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THE ECONOMICS OF INDUSTRIAL POLLUTION ABATEMENT

A. H. Ekpo

Department of Economics

*University of Uyo, Uyo, Akwa Ibom State
and*

O. J. Umoh

Department of Economics

University of Uyo, Uyo, Akwa Ibom State

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Abstract

Industrialisation has assumed the central position in the growth and development of less developed as well as developing nations. However the process of industrial development presents some externalities on the immediate environment. Various industrial plants are known to release waste products, (hazardous gases, effluents, dusts, waste-waters and solid wastes which degrade the natural environment and thereby render the natural ecosystem unstable and less viable. This paper maintains that it is possible to minimize the cost to the environment of industrial activities. From an economic point of view, the cost-benefit analysis of an industrial project is capable of helping in the choice of industrial projects with high benefit-cost ratio. In which case the lower the cost of an industrial project to the society in terms of the hazards of pollution, the more desirable would be such an industrial project. To achieve this, the externalities of industrial projects must be internalized as much as possible through the enforcement of environmental regulations.

1. Introduction

The aim of development is to minimize and possibly eradicate poverty. However the importance of environmental factors in the development process of any nation prior to recent times, was never seriously considered. Now, scholars, policy makers and executives have come to realize that sustainable economic development may be difficult to achieve if environmental issues are not adequately addressed. Since it is a legacy that future generations continue to enjoy and benefit from the fruits of environmentally sensitive and induced development, this paper examines those vital environmental issues which relate to the externalities of industrial pollution and their abatement in the interest of the society.

Industrial pollution is an integral aspect of environmental pollution. Environmental pollution is a phenomenon which is inextricably interwoven with the process of development. It is generally the result of human and economic activities. Industrial pollution specifically involves the degradation of the environment a result of the externalities of industrial activities. As an economy grows, the industrial sector assumes a leading position and may become susceptible to the possibilities of innovation as new resources are exploited and/or explored. Such process of industrial development necessitates externalities some of which do constitute hazards on human health, ecology and biodiversity, with negative cost implications.

The environmental impact of industrial pollution more or less leads to conflict of interest between the polluters who pursue their economic objectives of output, profit and cost optimization and the victims of pollution who are entitled to hazard-free environment for healthy living. The need to reduce such conflict as much as possible forms the basis for pollution abatement efforts. Industrial pollution abatement pertains to the control of industrial activities which release harmful pollutants into the environment. An industrial abatement programme would be beneficial if it renders the benefits of such an industrial activities higher than the environmental cost to the society of whatever unavoidable externalities it generates.

2. The Environment and the Macroeconomy

It is observed that most texts in economic development and planning pay relatively less attention to environment. Environmental analyses in the economic context have been limited to specialized texts on environmental and resource economics. Yet, the inability to consider environmental issues can bias any economic analysis relating to development. In other words, the absence of an environmental cost results in less optimum situations. The apparent neglect of the environment in developmental economics has a human cost. This cost shows up as the deterioration of human capital via ill health and premature mortality resulting from environmental risks, as forgone GNP because of the failure to recognize the high economic rate of return to many environmental investments, and as the erosion of the natural capital base on which the development of many countries depend.

Environmental assets and natural capital plays a role in development analysis. Given the importance of savings and investment in economic theory, it is perhaps surprising that the effects of depleting natural resources and degrading the environment has not, until in recent times, been considered in the measurement of national savings. This omission may be explained both by the models economists use and the fact that the UN system of National Accounts (SNA) ignores depletion and degradation of the natural environment (Hamilton, 1994).

The methods of valuing the depletion, discovery and growth of commercial natural resources in the context of the System of National Accounts (SNA) remain problematic. Likewise the valuation of environmental degradation. The UN guidelines for environmental accounting favour valuing degradation in terms of maintenance cost, that is, the cost of restoring the environment to its state at the beginning of the accounting period. The most recent approaches (Gandhi, 1995) suggest that the marginal social costs of pollution are the correct basis for valuing waste emissions to the environment.

The above issues can be formalized thus:

$$MEW = C + I - n(R - g) - \sigma(e - d) + PB \quad (I)$$

Where:

- MEW = economic welfare;
 C = consumption;
 I = investment;
 n = the unit resource rental rate net of emission taxes on production;
 R = resource extraction;
 g = resource growth;
 σ = Marginal social costs of pollution;
 e = pollution emissions;
 d = natural dissipation of pollution; and
 PB = the willingness of consumers to pay for environmental services B.

For non living natural resources the term in g is zero while d is zero for pollutants with cumulative effects. The measure of sustainable national income simply drops the last welfare term from equation (1). The intuition is that $I - n(R - g) - \sigma(e - d)$ is the value of net investment when changes in natural resource stocks and stocks of pollutants, appropriately shadow priced, are included in addition to increments to the stock of produced assets. From equation (1), it is clear that environmental issues must be addressed if an economy is to maintain a sustainable level of national income. It is also possible to derive genuine national savings from the above expression. (Gandhi, 1995, pp. 85-88).

The basic conclusion is that environmental degradation gives rise to major economic costs in developing countries like Nigeria in terms of:

- (i) impairment of the human capital stock through premature mortality and morbidity.
- (ii) loss of marketed GNP through health affect and degradation of assets such as soil and forests,
- (iii) loss of non-marketed GNP that could be subject of capture through appropriately designed policies, domestic and international; and

(iv) reductions in genuine savings, which amount to the mining of the capital base on which many developing countries depend.

In assessing or determining an environmental project in a society, the cost-benefit methodology is recommended.

3.1 The Environment and Related Problems

Ecosystems in their natural forms are viable because they are balanced and stable and thus able to withstand shocks arising from natural and human actions. At the very initial stage of universal history, man himself was part of the said viability. Then, man's habitat demands were in a stable balance with the ecosystems of which he was apart. Presently, there does not seem to exist natural ecosystems due to the influence of man's technological known-how and other innovations which are used to facilitate the process of development (Umoh, 1998).

The environment consists of land, water and air in which we operate and from which we tap the resources we need. And there exists a dialectical relationship between human beings, other living organisms and the environment in which they live. We influence the environment and it influences us in turn. Such influences may be benefits or costs. It is therefore important to pay attention to the environmental resource-base. Environmental matters must be given its proper place in development economics as well as development planning. (Dasgupta and Maler, 1995). The developing as well as less developed countries depend heavily on natural resources such as the soil, water, forests and forest products, animals and fisheries. If these environmental resource-base are mismanaged and allowed to continually deteriorate unabated, the poor economies deteriorate the more. The very fact that the rural sectors of these developing economies are biomass-based calls for care in the exploitation of natural resources.

On the other hand, the industrial sector is mostly dominated by manufacturing activities. Jaffee et al (1975) distinguishes three categories of industrial pollution in terms of pollution abatement costs (Table 1).

Table 1: Categories of industrial pollution in terms of pollution abatement costs

CATEGORY	INDUSTRIES
A High Pollution Industries	(i) Paper and allied products (ii) Chemical and allied products (iii) Petroleum and coal products (iv) Primary metal industries
B. Moderate Pollution Industries	(i) Furniture and fixtures (ii) Fabricated metal products (iii) Electric and electrical equipment
C. Low Pollution Industries	(i) Printing and publishing (ii) Rubber and plastic products (iii) Machinery except electrical

Compiled by author from Jaffee, A. B. et al (1995). "Environmental Regulation and Competitiveness of U.S. Manufacturing" *Economic Literature*, Vol. XXXIII, No. 1 March.

The high pollution industrial include: (i) Paper and allied products; (ii) chemical and allied products; (iii) Petroleum and coal product; and (iv) Primary metal industries.

The moderate pollution industries include: (i) Furniture and fixtures; (ii) Fabricated metal products; and (iii) Electric and electrical equipment

The low pollution industries are made up of the following: (i) Printing and Publishing; (ii) Rubber and Plastic products; and (iii) machinery except electrical.

The problems relating to environmental abuse are many; some are direct while others are indirect. The World Bank (1992) identifies three main damaging effects of environmental degradation. These are harmful effects on human health, negative impact on economic productivity, and loss of various benefits enjoyed by people from the existence of an undamaged environment. Examples of environmental degradation that harms human health include contaminated and unsafe water, air pollution and poor sanitation. Environmental damages that result in loss of economic productivity include overuse and/or pollution of renewable resources such as soils, forests and water, etc. Table 2 shows the details of specific impacts of some industrial activities in Nigeria.

Table 2: Environmental Impact of Fossil Energy Resources in Nigeria

Mining	General Effect	Specific Impacts
Exploration	Landscape disturbance	Aesthetic deterioration of the Landscape
Mineral Extraction	Land degradation and ecosystem destabilization	Land surface devastation, land subsistence, disruption of drainage systems, deforestation, excessive water draw down, lowering and contamination of water table.
Processing, Transportation, Storage and consumption	Gas leaks, Oil spills, Noise and Pollution of the air, soil and water.	Thermal loading of water ways, increase in Co ₂ and Co, Ozone layer depletion, acidification of air, soil and water, weather modification, toxicity hazard to plants and animals, death of terrestrial and marine life, loss of crops and livestock, impairment of atmospheric visibility, damage to buildings and machinery, nervous disorders, cardiovascular illness, cancers and food poisoning.

Sources: U. M. Igbozurike, "Energy Development and Energy Crises with special reference to Nigeria", Department of Geography, University of Nigeria, Nsukka, 1983, p. 13.

It is also possible to broadly classify environmental degradation into domestic and global variants. The global type affect the "global commons", mainly the upper atmosphere change (greenhouse or global warming and ozon depletion). The domestic brand includes water contamination, air pollution, unsafe disposal of solid and hazardous wastes, soil degradation (erosion, loss of fertility, desertification, Salinisation, flooding, etc) deforestation and biological diversity. In addition, there is acid rain and the dumping of toxic waste - these could have spill-over effects on neighbouring countries.

The impact of environmental problems on the economy is presented in Table 3. It is clear that failure to address environmental issues in Nigeria will adversely affect economic growth and invariably poverty will accelerate. In Nigeria, the domestic varieties of environment damage constitute enormous problems. Table 4 indicates that less than 50% of the Nigerian population has access to health services, safe drinking water and good quality sanitation. Perhaps, the enormous environmental problems account for the worsening social

Table 3: Impact and Cost of Unsustainable Development in Nigeria

Priority Environmental Problems	Economic Growth Impact	Distributional Equity Impact	Resource Integrity Impact	US Million Per Year
Soil degradation	High	High	High	3,000
Water contamination	High	High	High	1,000
Deforestation	High	High	High	750
Coastal erosion	Moderate	Moderate	Moderate	150
Gully Erosion	Moderate	Moderate	High	100
Fishery Losses	Moderate	Moderate	High	100
Water Hyacinth	Moderate	Low	Low	50
Wildlife losses	Low	Low	High	10
TOTAL				5,110

Source: World Bank (1990), *Towards the Development of an Environmental Action Plan for Nigeria*.

Table 4: Social Indicators of Well Being

Country	Life Expectancy at birth (Yrs)		Under-five mortality rate		Daily calorie supply as %		Adult literacy		Population with access to health sources (%)	Safe water
	1960	1990	1960	1990	1965	1988	1970	1990	1987-89	1988-1990
Nigeria	39.5	51.5	316	167	95	85	25	51	46	48
Indonesia	41.2	61.5	225	97	81	120	54	77	80	28
All Developing Countries	46.2	62.8	223	112	90	109	46	64	64	68
Sub-Saharan Africa	40.0	51.8	284	175	92	89	27	51	48	40

Source: UNDP, *Human Development Report*, 1992, pp. 131, 135

Table 5: Some Environmental Indicators of Forest Depletion

Country	Forest area as % of total land area	Annual rate of deforestation (%)	Annual % change in fuel wood production	Annual rate of change in energy consumption	Urban population annual growth rate (%)
	1990	1980-90	1972-82	1980-89	1960-90
Nigeria	17	2.7	4.1	5.5	6.3
Indonesia	65	0.8	2.2	3.9	4.7
All Developing Countries	28	1.1	2.3	4.9	4.0
Sub-Saharan Africa	33	0.5	3.3	2.8	5.2

Source: UNDP, *Human Development Report*, 1992, pp. 169, 173

conditions in Nigeria. High under-five mortality and low life-expectancy rates in Nigeria may be due to air pollution and water contamination.

The impact of environmental problems on the economy is presented on Table 3. The environmental problems like soil degradation, water contamination and deforestation presents high economic growth impact for Nigeria. They also present high distributional and resource integrity impact. According to World Bank (1990), soil degradation costs Nigeria US \$3000m per year. Water contamination and deforestation costs the nation US \$1000m and US \$750 million per year respectively. The moderate impact environmental problems include coastal erosion, Gully erosion, fishery losses and water Hyacinth. Gully erosion presents moderate economic growth impact, moderate distributional equity impact and moderate resource integrity impact. The Nigerian economy loses US \$150m per year due to this problem. Wildlife losses present low economic growth impact, low distributional equity impact and high resource integrity impact and the economy loses US \$10 million per year due to this problem.

Indonesia which was at the level of development like Nigeria can boast of higher standard of living probably due to reduction in environmental problems relative to Nigeria (UNDP 1992).

Because of the problems of environmental activities on the economy, it is crucial that projects bordering on the environment be properly managed. This is important so that society can maximize its benefits from any environmental projects.

4. Industrial Pollution Abatement: Assessing Optimal Investment Requirement

The day-to-day operational decisions regarding the allocation of limited public investment funds on environmental relevant industrial projects are based on microeconomic technique of analysis known as "project appraisal". The methodology of project appraisal rests on the theory and practice of "social" cost-benefit analysis. The basic idea of cost benefit analysis is straight forward. In order to decided on the worth of projects involving public expenditure, it is required to weight up the advantages (benefits) and the disadvantages (costs) to

the society as a whole. The need for social cost-benefit analysis arises because the normal yardstick of "commercial profitability" that guides the investment decisions of private investors may not be an appropriate guide for public investment decisions.

Private investors are interested in maximizing private profits and thus normally take into account only those variables that affect net profit: receipts and expenditures. Both receipts and expenditures are valued at prevailing market prices for inputs and outputs.

The take-off point for social Cost-Benefit analysis is that it does not accept that actual receipts are a true measure of social benefits nor actual expenditures a true measure of social costs. That is, where social costs and benefits diverge from private costs and benefits, investment decisions based entirely on the criterion of commercial profitability may lead to a set of "wrong" decisions from the point of view of social welfare, which should be the government's major concern. Though social valuations may differ significantly from private valuations, the practice of cost-benefit analysis is based on the assumption that these divergence can be adjusted for by public policy so that the difference between social benefit and cost will properly reflect "social profitability" just as the difference between actual receipts and expenditures measures the private profitability of an industrial investment.

Invariably, social profit in any period can be defined as the difference between social benefits and social costs where these are measured both directly (the real costs of inputs and the real values of outputs) and indirectly (e.g employment effects, distribution effects etc.) The calculation of the social profitability of an investment involves a three-step process:

- (i) We must first specify the objective function to be maximized, normally "net" social benefit-with some measure of how different benefits (e.g per capita consumption, income distribution) are to be calculated and what the trade off between them might be.
- (ii) In order to arrive at calculations of net social benefit, we need some social measure of the unit values of all project inputs and

outputs. Such social measures are called "accounting" or "shadow" prices of inputs and outputs to distinguish them from actual market prices. That is, a shadow price reflects the true opportunity cost of a resource. In the techniques of linear programming, shadow prices are merely the solution values of the "dual to a liner-programming output or profit - maximization problem." In general, the greater the divergence between shadow and market prices, the greater the need for social Cost-Benefit analysis in arriving at public investment decision rules. The bedrock of social cost-benefit analysis is the calculation and/or estimation of the prices to be used to determine the true value of benefits and the real magnitude of costs. The reasons why in less developed countries, market prices of outputs and inputs do not give a true reflection of social benefits and costs include: (a) inflation and currency overvaluation, (b) wage rates, capital costs and unemployment, (c) tariff, quotas and import substitution, (d) savings deficiency and (e) social rate of discount.

- (iii) We need some decision criterion to reduce the stream of projected social benefits and cost flows to an index, the value of which can be used to select or reject a project or to rank it relative to alternative projects.

4.1 Choosing Projects: Decision Rule

The "return" on an industrial project can be expressed in a number of ways. One of the most common is in the form of a benefit-cost ratio:

$$\begin{aligned} \frac{B}{C} &= \frac{(b_1 - c_1)}{(1 + i)} + \frac{(b_2 - c_2)}{(1 + i)^2} + \dots + \frac{(b_n - c_n)}{(1 + i)^n} \\ &= \frac{K_1}{(1 + i)} + \frac{K_2}{(1 + i)^2} + \dots + \frac{K_n}{(1 + i)^n} \quad (2) \end{aligned}$$

Where; $\frac{B}{C}$ = Benefit Cost ratio

b_1, b_2, \dots, b_n = Series of gross benefits in years 1, 2, ...n
 c_1, c_2, \dots, C_n = Series of current costs in years 1, 2, ...n
 i = rate of discount

We were using equation (1) for planning and (industrial) investment, and if all prices reflected opportunity costs, we could select all projects for which $B/C > 1$. Alternatively, we might use the net present values (NPV) criterion and undertake all projects for which $B-C > 0$.

The final possibility is to calculate the internal rate of return r from the formula:

$$\frac{b_1 - (C_1 + K_1)}{(i + r)} + \frac{b_2 - (C_2 + K_2)}{(i + r)^2} + \frac{b_n - (C_n + K_n)}{(i + r)^n} = 0 \quad (3)$$

and select all projects for which $r > i$

The method in equation (2) is usually not convenient since it is possible to obtain multiple solutions for r and also it is not possible to provide for changes in the rate of discount over time.

It is also possible to rank pollution prone industrial projects in descending order of the NPV (B/C ratios). The project with the highest B/C ratio is chosen first, then the next highest and so on down the line until available capital investment funds have been exhausted.

There are controversies surrounding an appropriate social discount rate in the light of problems peculiar to the environment. Markandya and Pearce (1991) identified the following:

(i) Pure individual time preference; (ii) Social rate of time preference; (iii) Opportunity cost of capital; (iv) Risk and uncertainty; (v) The interest of future generations; (vi) Irreversible damage; and (vii) the management of natural resources.

The attribution of cost to the impacts of environmental degradation by industries allow policy-makers in developing countries to set intervention priorities. Some of the more sophisticated techniques of resource and environmental accounting allow the impacts of such interventions to be traced through all parts of the economy, so that a wide variety of economic costs and benefits are reflected, including those associated with improved health, greater energy

efficiency, and improved material use. Recent work by the US funded Environmental and Natural Resource Accounting Project (ENRAP) in Philippines illustrates the applicability of these techniques. Through appropriate interventions, it was estimated that the total economic benefits associated with pollution reduction exceeded the costs. It is therefore necessary that high priority be placed on reducing water pollution in selected sectors with high benefits-cost ratios. These include particular industrial sectors such as mining, quarrying and manufacturing (Delos-Angeles et al 1994)

From the foregoing discussions it is evident that the process of industrial production produce both benefits and costs to the society in terms of environmental impact. The negative impacts can be controlled, reduced or totally eliminated. The existing environmental regulations if thoroughly enforced could go a long way in ensuring that industrial concerns internalize their negative externalities. Otherwise industrial polluters of the environment must be made to pay for such actions.

5. Recommendations and Conclusion

There is no doubt that sustainable development must tackle the problems of environmental degradation in the course of industrialization.

There is need for constant public enlightenment campaign to be embarked upon to educate the citizens on issues of environment. To achieve this objective there must be an initiation of community health programme to create environmental awareness through the use of print and electronic media as well as traditional information media like town criers, songs, proverbs and folklore. Others include posters, regular workshops and symposia.

Environmental associations must be encouraged to be formed among youths in schools, colleges and universities. Communities should also establish environmental health viewing centres where members of a community can gather to watch issues pertaining to environmental health through televisions and videos. Communities

should also be encouraged to form community health committees to handle issues relating to environmental health. By so doing the host communities would be involved in waste management programmes through the creation of environmental cooperative societies.

The existing environmental protection regulations must be strictly enforced, especially those pertaining to the production of hazardous wastes, environmental impact assessment and land use. For instance the oil in Navigable waters act, cap 339 of 1990 creates pollution offences with response to pollution of Nigeria waters through oil discharge and prescribes punishment thereof. It also lays down the machinery for the application and enforcement of the provisions of this act and empowers the minister of environment to make regulations to check the discharge of oil into the sea through the installation of special equipment to this effect. Furthermore the Environmental Impact Assessment (EIA) decree 86 of 1992 makes environmental impact assessment mandatory for new major industries and prescribe the process, follow-up actions and conditions. To ensure effective enforcement of environmental regulations, the federal ministry of environment as well as various state ministries of environment must employ field workers to monitor the environment constantly.

Moreover industrial ventures must be regulated in such a way that they internalize the negative externalities (waste products) which constitute cost to the society. Such internalization can be achieved through the modification of production equipment to enhance reduction in waste strength through a reduction in the amount of contaminants entering the waste stream. Another way of internalizing industrial externalities is through by-product recovery. Again, with adequate technologies, this is feasible. In which case the associated wastes of a given production process is critically studies and useful waste components recovered. For example it is possible to use ion exchanges in metal-plating industries to recover copper, nickel and chromium from plating solutions. The de-ionized water then becomes useful for broiler feed requirement. Other approaches includes waste proportioning, wastes equalisation, waste segregation etc. (Asuquo, 1998).

Our waste management should be commercialized at all tiers of government, especially at the state and local government levels. The communities must be involved in waste disposal and management. Such commercialization could be done using the "Polluter-pays-principle" (PPP). This is in line with the provision of paragraph 36 of schedule 1 of the petroleum act which maintains that the polluter pays fair and adequate compensation for the disturbance of surface or other rights to any person who owns or is in lawful occupation of the licensed or related lands.

The right to a clean and healthy environment must be seen as a fundamental human right. This is in view of the fact that the right to a minimum universally acceptable quality of life is an integral aspect to the right to life as embedded in national constitutions. Any adverse environmental condition(s) which affects health, physical wellbeing, emotional balance or means of livelihood threatens life. Some developing countries of Asia and Africa where pollution has become a menace, have already elevated environmental protection to the status of Fundamental Human Rights duely included in their constitutions. There is also the need for the co-ordination of environmental issues in the ECOWAS sub-region. This is sequel to the fact that there are international legislations on environmental issues. This would enable every country in the sub-region to appreciate the need for a viable and effective dispute resolution process by stricking a balance between the profit motivation of multinational companies and other industrial concern and the weak socio-economic status of the citizens. Furthermore co-ordination is necessary to check the effects of industrial pollution with the territorial limits of the country and avert trans-boundary effect (Smith, 1998).

To be able to achieve all the above recommendations, the government must however provide adequate funding for environmental monitoring and the enforcement of existing legislations. In assessing or determining and environmental project the cost- Benefit methodology is recommended, if pollution is to abate.

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