DISTRIBUTIVE JUSTICE AND THE CONTROL OF GLOBAL WARMING

V. Bhaskar*

Delhi School of Economics

Delhi University

Delhi 11007

India

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1. Introduction

"Global warming raises unique questions about our responsibilities to future generations." Thus begins John Broome's recent book, which argues that we have a responsibility to take action today so that the welfare of future generations is not adversely affected. The argument that Broome makes is a moral one, not one based on self-interest - after all, you and I will be dead and gone by the time that the greenhouse effect makes the oceons rise and alters our planet's climate is unforseeable ways. The unborn are powerless, and if we choose to be guided purely by self-interest, we could bequeath them a wasteland, and we would not even be around to hear their reproach. Broome argues that our actions must be guided by ethical criteria, and that we must take remedial action to curb the emissions of greenhouse gases. The precise extent to which we do so depends upon how we morally evaluate alternative distributions of "well-being" across generations. Broome does not provide any answers to the question, how much must we curtail greenhouse gas emissions. His purpose is instead to set out a framework, an ethical framework, within which such questions may be addressed.

Broome's dissection of inter-generational distributional questions is insightful and valuable. It brings out clearly that global warming is a *moral* issue. No discussion of it can be divorced from ethics, and from the ethical responsibility of todays denizens of the globe towards their descendents. However, one omission is striking - there is no mention of the heterogeneity of today's generation, of the difference in well-being between the typical American and the typical Sudanese today, or indeed between tomorrow's Japanese and Bangladeshis. Nor is there any discussion of the different degrees to which these societies have exploited the global commonsto date. What implication do these large differences have for the division of responsibilities? Does a Sudanese and an American have equal

responsibility to future generations? What does "equal responsibility" mean in the context of global warming?

Of all issues which impinge upon the welfare of future generations, global warming is perhaps the one issue which explicitly requires a treatment of intra-generational distributional issues. The global environment is a global public good, and greenhouse gases, which contribute to global warming, are an archetypal public bad. It does not matter whether a unit of carbon di-oxide is emitted in Bangladesh or the United States - it contributes equally to global warming in either case. Consequently, we must define, in global terms, the responsibility of current generations the world over to future generations. In doing so, we confront, inevitably, the division of the burden of this responsibility within the current generation.

This paper begins where Broome's book ends. Taking as given that we have a moral responsiblity towards future generations, I ask, what is the moral basis for distributing the burden of our responsibility within the current generation. How, in particular, should this burden be distributed between nation states (although, in principle one can go further, and allow for heterogeneity within nations)?

The pre-occupation of this paper, with the ethical basis for distributing the burden of emission control, has been questioned. It is argued that questions of ethics are irrelevant, and the distribution of international burdens across countries will inevitably be determined by power-politics. I do not believe that this is entirely correct. The outcome of international negotiations may be determined by bargaining power; however, bargaining power is not determined *entirely* by material factors - it also influenced by the perceived morality of one's position. The importance of ethical considerations may be greater than usual in the case of global warming, since we will feel a need to undertake any emission control only if

we are concerned about future generations.

The remainder of the paper is as follows: section 2 details the empirical evidence on the current distribution of global emissions of greenhouse gases. Section 3 asks whether there is a conflict between an efficient program of emission reductions and an equitable one, and argues that tradeable emission permits can ensure efficiency, allowing use to base the allocation of emission entitlements on grounds of equity. Section 4 sets out a simple model which explains how earlier generations may use the global environment in order to affect the intra-generational distribution of welfare in the future. The rest of the paper focuses on the moral issues. Section 5 considers welfare based theories and theories based on rights, and suggests that in the case of global warming, both theories give similar answers. Section 6 discusses some of the specific criteria which have been suggested for allocating emission entitlements. Section 7 discusses the question of historical responsibility: since the stock of greenhouse gases is due to past emissions, which are overwhelmingly by the North, should we correct for this differential exploitation of the global environment in the past, or should we let bygones be bygones.

2 THE DISTRIBUTION OF GREENHOUSE GAS EMISSIONS WORLD-WIDE

Human economic activity has, in the last one hundred years, contributed to an increase in the concentration of "greenhouse gases" - carbon di-oxide (CO_2), methane, nitrous oxide and chloro-flouro carbons (CFCs) are the most important. The increased atmospheric concentration of these gases gives rise to the "greenhouse effect", whereby a larger proportion of solar energy is trapped by the atmosphere instead of being reflected back into space. This has the effect of raising global temperatures. A rise in global temperatures could have a major effects upon global climate. The consequent

melting of the polar ice-caps would raise the sea level, and could adversely affect low-lying areas such as Bangladesh, the Netherlands and island states. The precise size of the greenhouse effect, and its impact is matter of scientific debate, and far from settled. The economic costs of global warming are also a matter of controversy - Nordhaus (1991), for example, argues that the costs are small whereas Cline (1992) is less sanguine. Nevertheless, the issue is too serious to be dismissed given the magnitude of projected increases in CO_2 concentration. Carbon di-oxide emissions increase rapidly with industrialization and the use of fossil fuels. As developing countries industrialize, one can expect their level of CO_2 emissions per-capita to gradually "catch-up" with levels in the developed world. If business continues as usual, the Intergovernmental Panel on Climate Change (IPCC) estimates that CO_2 concentrations will be doubled (as compared to pre-industrial concentrations) by the year 2020, and will be more than quadrupled by the the end of the twenty-first century. These large changes are likely to have a non-linear impacts upon the global environment and the economy, which we can predict only with a large margin of error. Carbon di-oxide is resident in the atmosphere for a very long period of time, of upto 200 years. Consequently, changes in CO_2 concentration will be long-lasting, and can only gradually be reversed. For these reasons, it appears that precautionary measures to control the emissions of greenhouse gas emissions is warranted, and indeed the issue is on the international agenda today, although coordinated action to tackle the problem may yet be far.

Within the greenhouse gases, carbon di-oxide and methane are the most important - the role of nitrous oxide in global warming has been down-graded in recent years, and agreement has been reached on the phasing out of CFCs. Carbon di-oxide is resident in the atmosphere for a period which is estimated at being between 50 to 200 years, while methane has a shorter

residence time of about ten years. Consequently, the long term effects of emissions are substantially greater in the case of carbon di-oxide. The primary source of CO_2 emissions is industry, and this is mainly due to the combustion of fossil fuels. Second in importance are emissions from biota sources, due to deforestation and other changes in land use pattern, which are mainly concentrated in developing countries. Estimates of emissions from biota sources are extremely divergent, and for individual developing countries, total emissions can vary by a factor of two to four depending upon the estimate used. Table 1 presents an estimate of the distribution of industrial CO_2 emissions world-wide, as well as an assessment of the contribution of various regions to current concentrations.

There is substantial uncertainty about the extent of anthropogenic methane emissions. Methane emissions in developed countries are relatively small, and are due to the use of fossil fuels, and livestock/animal waste. In LDCs, methane emissions are mainly due to livestock waste and rice cultivation. The extent of these emissions are extremely difficult to calculate, and there are a range of estimates in the literature. Table 2 presents the 1988 emissions CO_2 and methane in terms of gigatons/tons of carbon equivalent.

Table 2 shows that the distribution of carbon emissions per head of population is highly uneven. The basic asymmetry is that the "North" has a level of per-capita emissions over four times that of the "South". There are further variations within the North, with North America having a level of per-capita emissions over twice as large as Western Europe and Japan. The USSR and Eastern Europe have higher per-capita emissions than W. Europe/Japan. Within the South, Brazil has a relatively high level of per-capita emissions, and the exact figure could be higher due to uncertainties about the contribution of deforestation.

It is also instructive to consider emissions per unit of GDP, not so much this is an appropriate way for allocating emission rights, but because this measures, very crudely, the efficiency with which output is produced relative to the global cost in terms of emissions. GDP is measured in dollars, and the conversion can be made either at the market/official exchange rate, or in purchasing power parity units. The latter is a better measure of real income, and we therefore use this in the paper. Table 2 shows that the South has a higher rate of emissions per unit of GDP than the North, but this difference is not as large as one might imagine, being about one-third higher. Eastern Europe and the USSR have very high emission/GDP ratios, over double that of the OECD countries. There is also substantial divergence between OECD countries, with North America having an emission/GDP ratio one and a half to two times that of Japan/W.Europe.

3 EFFICIENCY VS EQUITY IN EMISSION CONTROL

Is there a conflict between efficiency and equity in the distribution of emission entitlements? Prima facie, there indeed seems to be some conflict. Many of the developing countries have a low level of overall emissions - as we saw in Table 2, per capita emissions are much lower in the developing world as compared to the developed world. However, the industries in these countries are often energy inefficient, use older technologies and are hence more polluting. A crude measure of this is the higher level of emissions per unit of GDP in the developing world - this is only a crude measure since the composition of GDP is very different in different countries. Countries with a high ratio of emissions to GDP, and in particular with a high ratio of fossil fuel CO_2 emissions relative to GDP, will tend to have lower costs of abatement. This is because their current technologies/practices are often energy inefficient relative to alternative technologies which are

available. It is argued that this is the case in the former USSR/Eastern Europe and China and India, where the greater use of coal also contributes. Many developing countries could also reduce emissions by controlling deforestation, and this is a measure which may be warranted independently, quite apart from its impact upon the greenhouse effect. Since greenhouse gases are a truly global pollutant, it matters not, from the point of view of global warming potential, where emission reductions are brought about. If it is cheaper to reduce emissions in developing countries rather than in developed countries, this would be an efficiency argument for focusing on reducing emission in the former. However, would this not conflict with the equity?

It is indeed the case that any system of non-tradeable emission entitlement will bring about a conflict between equity and efficiency. There is no reason for these two principles to coincide, and indeed, for some very plausible principles of equity, such as equal per-capita entitlements, the divergence can be very large. This criterion implies that developing countries could increase emissions, while developed countries will have to make substantial reductions. However, an efficient system of emission reduction is one where emissions are reduced at lowest cost, in terms of output. If emission entitlements are distributed on a per-capita basis, targets which are acceptable to developed countries will be well above what developing countries need, and hence the latter will be under no pressure to reduce the GHG emissions in process of development.

Barrett (1991) estimates costs of reaching a given emission target for the European Community under alternative schemes for distributing this target among member states. He finds that uniform obligations are very cost inefficient, and in an illustrative calculation, finds that their total cost is almost 50 times the cost of a cost effective policy. The cost difference is likely to be even larger in the case of the world as a whole, where

differences in the marginal costs of reducing emissions are likely to substantially larger than within the European Community.

A second problem with non-tradeable emission entitlements is that distributional considerations will influence the global emission target. To illustrate this point, consider the case of a equal percentage reductions. This will be extremely costly for low polluters and for the developing countries, and consequently they will press for higher global emission targets. Considerations of equity will therefore dictate a higher global target, than that indicated by our earlier analysis. Take another case, of equal per-capita emissions. This may be more equitable. However, countries with low levels of per capita income, but with a high level of emissions relative to income (such as many developing countries including China), will have no incentive to reduce emissions, even when these can be acheived at relatively low cost. Opportunities for cheap emission reductions will be foregone as a consequence.

This conflict between efficiency and equity can however be avoided by allowing emission entitlements to be traded. With tradeable entitlements, a country which is obliged to reduce emissions must either do so itself, or persuade another country to do so, and buy its entitlement. A country such as the United States which has a high level of emissions, but which may also have a high marginal cost of reducing emissions, has the option of persuading China to control its emissions in exchange for monetary compensation. Indeed, if the market for tradeable entitlements is competitive, it can be shown that the resulting distribution of emissions will be efficient - a target level of emissions will be achieved at minimum cost. Conseqeuently the entitlements may be distributed on an equitable principle, since trade allows us to achieve efficiency independent of the intial distribution of entitlements. The system we refer to is of course one of tradeable emission quotas. Each country is

allocated a quota of permissible emissions on some distributional principle. Countries may however trade their quotas, so that a country which would like to emit more CO_2 than its quota can buy quotas from a country which has a surplus of quota relative to emissions. If the market for quotas is competitive, the price of one unit of emission quota is the opportunity cost of one unit of emissions in terms of convertible currency, and this is the same for all countries. Consequently, this system achieves an efficient allocation of emission reductions.

It must be noted here that a global target for emissions can also be achieved efficiently via a uniform global tax on emissions, which would be levied by an international authority upon individual countries. This is the carbon tax which has been discussed by a number of authors (Epstein and Gupta, 1990; Hoel, 1992; Whalley and Wigle, 1991). This tax revenue can be re-distributed to countries, in way consistent with distributional criteria. It can then be shown that the global tax acheives an efficient allocation of emission reductions provided that no country has a large share in tax revenues, *at the margin*. A system of tradeable entitlements is similar to a global carbon tax - indeed, in the absence of uncertainty and with an appropriate distribution of tax revenue the two systems are equivalent. We shall focus on quotas since they can be naturally related to our discussion of equitable entitlements.

4 INTER AND INTRA- GENERATIONAL DISTRIBUTION

Greenhouse gas emissions are a case of market failure, and indeed of the failure of individual nation states, which requires remedial action at the international level. Individuals, in the course of economic activity emit greenhouse gases which contribute to global warming. The costs of their economic activity are incurred by future generations, world-wide. Although

each individual may be concerned about the welfare of future generations, he/she has too small an impact as an individual to be able to take corrective action unilaterally. Indeed, since the greenhouse effect is a global problem even nation states are too small to internalize this negative externality. The global environment is perhaps best seen as a public good, which current generations collectively bequeath to future generations. Individual nations, by reducing their emissions, leave a safer environment for future generations in the entire world. However, emission reductions in any one nation may be too small to have a significant global effect, and furthermore, can be offset by increased emissions by other nations. Collective international action in order to solve this problem is therefore imperative.

Consider the following stylized representation of the problem, which may clarify the interaction between inter-generational and intra-generational issues. Let there be N countries, and index countries by the superscript i. Current national income, y^i, is assumed to be a increasing, strictly concave function of the level of GHG emissions in country i, g^i - this reflects the fact that control of greenhouse gas emissions is costly, and the marginal cost of emission control is increasing, the more we reduce emissions. National income may either be consumed or saved; in the latter case t^i is transferredto the future generation. Write U^i for the utility of the current generation in country i. This depends both upon the current generation's consumption, and upon the utility of its descendents, V^i. V^i is increasing in the transfer received by the tomorrow's generation, t^i, and decreasing in the total level of global emissions, G.

$$G = \sum_i g^i \qquad (1)$$

$$U^i = U^i(y^i - t^i, V^i) \qquad (2)$$

$$y^i = f^i(g^i) \qquad (3)$$

$$V^i = V^i(t^i, G) \qquad (4)$$

This stylized model incorporates two features which we think are important. The current generation in each country is "partially altruistic" in two senses. Firstly, it cares only about its own descendents, and not the future generation the world over, so that its utility depends only on V^i. Secondly, its concern about its own descendents could be limited, so that V^i could affect U^i only weakly.

If each country chooses according to its self-interest, it maximizes its utility function with respect to the level of emissions, g^i, and the level of transfers, t^i. This gives rise to the first-order conditions:

$$dU/dg^i = U_y(.)\, f_y(.) + U_v(.)V_G(.) = 0 \qquad (5)$$

$$dU/dt^i = -U_y(.)\, f_y(.) + U_v(.)V_y(.) = 0 \qquad (6)$$

(5) and (6) must be satisfied at an optimum for each country. Recall from (4) that the partial derivatives of V depend upon G, the total level of global emissions. Hence, each country's optimal choice depends upon the sum of emissions of every other country. A non-cooperative equilibrium, is a pair (g^i, t^i), $i = 1,2,\ldots N$, such that (5) and (6) are simultaneously satisfied for each country. It is instructive to re-write the first order conditions as (7):

$$V_G(.)/V_y(.) = -f_g(.) \qquad (7)$$

This has a ready intuitive explanation. Each country chooses g^i to equate the marginal rate of substitution of its descendents between income and emissions, to the marginal cost of reducing emissions, in terms of income.

It is easy to see that such an equilibrium is inefficient, because emissions are a public bad. Each country's emissions decrease the welfare of future generations in all other countries, but the country only takes into account the effect on its own descendents while making its choice. However, our primary concern is with the ethical aspect of this problem. What are the implications of this doubly partial altruism for intra and inter-generational distribution?

Consider first the implications of the fact that each country cares only for its own descendents. Its concern is expressed through a transfer in two forms - a transfer of the private good, t^i, and a transfer of the public good, the global environment. The former can be directed exclusively to its own descendents, while the latter necessarily accrues to the future generation the world over. Since the country is concerned only about its own descendents, the transfer of the private good is more effective for this purpose. Consequently, partial altruism results in an excessive level of emissions. Each country will over-exploit the environment, thereby adversely affecting future generations in other countries. It compensates (or in fact, overcompensates) its own descendents for this adverse affect by transferring the private good. In effect, each country uses the global environment to alter the distribution of welfare within the future generation - it takes welfare away from the other countries and gives to its own descendents.

If all countries are symmetrically placed, the redistributive effect cancels out. The inefficiency still remains since the level of emissions is too high, being used for this re-distributive purpose. The redistributive effects do not cancel out if countries are asymmetrically placed. To take a simple example, consider two countries which are otherwise identical, except for the the fact that the first (the rich country) is generates more income from each unit of emissions than the second (the poor country). In

equilibrium, the first country will have a higher level of emissions than the second, and will also transfer more income to its descendents. In effect, the present generation in the first country can effectively re-distribute welfare within the future generation, from country two to country one.

Although we may care for the future generation, we may do so insufficiently, so that V may carry very little weight in our utility function. What are the implications of this sort of limited altruism? The first implication is that we may transfer too little to the future generation, both in terms of the private transfer and by degrading the global environment. An ethically adequate altruism will imply that we would have to increase both transfers. In other words, we would be called upon to reduce emissions of greenhouse gases to a level which is consistent with the future generation having a level of welfare to which they are morally entitled, rather than that which we deign to give them.

5 MORAL THEORIES IN THE CONTEXT OF GLOBAL WARMING

To recall our discussion in the introduction of this paper, concern about global warming is essentially a moral concern. There are two quite different ways in which a moral concern for future generations can be expressed. The first, which is the route taken by welfarism, is a concern with the well-being of the future generations, so that their welfare is incorporated along with that of the current generation in the social calculus. A welfarist concern suggests that the uncontrolled emission of greenhouse would reduce the (expected) welfare of future generations below acceptable limits. It asks us to place ourselves in a neutral position, to divorce ourselves from our position in the current generation, and to ask, is the distribution of welfare between us and our descendents morally defensible. An alternative moral position concerns itself not with the welfare of future

generations, but their rights. In this view, the global environment is a common resource of us and of future generations. We can in justice appropriate a part of it for our purposes only if there be, in Locke's words, "enough and as good left in common for others".

Let us begin by examining the implications of a welfarist position. There are, of course, several variants of welfarism. Utilitarianism asks to choose between alternative social states so as to maximize the sum of individual utilities. Rawls' difference principle (1972) asks us to maximize the welfare of the worst-off person. Broome (1993) favours critical-level utilitarianism, which was first proposed by Blackorby and Donaldson (1984) - we should seek to ensure that every one has a critical minimum level of welfare, and having achieved this, we should be utilitarian. These welfarist principles are very different. However, in the context of global warming and on the question of intra-generational distribution, it is possible that they may give very similar conclusions.

How is this possible? After all, Rawls requires that we maximize the welfare of the least well off, whereas utilitarianism simply looks at the total sum of utility, irrespective of its distribution. These different theories may have similar practical implications because the distribution of welfare in the world today is so far removed from any utilitarian optimum. Given the widespread inequalities in the world today, it seems very likely that the marginal utility of one dollar to a poor Bangladeshi is substantially greater, and in fact of a different order of magnitude, than the marginal utility of one dollar to an average American. Utilitarianism would, in this context, require a re-distribution of dollars towards the Bangladeshi until marginal utilities were equalized. Until that point, the practical difference between utilitarianism and the difference principle may be slight.

One may of course dispute the claim regarding the relative sizes of

the marginal utility of one dollar. However, it seems to me that the only reasonable way to dispute this is by denying that one can compare utilities across persons. If we do not allow for inter-personal comparisons of utility, we do not allow for the possibility of any utility-based moral theory. To the extent that we want to use any welfarist moral theory, we must allow for inter-personal comparisons of utility, and having allowed that, it seems unreasonable to dispute the conclusion regarding marginal utilities.

To conclude, any welfarist theory suggests that the burden of global warming should be put squarely upon the shoulder of the North. Of course, the qualititative conclusion is quite independent of the issue of global warming. The above argument would suggest a large transfer of wealth from the North to the South even if global warming was not a problem.

The welfarist theory of justice is disputed by rights based theories, such as those advanced by Locke, and more recently, by Nozick (1974). Nozick argues that the justice or otherwise of a social state cannot be evaluated by simply looking at the well being of individuals in that state. Individuals have rights, including the right to appropriating what they have produced or acquired justly, and any re-distribution on welfarist grounds would infringe their rights. Nozick's theory would argue that the difference in well being between the American and the Bangladeshi is irrelevant, and may be consistent with justice. What matters is whether the resources which allowed the former to be well off are justly appropriated or not. If the condition of just appropriation is satisfied, redistribution is uncalled for. If the original appropriation is unjust, redistribution may be called for in order to ensure "justice in rectification".

There are two questions which arise in the context of the exploitation of global environmental resources. First, what does a rights based theory imply for the obligations of the current generation towards

future generations? Second, if differences in well being in the world today are related to unjust past appropriation of global environmental resources, is redistribution called for on the grounds of "justice in rectification"? We address the first question in the remainder of this section, and leave the second for the final section.

Locke suggested that private appropriation of a resource was just if there be "enough and as good left in common for others". In the context of a scarce resource (such as the global environment), it is clearly literally impossible to leave enough behind for others if one uses it at all. Nozick therefore re-interprets the proviso: my appropriation is just if "the situation of others is not worsened" (Nozick, 1974, p 175). Nozick's proviso is very weak, as Cohen (1986) argues, since it allows the appropriater all the retain all the benefits of acquisition. Nevertheless, even this weak proviso has some bite in our context. If we contribute to the greenhouse effect, thereby adversely affecting the future generation, it is incumbent upon us to compensate them for this adverse effect. Our exploitation of the global environment allows us to enjoy a higher level of real income than would be possible in the absence of such exploitation. We should save a part of this real income, and transfer it to the future generation, say as capital.

The future generation is however heterogeneous, and will be differentially affected by global warming - land-locked Switzerland may not suffer any adverse effects from global warming and may even benefit whereas a rise is the sea level could be disastarous for an island state such as Tahiti, or low-lying Bangladesh. Here the Nozickian proviso, that no one be worse off, requires us to make *differential* transfers - more to tomorrow's Tahitians and less to the Swiss. A given level of global emissions today entails a distribution (across countries or regions) of ill-effects in the future. These adverse effects must be compensated for by transferring resources from today's

generation to those affected in the future.

The above discussion makes clear that current emission entitlements also entail a corresponding liability, for compensating future generations. How are the emission entitlements to be distributed within the current generation? The Lockean provise, that "enough and as good be left in common for others", suggests that each individual in the current generation has an equal share in this global resource. It suggests that countries should be distributed emission entitlements on the basis of their populations. Further, the liability to compensate future generations should be based upon the emission entitlement.

6 CRITERIA FOR DISTRIBUTING EMISSION ENTITLEMENTS

A number of criteria have been proposed as bases for distributing emission entitlements, which we can examine in the light of the preceding discussion.

1) *Entitlements based on "Grandfathering"*

Grandfathering refers to the establishment of a property right through use. In the context of the global environment, this criterion implies that entitlements to emit in the future will be equal to current emissions. In other words, those who are currently polluting excessively have thereby established a right to continue polluting in the future. If total emissions are to be reduced, this principle implies that emission entitlements will be proportionately reduced, so that each country will be called upon to make *equal percentage reductions* in emissions. In either case, this criterion is facourable to the developed countries, which have a high level of current emissions, and adversely affects developing countries. On this basis, Table 2 suggests that developed countries with 23 percent of the world's population will be alloted 58 percent of the world's emission entitlements, whereas

developing countries with 77 percent of the world's population will be alloted 42 percent of entitlements. Per-capita entitlements in the North will be, on average, 4.6 times as large as those in the South. Since this doctrine is unfavourable to the South, it is sometimes sought to be tempered by requiring deeper cuts for countries which have had a greater historical contribution to emissions. Extending this, it may also be possible to allow for *negative cuts*, i.e. to allow developing countries to increase emissions. However, the underlying basis on which rights to the global commons are sought to be defined is the same in all these variants - the right is established through usage.

Grandfathering is based upon the *status quo doctrine* : the current rate of emissions confers a *status quo* property right that is established by the use of the right in the past. Consequently, if reductions are to be made, each country must be dispossessed from its status quo right equally.

This is grossly inequitable, since developing countries, whose emissions will surely rise from their extremely low levels at present, are penalised. Even among developed countries, it punishes those countries which have made the greatest efforts at energy efficiency such as Japan. Such countries have lower levels of emissions as compared to the US, and the costs of additional emission reductions are substantially greater for them.

Recall our discussion of section 4, where we argued that a rich country could use the global environment as a way of transferring welfare to its descendents. Grandfathering is doubly dubious: not only is this transfer not addressed, a further benefit is conferred upon those who over-exploit the environment.

2) *Emission Quotas Proportional to GDP*

The logic of this allocation is that all production should be required to be equally clean. This may seem an efficient way of achieving any global target,

but this is not the case if quotas are not tradeable. The scheme without tradeable quotas requires countries to achieve the same *average* level of GDP to emissions. This is different from equating the marginal cost of emissions in terms of international currency. The latter can be shown to be the appropriate criterion for an efficient allocation of emission reductions. Distributionally, this scheme would be most favourable to Japan and Western Europe, and least favourable to Eastern Europe/former USSR and the developing countries. Given that there is no efficiency requirement for operating this scheme, the distributional criteria is based on the idea that the richer countries should have more of the world's common resource.

3) *Equal Per-Capita Emission Quotas*

The basis for this principle is that the world's environment belongs equally to all human beings, and each one is entitled to an equal share. In other words, whatever the target level of emissions, permits should be shared out between countries on the basis of their share in world population. This principle entails a distribution of emission entitlements which is very different from the distribution of actual emissions, since the LDCs have a greater share of world population than of emissions. Opposition to this principle is essentially on the "pragmatic" ground, that this would be unacceptable to developed countries.

With equal per-capita entitlements, each country would have an aggregate entitlement proportional to its population. The question arises, should the aggregate entitlement in a particular year be based on the population in that year, or should it be based on population in some base year, say 1994? Several writers (Grubb, 1989 for example) have argued in favour of the latter. They suggest that if entitlements were based on current population, poor countries, which would trade some of their entitlements for foreign exchange, would have a positive incentive to increase population, so

as to increase their foreign exchange earnings. The emission entitlements scheme would therefore have the undesirable effect of increasing population. This argument however seems incorrect, at least on the assumption that governments are concerned with per-capita income (or per-capita welfare). An increase in population which raises total entitlements may increase the total foreign exchange earned by selling entitlements. It will not increase per-capita foreign exchange earnings, and will therefore not raise per-capita income. Per-capita income is likely to fall due to the rise in population, given the scarcity of other factors such as land and capital. Consequently, a tradeable entitlements scheme based on current population will be neutral in its effect on population - it creates no additional incentive for higher or lower population size. Of course, if entitlements are based on population in the base year, this creates an additional incentive to reduce population growth.

If we start from the position that each individual has an equal right to global environment, the allocation of emission quotas is straightforward. Given the global emission target, this is simply divided by the global population, and each country is allocated quotas in proportion to its share of the world population. It is immediately obvious that most developed countries would then have a deficit of allocated emission quotas relative to their desired level of emissions, whereas developing countries would have a surplus. Consequently, trade in quotas would bring about transfers between countries. An equivalent allocation can be brought about by an international carbon tax. This would be a specific tax which would be levied on each ton of equivalent carbon.

7 RECTIFYING HISTORICAL INJUSTICE AND GLOBAL WARMING

The discussion hitherto has been based an allocating entitlements to current emissions, without reference to the historical record of contribution

to current concentrations of greenhouse gases in the atmosphere. This is inadequate for the following reason: increases in the concentration of CO_2 in the atmosphere have taken place over a prolonged period of time, and the long life of CO_2 in the atmosphere implies that CO_2 emissions have their effect over a long time span, of 100 -200 years. In other words, the greenhouse effect is not merely due to current generations but also due to generations past. Fujii (1990) and Smith (1991) have attempted to calculate the overall responsibility for different countries for current CO_2 concentrations. This involves calculating the cumulative effect of emissions since 1800, where emissions at an earlier date are discounted by the rate of CO_2 decay. In the case of methane, the residence time in the atmosphere is short, so that the difference between current emissions and cumulative emissions is not very large. Table 1 shows current emission shares and the overall contribution to concentration, region-wise. The contribution of Western Europe and North America to the concentration is much greater than their share of current emissions. Historical emissions from LDCs have been extremely low, and hence their low share in contributing to overall CO_2 concentration.

Fujii (1990) argues that each individual in each generation has the same emission entitlement. He divides each region's contribution to current GHG concentration by the total population of the region, past and present, in order to derive the contribution per-capita. This is even more unequal across countries than the distribution of current emissions per capita. Fujii argues that developed countries owe LDCs a debt because of their excessive emissions in the past. This point is also made by Smith (1991, 1993), who calculates a natural debt index - an index of how much each country has borrowed from the natural environment. Both Fujii and Smith argue that this debt should be repaid, and that emission entitlements should correct for this repayment.

Consequently, equitable allocation would require that LDCs have greater emissions per capita as compared to developed countries, reflecting the difference in natural debt.

What is the validity of this argument, which holds current generations in the North responsible for the emissions of their ancestors? Can one argue, as Fujii and Smith do, that the North must today repay the natural debt incurred by previous generations? Or can one take refuge in an individualist position, and argue that the natural debts incurred by past generations in the North have perished along with those who incurred them?

If one takes a welfarist moral position, one can argue that history is irrelevant. One can argue for a re-distribution between North and South on welfarist criteria, given the enormous inequalities that exist in the world today. However, the question of precisely how these inequalities came about is irrelevant for a welfarist, and the fact of past exploitation of the environment by the North makes no difference to the argument. However, for a rights-based moral position, the question of the historical responsibility is indeed critical. Can one then take a purely individualist position, and argue that nations as such bear no responsibility, and it is merely the individuals who lived in the past who bear responsibility? If current generations in any country are not responsible for the acts of their parents or of earlier generations, Why should they have to repay a debt which they played no part in incurring? On this reckoning, developed countries may have indulged in excessive emissions of greenhouse gases in the past, but there is no way they can be held responsible for this, since the individuals who were responsible no longer exist.

This argument does not stand for several reasons. The first, and rather obvious reason, is that much of stock of carbon di-oxide currently in the

atmosphere has been emitted in the lifetime of the current generation. However, more importantly, it can be argued that the current generation may also have to take responsibility for past emissions, even if we do not want to attach any moral opprobrium upon them for this. The current generation is the beneficiary of *resource transfers* from previous generations. These resource transfers take various forms, including physical capital, human capital investments, and knowledge, as well as natural and environmental resources *within* developed countries. These resource transfers have been possible only because of the exploitation of global environmental resources by previous generations. If the earlier generations in the developed world had been constrained from degrading the global environment to the extent they have actually done, they would have suffered through lower level of per-capita income. In consequence, they would have been less able to to save and invest in productive capital, and less able to transfer productive assets to the current generation. Developing countries have a claim to a part of these transfers, simply because they were made possible by the excessive use of global environmental resources by previous generations in the developed countries. Put somewhat differently, if current generations in the Northaccept *assets* from their parents, then its is incumbent upon them to also accept the corresponding *liabilities*.

There are two caveats in applying this argument. Firstly, if the past generation has transferred more liabilities than assets, the current generation in the North could well be justified in accepting neither. However, this qualification would not be relevant in this context, given the large amounts of wealth transfers to the current generation. Secondly, excessive Northern exploitation of environmental resources may have also enabled a greater stock of global *public* goods to be transferred. Scientific knowledge is one example. These public goods may benefit all countries today, albeit to

different degrees, and to the extent that such transfers were enabled by environmental exploitation, and to the extent that they benefit the South, the North today has to compensate the South less.

What about the argument that the natural debt idea is invalid since the North was unaware of the possible harmful effects of emissions of greenhouse gases? It seems to us that this argument is misplaced. Ignorance of the harmful effects simply means that previous generations bear no *moral* blame for their actions. However, no matter what the motivation of their actions, their effect was to benefit their children, by permitting a larger extent of transfers of assets, and to worsen the global stock of environmental resources. Ignorance does not undo the case for corrective action today. A theft analogy is appropriate here. If I take an object, not knowing that it belongs to you, and give it to my daughter, you are surely entitled to reclaim it, even though neither my daughter nor I may be a thief.

8 CONCLUSION

We have argued that questions of inter-generational as well as intra-generational equity must necessarily be confronted if we are to have a meaningful discussion of global warming. These questions of distribution can be addressed from a number of divergent viewpoints. Nevertheless, we find all these viewpoints seem to give qualititatively similar conclusions - that current generations have a responsibility to the future, and the burden of this responsibility must be borne largely by the North.

TABLE 1

PERCENTAGE SHARES IN CO_2 EMISSIONS, POPULATION, GNP

	(1) 1988 emissions	(2) cumulative emissions	(3) population	(4) GNP
North America	25.2	33.2		
W.Europe	15.0	26.1		
E.Europe+USSR	25.6	19.6		
Japan + Oceania	6.1	4.8		
Developed countries	71.9	83.7	23	84
LDCs	28.1	15.0	77	16

Notes: (1): Industrial CO_2 emissions. (2) contribution to current concentration of CO_2 in the atmosphere, based on cumulative emissions since 1800, adjusted for decay.

Sources: Grubler and Nakicenovic (1992), Young, 1991.

TABLE 2

TOTAL CO_2 AND METHANE EMISSIONS, 1988

	(1) 1988 emissions	(2) Per capita emissions	(3) Emissions per unit GDP
N. America	1.64	6.06	0.34
W. Europe	1.00	2.62	0.21
Japan + Oceania	0.40	2.82	0.22
E.Europe+USSR	1.70	4.25	0.75
Developed countries	4.73	3.97	0.35
LDCs	3.39	0.87	0.45

Notes: (1) Total emissions in gigatons of carbon equivalent

(2)tons of carbon equivalent per head of population

(3) tons of carbon equivalent per $1000 PPP equivalent.

Source: Grubler and Nakicenovic (1992).

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