time periods fall in production has been significantly greater within distance range of 1 km. It is also observed that higher size of farms means lower proportional fall in productivity.

In order to examine the impact of distance from factory on extent of fall in production we conduct separate regression analysis with three distance Dummies to represent different distance ranges from the factories with the intercept representing the highest distance. The regression results given below show extent of fall in productivity rises significantly with reduction in distance from the factory. This confirms the highly negative impact of pollution on agricultural productivity.

REGRESSION 3

Relation between Distances from Factory and Fall in Production (Purulia)

$$Y = \beta + D_1 + D_2 + D_3$$

Y= Fall in production

D_1=1, Distance from factory (0<0.5)

=0, other wise

D_2=1, Distance from factory (0.5<1)

=0, other wise

D_3=1, Distance from factory (1<2)

=0, otherwise

ε = Random disturbance term

Regression Statistics	
Multiple R	**0.42**
R Square	**0.18**
Adjusted R Square	**0.17**
Standard Error	**29.92**
Observations	**270**

ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	**3**	**53096.89**	**17698.96**	**19.75**	**1.35671E-11**
Residual	**266**	**238265.24**	**895.73**		
Total	**269**	**291362.14**			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	**28.04**	**3.68**	**7.61**	**4.67256E-13**
Dummy(0<0.5)	**46.17**	**8.80**	**5.24**	**3.21876E-07**
Dummy(0.5<1)	**36.83**	**5.52**	**6.67**	**1.44689E-10**
Dummy(1<2)	**13.95**	**4.48**	**3.11**	**0.002**

REGRESSION 4

Relationship between fall in Production and farm size, distance from the factory in Bankura

Regression Statistics	
Multiple R	0.31
R Square	0.10
Adjusted R Square	0.06
Standard Error	11.75
Observations	52.00

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.00	731.55	365.77	2.65	0.080799
Residual	49.00	6764.65	138.05		
Total	51.00	7496.20			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	**23.01**	3.84	5.99	0.00
Cultivated land	0.37	0.36	1.04	0.30
Dummy (less than 1 km))	**8.23**	3.65	2.25	0.03

In Bankura extent of fall in production rises significantly with fall in distance, but extent of absolute fall is smaller compared with Purulia.

REGRESSION 5
Relation between Distances from Factory and Fall in Livestock (Purulia)

$$Y = \beta + D_1 + D_2 + \varepsilon$$

Y= Fall in Livestock
D_1=1, Distance from factory (0<0.5)
=0, other wise
D_2=1, Distance from factory (0.5<1)
=0, otherwise
ε = Random disturbance term

Regression Statistics	
Multiple R	**0.08**
R Square	**0.006**
Adjusted R Square	**-0.014**
Standard Error	**45.58**
Observations	**142**

ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	**3**	**1892.54**	**630.84**	**0.45**	**0.71**
Residual	**139**	**288832.13**	**2077.92**		
Total	**142**	**290724.68**			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	**21.59**	**8.77**	**2.46**	**0.015**
Dummy(0<0.5)	**9.94**	**10.88**	**0.91**	**0.36**
Dummy (0.5<1)	**8.58**	**10.43**	**0.82**	**0.41**

As the regression results show the differences in percentage fall in production across different distance ranges are statistically significant indicating strong reason in favor of accepting the hypothesis that presence of the factories is crucial in causing the deterioration in agricultural production. The percentage fall in production for the households having their land in the distance of 2 Kms and above from the factory is 28.05%, which rises to 41% for the households having their land in the distance range 1-<2 Kms from the factory and to 64% for land in the distance range of 0.5-<1 Kms. For farmers having their land at a distance of less than 0.5 KMS there has been as high as 74% as the regression results show.

REGRESSION 6
Relation between Distances from Factory and Fall in Livestock (Purulia)

$$Y = \beta + D_1 + D_2 + \varepsilon$$

Y= Fall in Livestock
D_1=1, Distance from factory (0<0.5)
=0, otherwise
D_2=1, Distance from factory (0.5<1)
=0, otherwise
ε = Random disturbance term

Regression Statistics	
Multiple R	**0.08**
R Square	**0.006**
Adjusted R Square	**-0.014**
Standard Error	**45.58**
Observations	**142**

ANOVA	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	**3**	**1892.54**	**630.84**	**0.45**	**0.71**
Residual	**139**	**288832.13**	**2077.92**		
Total	**142**	**290724.68**			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	**21.59**	**8.77**	**2.46**	**0.015**
Dummy(0<0.5)	**9.94**	**10.88**	**0.91**	**0.36**
Dummy (0.5<1)	**8.58**	**10.43**	**0.82**	**0.41**

Regression with live stock shows the intercept is highly significant indicating that there has been significant fall in livestock population even in the distance range of 1-<2 kilometers However the coefficients of other distance dummies not being statistically significant, we may conclude that extent of fall in live stock population, though significant in absolute terms, does not vary according to distances within two kilometers distance from the factories: This may be due to the fact that within the range of two kilometers distance from the factories households may be using same grazing lands irrespective of the distance of their residences from the factories.

Section III

3.1. Regulations, Compliance and Governance

The Ministry of Environment and Forestry, Government of India has listed the Sponge Iron Industry under broad group of polluting industries. The firm units require environmental clearance from State Pollution Control Board before project initiation and expansion and have to abide by regulatory measures for control of pollution. The Environmental Impact Measurement Authority in its notification 2006 issued some guidelines for sitting of industries. First, in establishing an industry a distance of at least 25 kms from ecologically sensitive areas and from the projected growth boundary of major settlements (3,00,000 population) should be maintained. The areas that are included in "sensitive" areas though include tribal settlements, excludes non-tribal rural settlements with less than 3,00,000 population. Furthermore, sometimes economic criteria stand in conflict with environmental criteria. For instance, while proximity to sources of water, high way, major settlements, market for product and raw materials is desired for economy of production, they may come in conflict with environmental criteria, and economic criteria may receive priority in case of failure to strike a balance between the two sets of criteria. While there are provisions for preventing conversion of forest land and prime agricultural land, there is no explicit provision for protecting grazing land, water bodies and less productive agricultural land which some times are used as important sources of livelihood for large population dispersed in small and separated settlements. Purpose of Environmental Impact Assessment is to identify and evaluate the potential beneficial and adverse impact of development projects, after taking into consideration meteorology and air quality, hydrology and water quality, site and its surroundings, details of treatment and disposal of liquid, air, and solid effluents and the method of their alternative uses, occupational safety and health, transportation and raw material handling, impact on sensitive targets, control equipments necessary to install and pollution control measures to be adopted; however no assessment is made regarding probable adverse impact on agricultural production, livestock , fruits and vegetables and human health against probable benefits, affecting directly the lives of poor local inhabitants and extent of potential loss they are expected to suffer.

3.2. Environmental Degradation: The Role of Non–compliance:

In order to deal with the problem of pollution control the traditional method of command and control is followed with the use of technological instrument. Each unit is instructed to install electro static precipitator (ESP) for controlling emission of hazardous gas, induction furnaces are to be provided with implements for controlling emission of hazardous materials, and proper technological measures are to be taken to control fugitive emission. Proper storage system for materials and product with loading and unloading system is to be provided to prevent pollution through spread of hazardous particulate matters. Clean handling of solid wastes and recycling of gaseous and liquid effluents are strongly suggested. Each industrial unit is to maintain forty percent of its covered area under plantation. Each unit is to comply with all this norms and obtain certificate to this effect from the authority at the time of initiation and expansion of the project. Further they are to submit compliance report every six months. Local pollution control centers are to maintain strict vigilance and to suggest measures against any act of violation of standard. Such measures include system of Bank Guarantee, imposition of Pollution Cost and Closure Notification.

In order to examine the degree of non- compliance and its role in causing environmental degradation we carried out an investigation in one of our survey areas. People living in mouzas surrounding each of the seven factories are interviewed with the use of questionnaire on different aspects of violation of pollution control norms by the factories, which directly affect them. People reveal their observations regarding operation of the ESP machine by the factories as non-operation of the machine results in emission of the black smoke creating air pollution which makes it impossible for them to breath in fresh air. They also have observations on dumping of solid wastes in the open field creating enormous hazards to their lives; they record their observations regarding discharge of liquid effluents in open fields and ponds and indiscriminate use of ground water leading to fall in water table in the region which is already dry. When the machine remains non-operative throughout the night, people find it impossible to use pond water in the morning due to the thick black cover over the ponds adjacent to the factories. We also had informal discussion with some officials in charge of monitoring implementation of pollution control rules, on the current status of all these units regarding degree of compliance of rules. On the basis of these two sets of observations, we assign some values for each of the criteria to indicate the degree of attainment of the criteria by a particular factory. Each of the factories thus gets a particular value obtained by adding up all different values assigned to it on fulfillment of different criteria in different degrees. We have taken into account five criteria of compliance which are common to both in the report we obtain from our interview of the affected people and in the compliance report obtained by the officials from their routine inspection which we collect through informal discussion with the latter. We take into account such criteria as 1) level of gaseous emission which is recorded from public interview in terms of number of times the ESP machine become non operative so that black smoke is found to come out of the chimney, cross checked from official reports on emissions and black smokes as well as operation of the machines and different smaller devices of controlling emission. 2) method of handling solid wastes recorded and cross checked from the same sources the 3) recycling of the wastes recorded solely from official source 4)safety measures for the workers recorded from officials informally5)extraction of ground water, recorded from both the sources. We assign a value of 10 for hundred percent non-compliance with regard to a particular criterion. The value declines as the degree of compliance rises. Thus we get an aggregate value of compliance for each of the farms with total value of compliance being 50 in case of full noncompliance with regard to all the five criteria. In table 6 we have ranked the factories according to values obtained on the degree of compliance, with a lower value indicating a higher degree of compliance. We observe by and large a close inverse association between degree of compliance and percentage fall in productivity.

Table-5

Codification on the basis of degree of compliance	
A) Operation of the ESP machine	
Description	Code
Most the of time it is running	1
Opens in day but closes in night	2
Opens few times a day	3
Opens few times a month	4
Opens only at the time of checking	5
B) Source of water	
Description	Code
Damodar Valley Corporation	1
Open access water body	2
Shallow tube-well * Number of tube-well (x)	3x
Deep tube-well * Number of tube-well (y)	4y
C) Waste water disposal	
Description	Code
Inside the factory	1
In the open land outside the factory * Area damaged (z)	2z
In the pond	10
D) Waste dust disposal	
Description	Code
Carried away	0
In the open land owned by the factory	1
Open land outside factory area * Distance (d)	2d
In the open space very close to residential area	5
Open space at a distance d from residential area	5-d

This method of codification is used to find individual status of the factories with regard to compliance. In the table below we present the compliance status of all the ten factories along with the total value of percentage fall in output in surrounding areas of each factory. The SL NO 1 to 7 are factories of Purulia district and the last three factories belong to Bankura district. It can be seen that there is inverse relationship between degree of compliance and fall in productivity. While we could not collect data separately on each surrounding areas of each factory in Bankura, as the table-3 shows in Bankura the average production fall has been lower than that of Purulia, though in the table below we see Bankura shows greater degree of non-compliance. This raises question about official report. In fact we gather the impression that there is actually no hard and fast system of frequent visit of the factories. It is reported that officials visit the factories only when 'need arises'. Neither the factory owners compulsorily submit any six monthly report.

Table-6

Current Status with regard to Compliance

Factories Sl No	Gaseous Emission	Solid Waste Disposal	Source of Water	Recycling of wastes	Workers' Safety	Detection of Violation of norms	TotalCode	%ge fall in production
1	5	0	5	0	5	In 2003 - 2004	15	39.14
2	0	8	6	5	0		19	17.5
3	5	10	7	5	0	In 2007	27	33.44
4	7	10	10	10	0	In Jan 2008	37	39.35
5	10	8	8	10	5	In Aug 2008	41	23.25
6	10	10	8	10	5	In Jan 2008	43	36.2
7	10	10	4	10	10	In 2007	44	48.58
8	10	10	10	10	5	In 2008	45	-----
9	10	10	10	10	5	In 2008	45	-----
10	10	5	5	10	5	In 2008	35	-----

3.3. The Role of Governance and Technological Factors:

The entire task of maintaining environmental standard actually falls on the regional and sub regional offices under the state pollution control board. The Purulia district falls under the jurisdiction of Asansol sub-regional office, where as Bankura district falls under the Durgapur regional office. Environmental regulations follow the traditional method of command and control: First, it is mandatory to install pollution control machine (electro static precipitator) along with mechanical devices to control gaseous and fugitive emissions, at the time of installation and expansion of the factory. Continuous and uninterrupted operation of the machine and all the pollution control devices, their proper maintenance and faultless operation are also mandatory for the factories. Further, factories are required to maintain proper arrangement for disposal of particulate wastes and handling of raw materials and the products, covered shades with loading and unloading system have to be erected to minimize flying of dusts and installation of dry fog system for the purpose is considered as essential. The monitoring of the running of the pollution control system thus appears to be of utmost importance for preventing pollution. It is the quality of governance, which appears to be the most important factor in the process. The method that is followed consists of a) physical inspection of the factory, b) issuing notice with warning, c) imposing 'Bank Guarantee', d) awarding Fine known as pollution cost and e) finally issuing Closure Notice, in case of violation of rules.

Table-7
System of Regulations

	Type of Punishment				
	Closure Order	Fine	Year	Reason	Present Condition
1	Y	----	2003 – 2004	For no ESP	----
2	Y	5 lacs	2007	Gaseous Emission	Installing recycling System
3	N	5 lacs	2005	Dumping of Solid waste	Installing recycling System
4	N	2 lacs	2007	Dumping of Solid waste in the Field	Trying for Drying machine
5	Y	----	2008	Problem of ESP	----
6	N	5 lacs + 2 lacs	2007	Emission & open Disposal of waste	----
7	Y	5 lacs	2008	No safety measure & Emission	----
8	Y	5 lacs & 10 lacs BG	2008	Emission & all points of violation	----
9	N	5 lacs	2008	Open disposal of waste	----
10	Show Cause	BG 2 lacs	2008	Emission & All Reasons & all points of violation	----

As becomes evident from informal discussion with officials, there is no hard and fast rule regarding number of visits to be made by the officials for inspection of the factories. Only requirement is that ambient air quality are to be checked twice in a year. Factories are to maintain record of emissions. However factory owners get punishment only in cases where violation of norms becomes visible to the inspecting officials, which depends on frequency of visits. The amount of cash punishment appear to vary from Rs200000 to Rs1000000 depending upon the nature and intensity of the fault committed which appear to be too small compared to daily turnover. However imposition of closure is a stronger punishment judged by the amount of loss involved in a day's closure. But the time gap between imposing closure and its suspension which varies from few days to few months seems to depend on various factors other than estimation of loss due to pollution. Further, there is no system of regular checking of quality of coal and iron ore which is very important for maintaining the rate of generation of pollution at low level. While these characteristics of governance do not indicate the existence of a strong and rigorous system of implementation of pollution control regulations, the pollution control technology used in most of the cases involves huge recurring cost because of the huge amount of water that is required for its operation. It is this characteristics of the technology used which makes it very costly, particularly in dry areas where scarcity of water poses enormous problem. Even if we ignore the social cost of declining under ground water table through excessive extraction of water due to operation of the machine, the enormously high private cost of operating the machine makes it highly gainful for the factory owners to keep the machine non operative for few hours a day. In the absence of continuous monitoring it becomes obvious, under the present system of governance based on command and control, with physical inspection and imposing Fine being the only instrument of control, that rules would be normally violated and halting the process of generation of pollution would be almost an impossible task, given the existing technology as it is. The motive of violating rules for one firm, when other firms may or may not violate, may be explained by relative gain from violation against the probable cost a firm would have to bear under the alternative situations arising out of other person's behaviour regarding compliance or violation of rules. Since one firms' non compliance may lead to general deterioration of environment it would harm the interest of other firms in the area by inviting stricter vigilance and by compelling them to bear a greater burden of tax and abiding by some new norms which may be costlier. Since firms have their own association it seems easier for them to come under some agreement or at least some implicit understanding among themselves regarding complying with pollution control norms. But in practice we do not find any such effects. We face a situation of absence of unanimity among the polluters to comply with pollution control norms, even though they are organized under some form of association and even though non compliance invites hazards and increases financial burden to all firms. This can be demonstrated following a simple game theoretic framework:

Let the gain from one hour's non-operation of the machine be g and the loss inflicted on the society for such action for a year be c. If there are two firms A and B and both firms violate the norms, individual gain of each firm would be g and total loss to the society would be 2c. Now we suppose that the Government adopt a fiscal measure to control pollution. First damage cost to the society for one hour's non-operation of the machine per day for the whole year, by both firms, is estimated. A pollution tax is imposed every year to cover the damage cost so that total volume of tax T=2c, the total damage cost; each of the firm is to bear a tax burden=T/2=2c/2=c when both firms violate the rules.

If only one firm violates the rule, while the other complies, the total damage cost would be c. volume of tax would be T=c and tax burden of individual firm would be T/2=c/2. If on the other hand, both of them decide to abide by the rules they would arrive at a 'no loss no gain' situation:

The Pay off matrix is as follows:

	Player A	
	C	D
C	0, 0	-c/2, g-c/2
Player B		
D	g-c/2, -c/2	g-c, g-c

Violation is the dominant strategy under all the alternative situations g >c, c/2<g<c and g=c. If each of the firm while violating the rule attaches a probability of .5 that other person is also violating the rule and .5 to the other person complying with the rule, then his expected pay off would be 0.5x(g-c/2)+0.5x(g-c)= g – 3c/4. Violation of rules gives positive expected gain unless

and until g is not less than 3c/4. The cost of one hour's operation of the machine being very high, g is fairly large so that g-3c/4>0. Violating the rules appear to be gainful to the firms as long as g>c. In fact the tax imposed by the government may not be so high as to cover the entire damage cost. This is because in imposing the tax the government has to take into consideration the question of viability of the firms after imposition of the tax. It depends on the scale of operation of the firms whether they would be able to bear the heavy burden of tax. To examine a case of tax greater than gain, we assume, the damage cost of pollution generated by non compliance by one firm when other firm is complying, is c = g + e (e>o, g>e) and when both violate, the total cost 2c = 2 (g + e): let tax T = c = g +e (e>0), when one person violates and other complies, and T = 2g + 2e when both violate. We would have the following outcome.

	Player A	
	C	D
C	0, 0	-(g+e)/2, (g-e)/2
Player B		
D	(g – e)/2, - (g + e)/2	-∈, -∈

Still the tendency to violate the rule cannot be stopped since expected gain from violation of rule for each firm would continue to be positive if probability of other firms' violating the rule is 0.5 under a technological condition such that private gain from non operation of the machine for some time period is less than damage cost generated, by a very small amount. Under the situation the firms would mutually agree to follow the combination of compliance non – compliance strategy by turn.

However number of polluters is an important variable in explaining behaviour of individual polluter, since total volume of accumulated pollution which depends on total no of polluting firms concentrating in the area, is important in determining the amount of cash penalty. In fact the amount of damage caused by pollution is an increasing function of number of polluters concentrating in the area so that average cost per polluter rises with the number of polluters rising beyond a certain critical point. In order to deal with such a situation, we assume there are N number of polluting firms concentrating in an area. The damage cost caused by pollution rises proportionately with number of polluters up to the point where number of polluters is N*, beyond which it rises increasingly with further rise in the number of polluters such that average cost per polluter rises, instead of remaining constant. Under this condition the cost per polluter will be as follows:

C(n)/n=c(constant) up to the point where n=N*, c(n)/n=c(n+1)/n+1=c(n+2)/n+2 =........c(N*)/N*=c. But c(N)/N> c(N-1)/N-1> c(N-2)/N-2..........>c(N*+1)/N*+1>c(N*)/N*. The situation can be demonstrated as follows:

Under the assumption that damage cost generated is distributed equally among all the polluters as penalty; the pay off to player i if number of other players polluting is:

	N-1	N-2...............	N*	0
player i violates	g-c(N)/N	g-c(N-1)/N-1	.....g-c(N*+1)/N*+1...	g-c
player i complies	0	.........0.....................	0...........................	0

If number of polluting firms rises to N* player i's pay off would be g-c(N*+1)/N*+1 which is lower than g-c(N*)/N* i.e. his pay off would start falling at an increasing rate. Thus even if initially g remains greater than c allowing a positive net gain from joining with polluters, after the number of polluting industries rises to the critical figure of N*, joining with polluters would soon become unprofitable to any individual firm, since cost to individual firm rises to surpass g. We assume this stage to arrive at n = N-x, such that g<[{c(N-x)/N-x}-{c(N-x-1)/N-x-1}], i.e., increase in cost due to one person's inclusion as polluter is greater than his gain. If initially it is gainful to join with the polluters, it will remain gainful up to certain point. When the number of polluters is sufficiently large deciding not to join with the polluters will be the best strategy for player i. This points to the fact that while certain level of pollution appears to be unavoidable, even if the whole damage cost is transferred to the polluters, under the given technology, high rate of generation of pollution and damage would automatically create its own control mechanism with the system of full transfer of damage cost to the polluters in the form of taxes.

An alternative to pollution tax, a fine in cash combined with a system of granting cash awards to all the producing units of the area as an incentive in case of successful attainment of environmental standard, may be used to control pollution. Let a fine F be imposed in case a violation is detected, the amount of fine is determined on the basis of estimated damage cost of pollution. Let F= λ x c, λ >o, amount of damage cost = c when one person violates while the other complies, in a two person system and F = λ x 2c when amount of damage cost is 2c when both persons violate norms. Let the probability that a person violating the rule is detected, is p. Let the amount of cash award be W. The outcome under such situation would be as follows:

	Player-1		
		C	D
Player -2	C	W, W	0, {g – (p x λ x c)}
	D	{g – (p x λ x c)}, 0	{g – (p x λ x 2c)}, {g – (p x λ x 2c)}

This means there is always a positive gain to a firm from violation of rules irrespective of whether the other firm violates or complies as long as {g – (p x λ x c)} > 0. Whether compliance would generate positive gain to an individual firm would depend on whether the other person complies or not. If one firm thinks that other firm will always comply he will decide to comply only if W> {g – (p x λ x c)}. This means generation of pollution can be halted by setting particular value for λ and p such that (p x λ x c) > (g-W), i.e., λ x c > (g-W)/p given g and c as technological parameters and W a parameter set from out side, a lower p means λ has to be set at a high level such that the minimum threshold value of λ is equal to (g-W)/(p x c). Under this situation, the value of p, that is, the probability of detecting violation and identifying the violator, becomes a crucial factor in controlling violation. With the value of p=1, λ=(g-W)/c i.e. the ratio between the market value of water and electricity saved net of cash award, and the damage cost, which is nothing but the ratio between gain to the polluter for polluting, net of gain from total compliance, and the damage cost. If the technological condition makes g-W>c, this means λ>1 i.e., F>c .In any case lower the probability that violation is detected and the violator is identified, the greater should be the money value of the fine. Under an alternative technological condition, if (g-W)<c, for each value of p the required value of λ for halting generation of pollution would be lower, that is the required money value of fine would be lower compared to what it would be when (g-W)>c. However a lower value of p in either case would mean a higher required value of the fine.

The analysis thus suggests a package of regulatory measures consisting of (1) a set of new technological devices with sufficiently low operating cost compared to the benefit it generates, by preventing pollution (g sufficiently small compared to c), (2) Providing for cash award in case of maintaining high environmental standard and, (3) raising the probability of detecting the violation and identifying the violator (p) i.e. improving the level of monitoring.

As we can see from table 8, while Bankura shows evidence of monitoring in recent past Purulia appears to receive less attention. Distance from the regional and sub regional offices appear to play a negative role in the matter of monitoring pollution control activities. It can be seen from table 3 that fall in production in Purulia has been greater than that in Bankura in all the distance ranges.

Table 9, combined with data on negative effects of environmental degradation further indicate that the occurrence of violation of environmental rules is repeated again and again and even imposition of fine and closure order cannot stop it for ever; it goes on as a regular and irresistible phenomenon with its obvious negative impact on the economy, ecology and people's life. In fact, while the cost of compliance appears to be very high, the expected cost to the firms in case of non-compliance and detection by the authority, is too low to prevent its re-occurrence. It appears, existing system of governance which is based on traditional command and control measures of regulation, miserably fail to achieve its objective. The need for new instrument of governance becomes obvious.

3.4. An Alternative System of Governance

We have seen that the limitations of the traditional command and control measures of regulation have given rise to emergence of some new instrument of governance: Voluntary Agreement has been one such instrument, under which the Government comes under voluntary agreement with all the stake holders including the polluting firms. There can be an alternative to both the traditional instrument and the new instrument of Voluntary Agreement, which is a combination of traditional and a new instrument. Instead of the government appearing as an agent, collective participation of the heterogeneous stakeholders is supposed to provide an improved system of governance. It is easy to see that such collective action on the part of the stake holders is not only possible but also can act as a more effective instrument of control: We consider certain characteristics of the rural society which is affected by industrial pollution and is deprived of a very valuable public good that is pollution free environment. People in this society are mainly cultivators having land in different sizes. Animal husbandry also forms an important source of their livelihood. Land productivity is very low because of soil quality and lack of irrigation facilities. Because of lack of adequate infrastructure, industry is almost absent except for the highly polluting sponge iron industrial units concentrating in one area covering parts of two administrative blocks. The situation is almost equal in the two survey areas. The sponge iron industries provide supplementary source of livelihood to a small percentage of people. Most people are extremely poor and both our survey areas are marked as backward areas. These factors, apart from the importance of sponge iron as an industrial input play positive role in favor of sponge iron units getting quick approval of the authority. However because of extremely harmful impact they generate on environment people are extremely averse to such units and express their opinion in favor of closing down of the units in spite of the meager positive effects on employment. All these make people highly motivated in favor of protecting the area from industrial pollution to save their lives and for the small farmers it becomes a question of their existence since the drastic fall in agricultural productivity and livestock threaten their life support system. They raise protest against the units' extremely harmful behavior, to the local Gram Panchyat, but without any results in their favor. Informal discussion with authorities, namely, Pradhan of the Gram Panchyat, and local level officials of pollution control centers strongly indicate that close association of influential and powerful persons with the owners of the units protect the latter from any hard measure being taken against them.

It is against this background that the potential of collective action by the heterogeneous stake holders can be explored, as a supplementary to the existing system of regulation based on command and control: The stake holders can come forward to form a group with the objective to protect environment from the reckless behavior of the industrial units. The method would be to form collective organization based on voluntary agreements among all the stake holders including the representatives of the polluting industrial bodies, local leaders of the political parties, local bodies of social organizations, NGOs and members of the pollution control authorities, apart from the directly affected rural people. In so far as maintaining environmental standard would result in direct benefit to local residents, they will have to bear the cost involved in such negotiating activities through their contributions, though there can also be some voluntary contributors. On the other hand, the aim of the negotiation is to obtain full agreement on the point that the environment has to be kept completely free from pollution, which involves cost to the polluters. In order to make the agreement fully effective the collective body may propose to share a part of the cost out of their own contribution, in the form of a reward, in case of full achievement of the objective.

Let the benefit accrued to each contributor in case of full achievement of the goal be b(M), and total number of firms is M and total cost of such activity be C which includes, apart from other expenses, aggregate value of a reward W. If full agreement is honored by all the firms the pay off to the firms is W and pay off to each of the contributors is [b(M) - C/N] when total number of contributors is N. If full agreement is not achieved due to defection of m number of polluters when total number of units is M, the pay off to the complying firms is 0 and pay off to the contributors is [{b(M-m)} - {(C-W)/N}]. Each of the non complying firms would be awarded a penalty of p so that total penalty value=p.m will be distributed among the contributors increasing the pay off of each of the contributors to [b(M-m)+p.m/N]-[(C-W)/N] . The affected residents will have enough incentive to continue with their efforts. The advantages of such a heterogeneous body would be: (1) probability of detecting and identifying the defectors would be 1. (2) It is now possible to estimate the individual gain from non-compliance of rules and to determine the exact amount of fine so as to completely out weigh the gain from defection. If gain from defection can thus be effectively out weighed through correct detection of defection, correct estimation of such gain and the social power of the collective organization of the stakeholders to impose fine because of violation of agreement, there will be no incentive for the polluters to pollute.

While there is strong reason to believe that forming such Voluntary Association of stakeholders would help enormously in halting environmental degradation the question that still remains is who will take leadership in forming such Voluntary Association. It seems reasonable to accept that the small farmers are the greatest sufferers of environmental degradation in this particular area. Our survey results support this. While relatively better off families can lessen the impact of environmental degradation by their greater economic power, for the economically less powerful, maintaining environmental quality is the question of survival. It is this group of stake holders who can take the initiative and join with more powerful persons playing crucial roles in the society in different capacities and intellectually and morally sympathetic to the cause. How the coordination of interest of different groups would result in a desirable outcome can be depicted as follows:

		Poor	
		Takes initiative	Does not take initiative
Rich	Takes initiative	$P.X - c/2$, $P.x - c/2$	$p.X - c$, $p.x$
	Does not take initiative	$p.X$, $p.x - c$	0, $-\propto$

If the environmental quality is maintained by joint endeavor of both the poor and the rich the probability that both will be able to obtain the highest benefit, is P and their pay offs are $P.X-c/2$ and $P.x-c/2$ (with $X>x$) for the rich and the poor respectively. When the rich takes initiative but poor does not, the pay off of the rich falls since probability that environmental quality will be maintained under the situation is now p ($P>p$) and pay off of the poor is $p.x$. When poor takes initiative but rich does not, his pay off is $p.X$, and pay off of the poor is $p.x-c$. When both neglects the pay off of the rich is 0 and that of the poor is infinitely negative ($-\propto$). It is seen if the poor does not take initiative his expected benefit will be infinitely negative whatever may be the probability that the rich will take initiative under the situation. The only exceptional situation will arise when the poor is hundred percent sure that the rich will take initiative under any circumstances, he will take decision to cooperate only if $P.x-c/2>p.x$ that is $x>[c/2(P-p)]$. Higher the probability that joint initiative of both will result in full protection of environment and lower the probability that any one's initiative will produce same result, lower is the required value of the benefit from environmental protection, for the poor. If the poor is not so sure about the rich's good intention then for not taking initiative will be disastrous for him, So the poor will take initiative is the only realistic assumption under the circumstances. If the poor takes initiative the rich will also take initiative only if $[P.X-c/2]>p.X$ that is $X>[c/2(P-p)]$. And the poor will get larger benefit from cooperation than from not taking initiative if $x>[c/2(P-p)]$. Thus if we assume that poor's net benefit is larger from cooperation than from non cooperation, when rich cooperates, then the rich will surely cooperate, since $X>x$.

If we accept that the poor will always cooperate since his expected income from non cooperation is $[n.p.x+(1-n)(-\propto)] = -\propto$ when n is the probability of rich taking initiative and $1-n$ is the probability of the rich not taking any initiative, when the poor does not take initiative. If N is the probability of the rich taking initiative and $1-N$ is the probability of the rich not taking initiative when the poor takes initiative then the expected income of the poor will be $[N(P.x-c/2)+(1-N)(p.x-c)]$. For this to be positive the required condition is $x>[\{c(I+N/2)\}/\{NP+(1-N)p\}]$. A large N and a large P will mean that even a smaller benefit from environmental protection will be enough for the poor to ensure positive net benefit from cooperation. This condition will automatically ensure positive expected benefit for the rich from cooperation, since $X>x$ and since the rich attaches very high probability to the poor taking initiative for protection of environment, when the rich cooperates.

What comes out of the analysis is that since poor can not afford to neglect environment they will take initiative for protection of environment and once the poor takes initiative rich find it beneficial to take initiative to protect environment. Every thing however, depends on to what extent such joint endeavour will be enough powerful to put pressure on the polluters to comply with the rules. This depends on participation of the powerful agents of the society in the course of voluntary agreement, who may not be affected by the degradation but are sympathetic to the cause.

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