Ecological Resources Depletion, Inequality and Poverty

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Abstract:

In this paper, I develop a part of what I have been calling an ecological global political economy approach. I motivate the discussion by focusing on the links between ecological crisis and income distribution. I have chosen the concrete context of Bangladesh, a country likely to be affected severely by global warming and climate change to illustrate through simulation the theoretical results. Using a fairly neutral and conservative assumption of uniform distribution of loss it can be shown axiomatically that inequality increases when effective income is considered leading to ecologically adjusted income distributions. The simulations presented here for Bangladesh demonstrate that both inequality and poverty measured by some popular indexes increase significantly under even this mild assumption and the assumption of moderate income loss.

Keywords: Ecological Global Political Economy; Axioms of Inequality Comparisons; Axioms of Poverty Comparisons; Bangladesh; Equality of Misfortune Assumption: Adverse Health Effects of Ecological Damage; Resource Depletion; Inequality; Poverty

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INTRODUCTION

In this paper, I develop a part of what I have been calling an ecological global political economy approach. I motivate the discussion by focusing on the links between ecological crisis and income distribution. I have chosen the concrete context of Bangladesh, a country likely to be affected severely by global warming and climate change to illustrate through simulation the theoretical results.

More than three quarters of a century ago, the famous Bengali poet Rabindranath Tagore brooded over the modern industrial civilization on his way to Japan. Depressed by the ugly sights of the Rangoon harbor and Penang he wrote, "As our ship slowly sailed up to port, and the ambitious projects of man began to loom larger than nature, and the factory chimneys kept drawing their straight lines across nature's curves - then I could see what an amount of ugliness had been created in the world through man's passions ... the trade monster ... wearies the world with its weight, deafens the world with its noise, soils the world with its refuse ...".[1]

Tagore was not an economist. However, his reaction to the negative externalities generated by haphazard industrialization would be understood by many serious economists today. Even as economic growth is recognized as necessary the ecological consequences of unrestrained growth have come to be viewed as important issues that economic analysis should also address.

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[1] Rabindranath Tagore, Japan Jatri, pp. 4, 24, 32, 61 translated in Viswa Bharati Quarterly, new series, 4.2:96, 104 and 4.3:187, 190, 193.

In this paper I focus on some specific consequences of ecological damage. I explore the possible connections between ecological damage,

income distribution and poverty. Adjusting the existing income distribution by taking into account the ecological consequences will result in a different, typically unobserved income distribution. What are the consequences for the measurement of inequality and poverty, once we are able to construct this new income distribution? After offering some theoretical answers to this question an attempt is made in this paper to apply the approaches developed to the case of Bangladesh. Despite limitations of data some reasonable simulations can be carried out showing the possible implications of existing and ongoing ecological damages for poverty and inequality in Bangladesh.

The *a fortiori nature* of the overall argument bears some emphasis. By all accounts, the possible effects of global climate change on Bangladesh will be much more severe than the estimates used for simulation purposes.[2] If the damage is even two or three times the upper bounds assumed here, the impact on the poor and class polarization in Bangladesh will be traumatic. Unfortunately, the actual effects may be even more drastic.

The simulation results actually carry a significant policy message. Since the well-being of the people are seen to depend on both economic growth and the quality of environment, addressing the ecological issues in a timely fashion can lead to improvements in economic well-being. In case of a poor country such as Bangladesh the improvement of the quality of environment will together with sustainable economic growth lead to a more rapid diminution of poverty as measured here. At the same time relative inequalities along some important dimensions will also decrease. In general then, a combination of policies of

[2] See for example Lael Brainard, Nigel Purvis,(2009) and Abigail Jones, *Climate Change and Global Poverty: A*
Billion Lives in the Balance?

pro-poor, pro-environment and pro-sustainable growth will lead to greater level of well-being for all, and in particular, the poor.

The main body of this paper is divided in four parts. In the next two sections the theoretical links between ecology, inequality and poverty are pointed out. Section III presents a summary of the present state of ecological destruction in Bangladesh. The possible consequences for inequality and poverty measurement in Bangladesh are pointed out via two sets of simulations in the following section.

I. *THE LINK BETWEEN ECOLOGICAL DAMAGE AND INEQUALITY*[3]

As is well-known, comparisons of inequalities in income distributions can be either ordinal or cardinal. In this paper an axiomatic approach to cardinal comparisons in terms of Gini indexes is used. This is to facilitate comparisons with existing calculations of Gini index in the simulations that follow. It is also assumed for the sake of simplicity that monetary equivalents of damage are either available or can be computed from the available data.[4]

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[3] The work in this area is of recent origin. Khan and Parvin (1984, 1990) proposed the incorporation of environmental factors in an axiomatic treatment of inequality and poverty comparisons. More recently Khan and Sonko (1994, 1997) have applied this framework to study the ecological and distributional aspects of structural adjustment programs in Africa.

[4] It is possible to construct some types of cardinal indexes by specific aggregation schemes when all the components of environmental damage are not convertible to money. Massoumi (1984) constructs such an index without identifying environmental components. In Khan (1992b) I have tried to identify such components explicitly. Intuitively, this involves weighting different components of welfare, including money income, environmental bads and public goods and adding up the weighted components. There are significant technical problems that are not relevant to discuss here. The interested reader is referred to the two sources cited here.

The starting point for inequality comparisons is the vector of incomes of the individuals (or households) in a particular society ordered from the lowest to the highest. The normative axiom on transfers between individuals (or households) in the income distribution profile is crucial for comparisons of two income distribution profiles. This is sometimes referred to as the Pigou-Dalton transfer axiom, later referred to in the text as condition P-D. According to the Pigou-Dalton transfer axiom, any transfer from a richer to a poorer individual which preserves the relative ranks of the two individuals decreases inequality. Conversely, a regressive transfer (i.e., from a poorer to a richer person without changing anyone's ranking in the income distribution profile) likewise will increase inequality. This statement applies to both ordinal comparisons using Lorenz curves and cardinal comparisons using indexes with numerical values. Clearly, cardinal indexes such as the Gini index can rank unambiguously income distribution profiles even when their respective Lorenz curves cross.

Suppose now we start with a given income distribution vector y for a particular society. There will be a certain cardinal index of inequality, say a particular value of the Gini index, associated with this income distribution y.

We now simplify by assuming that all environmental damages can be given a monetary expression. Of course, this damage may or may not be evenly distributed among the population. We have to, therefore, arrive at an observed distribution of the damage. But this is not available for most developing countries. However, we can still make some

progress in examining the links between ecological damage and inequality by making plausible assumptions regarding their distribution. Even these results, as subsequent exercises will try to demonstrate, can be quite revealing for both environmental and poverty alleviation policies.

In any case, given an environmental damage estimate x monetary units per person and its distribution over the population α we can derive a new or adjusted distribution z by subtracting the monetary equivalent of the damage from observed incomes. More explicitly, this can be done in the following way. Suppose there are n individuals in the economy, with the actual income of the ith individual given by y_i ($i = 1, 2, \ldots n$). After the environmental damage (which we may recall is assumed to be uniform across individuals) has taken place, real income, i.e., income adjusted for environmental damages of the same individual i is :$z_i = y_i - x$. We now compute Gini indexes for $y = (y_1, y_2 \ldots, y_n)$ and $z = (z_1, z_2 \ldots z_n)$ and compare G(y) and G(z), where G(y) is the Gini index for observed income distribution and G(z) is the `real', (i.e., post-environmental cost accounting) Gini index for income inequality. Likewise, poverty indexes, for example the familiar head count ratios, can be computed for both the observed income distribution y and the adjusted income distribution y. Comparison of the headcount ratios in these two cases will tell us how accounting for environmental damages in this manner will affect poverty measurements[5]. This is the essence of the inequality and poverty comparison methodology followed in this paper. In the process of deriving the inequality and poverty index values for various years after environmental damages have been taken into account, a special assumption is used. It is assumed that the damages affect rich and poor alike. Therefore everyone loses an amount

which is equal to the average, i.e., per capita damage is assumed to be identical. This assumption which is explained and justified later in the paper is called the 'equality of misfortune assumption.'

Some welfare theoretical issues:[6]

At this point some further analytical issues arise regarding the welfare economics of comparing inequalities when environmental damages not only reduce (true) income, but also contribute to growth. We must note that the relevant dynamic welfare comparisons are of two sorts. One is between the national welfare before the spurt of industrialization and modernization of agriculture (which increase both national incomes and the extent of ecological damage) and after. A second type of dynamic comparison is between the successive states of a growing economy after it has began industrialization and modernization. In both cases (but especially in the former) growth by itself enhances welfare. What is being claimed here is that the actual (environmentally adjusted) level of national income will be lower and hence the welfare effect of growth less than what is appears to be, if we follow the approach suggested. Furthermore, distributional effects of growth will also need to be taken into account in comparing the relevant welfare levels. More specifically, if, as we have just seen, both income inequality and poverty are affected by ecological damage, then we must also take these effects into account in judging the welfare

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5 In the next section, the methodology for poverty index comparisons (in the context of the FGT index of poverty) is discussed. The general approach presented in this paper should be applicable to any poverty index.

[6] Here the formulation is consistent with the utilitarian social welfare function approach. My current theoretical research is a ongoing attempt to formalize the capabilities approach in this context

effects of growth. On both counts, ecological damages are likely to reduce the overall welfare-enhancing effects of growth.

At the outset, let us distinguish between the accounting and economic aspects of the problem. As the recent literature on environmental accounting makes clear, subtracting environmental damages from total observed income is defensible on accounting grounds. However, this does not answer directly the question of how to evaluate (in utility terms or otherwise) the net social gain or loss from both growth and environmental costs of growth. The problem arises because in the context of the present paper (and for the inequality comparison literature in general) the relevant social welfare function (SWF) values both equality and increases in aggregate income. Without specifying a particular SWF we can not be sure a priori whether welfare is higher or lower with or without environmental costs. However, if we choose a certain type of SWF (which has the property of weighting relatively more egalitarian distributions more positively) then under our assumptions the following two statements are true:[7]

1. The aggregate income after environmental damages are accounted for must decrease.

2. Any cardinal inequality index will show more inequality than it did when environmental costs had not been subtracted from people's incomes.

[7] Technically, this class of welfare functions is known as Schur-concave welfare functions.

Therefore, on both counts for the any growth rate of income the post-environmental damage level of welfare will be lower than pre-environmental damage welfare level. It is, however, fairly certain that compared to the pre-industrial level of welfare, the growing economy will exhibit a greater level of economic welfare. Unless the pristine state of nature before growth is valued so highly (perhaps because the welfare economist in question is a luddite) that no amount of growth can compensate for the loss of environmental assets, this judgment will stand. The real problem is achieving an environmentally sustainable rate of growth which also preserves a modicum of distributional equity according to the society's perception of justice as fairness (Rawls, 1970)[8] and thus enhances welfare in an optimal fashion. Therefore, the discussion above should not be construed as anti-growth, but rather as a nuanced approach to the problem of sustainable growth with equity.

The role of equality of misfortune assumption (EMA):

It is necessary to pinpoint the role of EMA in the following analysis. There are two aspects of EMA — one is formal, the other substantive. Formally, EMA is in the nature of an a fortiori argument. In other words it is a weaker assumption than — for example — one that distributes costs of pollution more to the lower end of income distribution profiles. Given the previously mentioned Pigou-Dalton condition it then follows that under EMA the resulting inequality, other things being equal, will be higher than that reflected by the original (i.e., observed) distribution.

[8] Rawlsian maximin principle is not the only principle of justice that can apply. Sen (1992) offers justice as `capability equalization' as an alternative. For further discussion and an

More substantively, EMA reflects our ignorance about the actual distribution of environmental bads in Bangladesh. Volume II of the National Environment Management Action Plan (NEMAP) for Bangladesh (1995) acknowledges the problems of measurement and information pp. 16-29) and proper policy formulation in these regards. However, the overall picture is one of rapid environmental deterioration from which the poor may suffer the most.

> It is estimated that over 40 percent of the population regularly consume less than the absolute critical minimum of 1800 calories per day. These 50 million people are amongst the world's poorest by any standard of development. Furthermore, others have estimated that the numbers of absolute poor have risen significantly. The poverty of these deprived people is deep rooted, pervasive and multi-faceted, relating not just to the absence of reliable incomes and productive assets, but also to food, safe water, sanitation, education, shelter, inequalities, injustice and lack of power. These most deprived persons of the world are also extremely vulnerable to disaster and disease. The challenges posed by this mass of poverty are enormous for a country which is now populated in total by over 120 million, on a land base which is already the most densely populated in the world at over 800 persons per sq. km., with accelerating environmental degradation.
>
> (NE MAP: 18)

Thus EMA is a much more conservative assumption regarding the distribution of environmental bads than the actual situation — in all probability. The actual states of post-ecological accounting inequality and poverty are in all likelihood even worse

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extension of the capabilities approach see Khan (1998).

than what is presented in this paper. Since no estimates are available of either the distribution of environmental bads or of post-ecological accounting inequality and poverty at present, the results reported in this paper may be seen as the best conservative estimates that policy makers may be able to use.

II. *ECOLOGICAL DAMAGE AND POVERTY*

By not considering the role played by ecological damage in effectively reducing people's incomes the extent of poverty may be underestimated. I consider here the question of how one particular index of poverty, the FGT index may be affected, so that comparisons with the earlier estimates for Bangladesh (for example, Ahmed et al. 1991; Khan 1992a, 1994) are possible.

Since Sen's (1976) axiomatic treatment of poverty comparisons several new indexes of poverty have emerged. Among them the one developed by Foster, Greer and Thorbecke (FGT) satisfies both desirable theoretical conditions and is also additively decomposable. Thus this index can take into account the intensity of poverty for different groups of poor people. This is done by looking at the deprivation of calories. The poverty measure is given by:

$$p = 1/n.\sum_{j=1}^{q} (G_j / z)^a$$

where n = total population

q = the number of poor

z = the poverty line

G_j = expenditure shortfall of the jth individual

Initially, the index was proposed for measuring food poverty.

In the simulation a value of a = 2 is used. At a lower value of 'a' some of the axioms are violated. At a higher value of 'a' the shortfalls of the poorer segments are weighted more heavily; therefore the intensity of deprivation by the poorer segments (in particular the poorest) will be magnified for value of 'a' greater than z. For this value of `a' both the montonicity and transfer axioms of Sen are satisfied. We may recall that both these axioms have to do with the sensitivity of the index to the incomes of the poor as opposed to simply the number of poor. Thus, the monotonicity axiom states that, ceteris paribus, a decrease in the income of a poor person should increase the poverty index. The transfer axiom states that, ceteris paribus, a transfer of income from a lower income poor person to a higher income poor person increases the poverty index. It can be checked easily that this is true for the FGT index when a = 2.

It should be emphasized that ecological damage does not affect food poverty line (i.e., cost of minimum calories that are required). However, ecological damage does result in a reduction in income if proper accounting for such damage is done.[9] An intuitive way of justifying this is to think of such damages as increasing certain defensive

[9] See for example, the volume on ecological economics edited by Robert Costanza (1991). In particular, Salah El-Serafy in his essay "The Environment As Capital" in this volume argues that capital depreciation can be linked to a diminution of actual present and potential future incomes.

expenditures for the family, increased health care expenditures due to pollution-induced illnesses, for example. This will force the individual to operate at a lower level of welfare than in a world without ecological damages offering her the same money income. With this justification in mind some simple experiments assuming various degrees of damage and the EMA can be carried out. In all cases, we compare before and after damage poverty[10]

III. *ECONOMIC GROWTH AND ECOLOGICAL DAMAGE IN BANGLADESH: A QUICK OVERVIEW*

After an initial decade of relative stagnation since the country's independence in 1971 the growth rate picked up in the 80's and 90's. The average GDP growth for 1980s was 4.3 percent per annum. In 1990 the growth rate accelerated to 6.6, but could not be sustained. But from 1992 onwards the growth rate has been over 4 percent, and in 1996 and 1997 it exceeded 5 percent, reaching the highest level of 5.7 percent I 1997 (Asian Development Outlook 1996 and 1997; 1998). At the same time, inspite of success in population planning the growth rate of population is still close to two percent per year. Hence, the per capita growth rate is somewhat less impressive. As the following sections show this growth record has certainly led to some poverty alleviation; but the extent is not very large; whereas inequalities have remained fairly the same, increasing somewhat in the 1990s.

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[10] We should keep in mind the distinction made previously between static and growing economies. The relevant comparisons are between poverty with and without environmentally adjusted growth.

This growth process which is necessary for poverty alleviation does have an environmental cost that is usually not taken into account. As the BBS document 'Bangladesh: Framework for Development of Environmental Statistics,' points out:

> However, on the input side of the economy, both the non-renewable and renewable resources are being used up in an unplanned way that cannot be sustained in the long run. On the output side, ambient environmental qualities are being deteriorated continuously, ill effects of which are felt on the biotic system in particular and on the entire ecosystem in general. Thus the growth process is physically constrained by the stock and flow of natural and environmental resources (p. 3).

Recent attempts to classify the various types of environmental damages have led to the identification of six areas. These are: 1) flora; 2) fauna; 3) atmosphere; 4) water; 5) land/soil; 6) human settlements. Unfortunately, systematic environmental accounting is only at a conceptual stage right now. One purpose of this paper is to show the importance of such accounting by presenting some simulation results. This is all one can do in the present context; but in the future, when systematically collected data become available the methodology of this paper can be used to gauge the exact effects of environmental damages on inequality and poverty.

The methodology of classification mentioned in the previous paragraph is based on the recognition that ecological damage can occur in different areas of the ecosystem. Chief among these in Bangladesh are the problems of deforestation, soil erosion,

contaminated waterways, vulnerable coastal zones, overcrowded and polluted urban environment.

Once forest covered vast tracts of tropical Asia, including Bangladesh. Much deforestation in Bangladesh has taken place because of population pressure and the shortage of alternative fuels, especially for households at the lower income levels. Although there are short-term gains to needy farmers and profits to timber concessionaires deforestation generates long-term losses of the diverse forest ecosystem itself implying loss of livelihood for some people and of watershed and nutrients for the larger ecosystem. Top soil unanchored by roots is carried away by the rains. The deposit of silts in the rivers makes floods much more likely than would otherwise be the case. It is because of such threats that an ESCAP report in 1990 characterized deforestation as "the most serious environmental threat in the region."[11] However, the exact effects on people's livelihood and incomes are not easy to estimate. Probably, the best approach is to impute a loss of national income through the loss of assets by using some sort of depreciation schedule [Elseraty (1991), Bartelmus, et.al., (1991)].

Bangladesh is a land of rivers. The Padma, Brahmaputra, Meghna - just to mention a few-flow through the country like the main arteries in a body. These rivers provide water for the fields, serve as transportation links and means of livelihood for numerous people. However, along with the dwindling forests the rivers are also dying. Sedimentation is making the river beds increasingly shallow. Fertilizers and pesticides from

[11] ESCAP (Economic Commission for Asia and the Pacific), State of the Environment for Asia and the Pacific, Bangkok, 1990.

the fields drain into them. Domestic sewage is also flowing into the rivers. The figures for Bangladesh are not available, but in India out of 3,110 towns and cities only 217 have some form of sewage treatment. The ratio of towns with sewage treatment to total is in all likelihood similar in Bangladesh. Although the environmental damage figures are not readily available, some costs could reasonably be imputed and subtracted from the computed GDP.

In Bangladesh shrimp nurseries have made the water salty leading to a change in the taste of coconuts in districts like Khulna. Apparently, the productivity of paddy land has decreased as well, falling from 1.7 metric tons/hectare to .5 metric tons/hectare.[12] The yield of fruits and vegetables has also dropped even as shrimp production for export has risen. According to a survey by Prof. Mufazzalul Haq of Dhaka University, nearly 75% of the all shrimp cultivators are fairly wealthy individuals from outside the region. According to his study,

> Encouraged by government incentives, they first ingratiate themselves with the village elders and purchase a small plot of land for shrimp cultivation. Later they use money and muscle power to oust small and marginal farmers from their lands and use them for shrimp culture. A case in point is Dakatia that comprises 60,000 hectares of marshy land in Khulna district. This area was used for paddy production by its indigenous peasant Hindu community. Now the entire community has been driven away by the shrimp farms and there is no sign of paddy production in Khulna. For many farmers, their land was the only source of food. Its loss means they have migrated to the cities to look for jobs. In the

[12] Voice of Bangladesh, July 1992, New York p. 2.

> Satkhhira sub-division of Khulna district alone nearly 1,200,000 peasants have lost their land to shrimp beds."[13]

As incomes increase in some activities for some people, other activities disappear affecting people previously engaged in them. This is the 'normal' income-enhancing growth process. What is different here is that the new activity has a high environmental cost. Furthermore, these costs are distributed unevenly. It is also difficult to estimate the total loss of income to the people at the lower end of the income distribution. Nevertheless, it may be a valid conjecture that for the small marginal farmers considerable income has been lost leading to a further worsening of inequality and poverty. It is unlikely that these former farmers all found better paying occupations elsewhere. Since no compensation principle seems to have been applied the chances are that the poor are both absolutely and relatively worse-off than before.

The aforementioned shrimp ponds have also affected the vulnerable coastal mangrove forests. In the Sunderbans on the border of India and Bangladesh trees are being cut-down. According to the source cited previously already about 10,000 acres of forests have been converted. Coastal embankments have also led to the flooding of fields by saline water. Thus the coastal areas including Asia's largest mangrove forest are quite vulnerable. Once again the immediate and long-term costs are not easy to estimate. But the logic of environmental accounting [Bartelmus, et.al., 1991, Costanza, 1991, ESCAP, 1997] suggests these costs are to be subtracted from measured GDP[14].

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[13] Ibid.

[14] The main architect of the `Accounting and Valuation of Environment,' Dr. B.D.. Pant has emphasized in conversations with the author the necessity for developing countries like Bangladesh to have a set of integrated environmental accounts which include and link costs

The overcrowded and polluted cities contribute in their own deadly ways to the sufferings of the vulnerable groups. Forced to live in overcrowded slums under unhygienic conditions the impoverished groups are much more likely to be ill and mortality rates are correspondingly higher. The work environment is also highly polluted and contributes to sickness and early death. It is not an easy task to attribute the exact amount in monetary terms to these environmental factors[15]. However, once again it is clear that some (probably quite significant) portion of effective income loss can be attributed to the environmental factors.

It should be clear from the foregoing discussion that it is quite reasonable to claim that all people, especially the poor and the disadvantaged groups effectively lose a portion of their incomes because of deteriorating environment. Therefore the case for looking at environmentally adjusted income profiles in Bangladesh is a justifiable one. As observed before, it is not possible at the moment to offer exact estimates of these losses. In what follows simulations are carried out under fairly conservative assumptions of income loss. The distribution of damages, as mentioned before, are assumed to be the same for each individual.

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of all environmental damages in an economy wide sense. The above discussion of soil erosion, ground water salinity and deforestation are integral in this sense to the economy wide picture of environmental costs that is attempted here, albeit only as a snapshot. I am thankful to Dr. Pant for many illuminating conversations on these and other issues related to environmental accounting in Asia.

15 Alternatively, we may prefer to state the case in terms of negative welfare attributes (Maasoumi 1986, Kolm 1977).

IV. *SOME SIMULATIONS OF ECOLOGICALLY ADJUSTED INEQUALITY AND POVERTY MEASURES*

Given the limitations of data it is possible only to offer some range of estimates of ecologically adjusted inequality (EAI) and ecologically adjusted poverty (EAP) measures for Bangladesh. The main assumption made in the analysis that follows is quite conservative, as was pointed out in Section I.

Any loss of income is assumed to be uniformly distributed among the whole population. As in Section I, this is indeed the `equality of misfortune' assumption. It may be surprising that by this assumption the poor suffer in absolute terms as much as the rich. But that is precisely the role the assumption is meant to play. In reality it is quite likely that the poor suffer more than the rich in absolute terms as well. A consideration of the location of poor people's houses, their work environment and the daily hazards of inhaling polluted air or drinking contaminated water will be enough to make a stronger assumption (one that makes the poor suffer more absolutely) justifiable. True, under the equality of misfortune assumption rich and poor seem to suffer alike absolutely. However, in terms of the standard axioms of inequality comparisons it can be shown that even under the mild assumption of `equality of misfortune' inequality will increase. This is because the lower income groups lose proportionately more than the upper income groups.[16] If for some groups the loss is more than the difference between their incomes and the poverty line, poverty as measured by the head count will increase. Since the poor experience an increase in their shortfalls,

[16] Although the proposition is intuitively almost self-evident, the application of P-D requires a few extra steps. For a proof please see Khan and Sonko (1994) p. 195.

poverty as measured by the income gap ratio will also show an increase.[17] It is likely that the FGT measure will also record more (food) poverty. In what follows the consequences of equality of misfortune are explored in terms of the Gini index of inequality and the FGT index of poverty. For inequality comparisons this is done for three different income loss assumptions. First, a loss of mere 0.5% is assumed. Next, the loss is increased first to 1% and then to 2%. Tables 1 and 2 describe the ordinary inequality index and EAI respectively. Tables 3 and 4 give the results for ordinary FGT index and the EAP and FGT index respectively.

Table 1
Inequality in Bangladesh

Year	Gini index of inequality
1973/74	0.36
1981/82	0.39
1983/84	0.35
1988-89	0.38
1991-92	0.37
1995-96	0.43

Source: Khan and Hossain (1989) and the author's computation from BBS data. 1995-1996, Household Expenditure Survey, p. 32).

[17] For a proof of these as well as the condition under which the Sen-Index will register more poverty see Khan and Sonko (1994) pp. 197-199.

Table 2

Loss of National Income and Resulting Inequality

Year	0.5 Percent	1 Percent	2 Percent
1973/74	0.41	0.43	0.49
1981/82	0.42	0.46	0.51
1983/84	0.39	0.42	0.47
1988/89	0.40	0.44	0.49
1991/92	0.39	0.43	0.48
1995/96	0.46	0.48	0.53

Source: Author's calculation.

As expected the EAI are in each case indicative of greater inequality. Moreover, the increase in inequality is directly related to the increase in the size of ecological income loss. Given the nature of this particular index this is not surprising. In terms of welfare loss any welfare function consistent with the condition P-D will rank the EAI states as welfare lowering as compared with the ordinary values of inequality. Thus it is clear that ecological losses matter very much in terms of inequality and welfare. Does it also matter for poverty measurements? Our theoretical answer to this question was that it should matter in most cases. Let us turn now to the simulation results using the FGT index of poverty.

Table 3

A Profile of Poverty in Bangladesh During the 80s

Area Total	Poverty Line (Kcal/cap/month)	Poverty Severity (P)	% Contribution to Total Poverty[a]	Poor	
				Area	Percentage
			FY82		
Rural	61,472	0.0401	94.3	71.8	61.8
Urban	63,115	0.0150	5.7	65.3	9.1
Bangladesh		0.0366	100.0	-	70.9
			FY 86		
Rural	61,472	0.0197	89.9	51.6	45.1
Urban	63,115	0.0153	10.1	66.8	8.4
Bangladesh	-	0.0191	100.0	-	53.5

[a]Calculated as: 100 (area population/total population) (area P)/total P.

Source: Ahmed, Khan and Sampath (1991).

Table 3 shows the profile of poverty in Bangladesh before incomes are adjusted for ecological damage. Even so the situation looks quite grim for both FY 82 and FY 86, the two years for which this index was computed. Rural and urban poverty are both severe, but rural poverty is much more severe than the urban poverty, especially in 1982.

Table 4 shows the computation for 1% income loss. Later same type of computations for 1 percent income loss are carried out for 1991-92 and 1995-96.

Table 4
A Profile of EAP in Bangladesh During the 80s

Area	Poverty Line (Kcal/cap/month)	Poverty Severity (P)	% Contribution to Total Poverty
			FY 82
Rural	61,472	0.0812	96.1
Urban	63,115	0.0325	3.9
Bangladesh	-	0.067	100.0
			FY 86
Rural	61,472	0.0315	90.2
Urban	63,115	0.0191	9.8
Bangladesh	-	0.0231	100.0

Using the same poverty line in terms of the cost of calories consumption, the income loss leads to a worsening of poverty profile in both rural and urban areas. Even under the assumption of equality of misfortune regardless of the socioeconomic class and location (urban vs. rural) poverty worsens. Thus the conclusion that EAP indicates more poverty is warranted. Equally true is the conclusion that the severity of poverty as measured by this particular index also increases in the presence of ecological costs[18].These conclusions are likely to hold for most other poverty indexes as well.

[18] Although the results for poverty here are derived via the FGT index, the logic of the discussion suggests a broader `ecological` notion of poverty. Short of a complete conceptual overhaul in the direction of poverty as `capability failure' income shortfall may also be used. As Jung and Thorbecke (1996) and Khan (forthcoming 1998) have shown the direction of

Poverty During the 90s

How has the situation evolved up to now with respect to poverty? In order to answer this question it is necessary to look at recent data. For this purpose, the latest household expenditure survey available (for the year 1995-96) can be used. Another earlier year in the decade for which data are available is 1991-92. Computations are carried out for this year as well.

The results of the computation for 1991-92 and 1995-96 are summarized in Tables 5 & 6 below:

Table 5

A Profile of EAP in Bangladesh in Recent Years
1991-92

Area	Poverty Line (Kcal/cap/month)	Poverty Severity (P)	% Contribution to Total Poverty
Rural	61,472	0.0652	85.4
Urban	63,115	0.0415	14.6
Bangladesh	-	0.0597	100.0

movement in these two indexes are the same. Therefore, at least for a broader income shortfall index, the results here should hold qualitatively.

Table 6

A Profile of EAP in Bangladesh in Recent Years
1995-96

Area	Poverty Line (Kcal/cap/month)	Poverty Severity (P)	% Contribution to Total Poverty
Rural	61,472	0.0531	83.5
Urban	63,115	0.0426	16.5
Bangladesh	-	0.0481	100.0

By comparing Tables 4, 5 and 6 it appears that environmentally adjusted poverty index in the 90s shows less poverty than in 1985-86; but it still shows more poverty than 1982-83. It is clear that during the 1990s economic growth has led to some poverty alleviation. However, the deterioration of environment in both urban and rural areas has attenuated the real impact of growth on poverty alleviation. Furthermore, in recent years urban environmental problems have become progressively more severe. If, in accordance with this observation, allowance for greater loss of welfare in urban areas is made the EAP will show greater poverty than is indicated in these tables.

CONCLUSIONS

It has long been conjectured that ecology and income distribution are connected. The foregoing theoretical observations and simulations show that these connections exist. Although theoretically the possibility that there may be circumstances where upper income bracket members of the society may lose proportionately more than the

poorer individuals can not be ruled out, under typical conditions the actual effect is likely to be inegalitarian.

Using a fairly neutral and conservative assumption of uniform distribution of loss it can be shown axiomatically that inequality increases when effective income is considered leading to ecologically adjusted income distributions. The simulations presented here for Bangladesh demonstrate that both inequality and poverty measured by some popular indexes increase significantly under even this mild assumption and the assumption of moderate income loss.

Bangladesh is one of the poorest countries in the world. The amelioration of poverty requires vigorous policy intervention according to many economists. Unfortunately the continuing ecological damage worsens the already serious condition of poverty. Thus ecosystem balance and maintenance is a sine qua non not just for sustainability but also for preventing the distributional and poverty problems from getting much worse than they already are.

From the policy perspective the results actually offer a useful policy complement to the usual poverty alleviation measures. To the extent that policies can be implemented to improve the environment a corresponding reduction in poverty could be effected. What is necessary is to engage in improvement of the deteriorating environmental conditions and in defensive activities designed to prevent future environmental deterioration. Appropriate environmental policies of this type will benefit everyone — in

particular, the poor and the most vulnerable groups. It should be emphasized that there is no logically or empirically inevitable relationship between income growth and environmental deterioration. As a recent paper by Islam (forthcoming in this journal) shows, there is no inevitable 'environmental Kuznets curve' for Asia. Therefore, there is no good reason to believe that Bangladesh is doomed to have environmental decay as income grows to a sufficiently high level before a turning point is reached. Much depends here on appropriate environmental policies. One way to estimate the `window of opportunity' in terms of available resource flow for sustaining policies of defensive environmental expenditures is to calculate the `environmentally adjusted surplus' for the country, as suggested by Khan and Lippit (1993). Recent formulation of such policies in National Environmental Management Action Plan is a good step forward as is the crafting of an overall framework for national environmental accounting. These steps at the national level have raised the hope that realistic policies based on solid data will be able to reverse the trend of environmental damage in the foreseeable future. With such environmental policies in place further economic growth and complementary public action to help the poor [deHaan and Lipton, forthcoming] can be expected to lead to further reduction in poverty levels as well.

Given the looming ecological crisis globally, countries like Bangladesh will be among the worst affected. The conventional analysis of political economy fails to capture the complex links between ecological damage, inequality and poverty. The analysis here can be seen as the beginning of a broader and deeper ecological political economy which could be extended to the global level. There is an urgent need to develop the research agenda and methodologies of a new ecological global political economy.

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