Justice, Equity and Efficiency in Climate Change:
A Developing Country Perspective

P.R. Shukla

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Chapter 9

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9.1 Justice and Equity in Climate Change

“Justice”, as Rawls (1971) has pointed out, “is the first virtue of social institutions”. Justice principles are needed to evaluate or propose alternate distributions. Justice in this sense is a distributive concept. A distribution may affect the evaluation criteria, such as welfare, directly or indirectly. Equity refers to normative criteria for judging the distribution. The equity is also defined as “the quality of being fair and impartial” (see Flexner, 1987). In either sense, equity is basic to the justice process. The global climate change phenomenon, arising from the accumulation of greenhouse gases in the atmosphere emitted by anthropogenic activities, influences the welfare globally. The climate change mitigation regime requires evaluation of alternate policies that would redistribute the welfare effects among the nations. It is therefore an important issue requiring justice intervention.

The complexity of justice question, in the context of climate change, arises from the global and long-term character of the problem and the asymmetry of actions and their external effects (i.e. impacts) spatially and temporally. The actions causing the climate change, i.e. the greenhouse gas emissions, take place globally. Limiting emissions helps to mitigate the impacts. The emissions limitation is a justice problem requiring distribution of rights to emit, i.e. to use the atmosphere, to different nations. This is just one dimension of the justice problem. Adaptation to impacts and the compensation to impacted parties are the other justice concerns.

The climate change impacts have two characteristics: i) for a given global emissions trajectory, the distribution of impacts across the nations is independent of emissions profile of each nation, and ii) the impacts are felt over a long time horizon due to the long life of greenhouse gases in the atmosphere (see Houghton et. al, 1996). The justice has to therefore address both the intragenerational and intergenerational equity concerns. This paper discusses primarily the distribution of emissions entitlements across the
nations, an intragenerational distributive justice problem, and the efficiency; from the perspective of developing countries.

9.2 Unfair Background Conditions

What shapes the distinct justice concerns of developing countries in climate change issue? This is a practical question, the understanding of which may help laying a robust foundation for climate mitigation regime. The primary justice issue in the present climate negotiations pertains to the distribution of emissions entitlements. This is a bargaining problem with multiple players. In bargaining theory, players reach a voluntary agreement only when it makes every player better off (Pareto improvement) compared to the status quo (see Kverndokk, 1995). When bargaining power is unequally distributed, the agreement may not be Pareto optimal.

The current balance of power is unequally distributed in favour of developed countries - who control most of global capital, military power, natural resources and knowledge resources. The unfair background conditions are the end-products of historical and natural processes. Their influence on the rules of bargaining is the principle justice concern for developing countries.

The developed nations are the main contributors to greenhouse gas emissions historically. Their emissions are now declining, whereas emissions from developing countries are rising. The energy resource endowments in many developing countries are more polluting, like coal in China and India. The unfavorable background conditions, compounded by rising future emissions can potentially translate into an agreement that may transfer mitigation burden to developing countries in contravention with several equity criteria discussed later. Justice in this context is vital for inviting wide participation from developing countries in the climate regime, a main criteria for the success of the regime (see Kverndokk, 1995).

9.3 Asymmetry of Emissions and Impacts

The causal relationship of emissions with impacts is central to the climate change issue. The climate change burden includes the costs of emissions mitigation, adaptations, impacts and risks (see Chichilnisky and Heal, 1993). The asymmetry between emissions and impacts highlights the equity concerns in climate change problem since a greater burden of impacts is distributed to poorer nations by natural processes, while most anthropogenic greenhouse gas emissions arise from economic activities in affluent nations. Since the impacts are inadequately understood, the higher risks are imposed on poorer nations. The valuation of impacts also pose serious difficulties, especially in developing countries where the insurance markets are not developed and the valuation is plagued by the controversies on value of life and future purchasing power parity trajectories (see Shukla, 1996b).
The climate change phenomenon coincides with the period when many developing countries are set for rapid economic growth. The timing of the phenomenon is thus unfavourable to developing countries. The asymmetry of emissions and impacts, and the unfavourable timing makes the climate change a classic problem requiring balance among the economic development, environment and distributive justice. The climate change mitigation strategies thus transgress into a larger economic development agenda, especially in developing countries, requiring simultaneous examination of justice, equity and efficiency concerns.

9.4 Minimizing the Burden Size

The United Nations Framework Convention on Climate Change (UNFCCC) advises that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost (see UNFCCC, 1992 - Article 3.3). The UNFCCC also exhorts that: Parties, that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration (see UNFCCC, 1992 - Article 3.2). The aim of climate negotiations is to thus minimize the cost as well as to distribute the burden equitably. In other words, the UNFCCC is concerned with minimizing welfare burden, and minimizing the mitigation cost as a corollary.

The economic theory of this perspective, the neo-classical economics, assumes existence of efficient market dynamics universally. The market efficiency and cost effectiveness are hence equivalent. To be efficient, the mitigation actions across the nations, sectors and time periods must have equal discounted marginal costs. The climate change being a global and long-term problem, the search for efficiency leads naturally into a where and when flexibility (see Richels et al., 1996), i.e. to decide the location and time of mitigation actions which equalize the marginal costs across the nations and in time, and thereby minimize the global mitigation cost, i.e. the size of the burden. The neo-classical economics, and the agenda of the developed countries, goes only this far. The distribution of mitigation burden is considered a separate problem, merely a secondary side-payment issue.

But, the emissions mitigation cost is just one component of climate change burden. The others are cost of impacts, which are distributed across the nations by climatic processes, and costs of adaptation. The aim of climate negotiations is to minimize the welfare losses and not the emissions or mitigation costs alone. Minimizing the welfare losses requires dealing up front with equity, i.e. the distribution of total welfare burden, including the distribution of side-payments. This is the basic aspect of developing country perspective in climate negotiations. The welfare concept subsumes both the efficiency and equity. The climate negotiations should first address the right measure for the burden. Economics is only then needed to help minimize the size of this burden.
9.5 Separability of Equity and Efficiency

A principal objective of the global climate change regime is to decide the norms for using the atmosphere, a global common. The Coase theorem (see Coase, 1960) stipulated that, in absence of transaction costs, the market exchange will lead to an efficient resource allocation regardless of the distribution of the rights. Alternatively stated, the Coase theorem suggests that the process of minimizing the size of the burden is independent of the burden sharing scheme. This result means that the market efficiency and equity are separate issues. To many neo-classical economists, this is a sufficient justification to discard the equity concerns from the domain of economics altogether.

This perspective, which during the past decade has gained ground with the emergence of the new world economic order, has treated the climate change problem merely as a search for a globally efficient mitigation regime. The focus of mitigation debate is restricted to minimizing the size of the burden. The market tautologies; like equalization of marginal costs across nations, sectors and time periods; have thus emerged as the sole means of deciding the participation of each nation in mitigation. The choice of efficient market instruments, like emissions permits or taxes, has been made the principle agenda for the global negotiations. This perspective, which justifies ignoring equity altogether, suits well the interests of industrialized nations in the climate change problem.

9.6 Equity and Efficiency: A Developing Country Perspective

The perspective above has apparent limitations. In negotiations, the parties not only have co-operative needs to minimize the global burden, but also competing needs to minimize own share. The game theoretic approaches which are designed around the concepts of efficiency and bargaining positions have contributed little to the global burden sharing problem, which is primarily a justice issue. The market efficient mitigation solutions naturally lead to significant mitigation actions in developing countries (see Manne and Richels, 1996; Richels et al., 1996) since the opportunities for low cost mitigation there are far greater due to prevailing market inefficiencies and inadequacies. Such proposals, arrived at by applying the efficiency concept alone, have raised obvious equity concerns from developing countries in the absence of simultaneous burden sharing proposals (see Shukla, 1996a).

Developing country perspective makes a contrary interpretation of the Coase theorem as compared to the existing neo-classical view. The cost-effectiveness, a la Coase theorem, is a simple technical issue of finding and agreeing on a market instrument such as emissions permits. The substantial issue in global negotiations then is not the efficiency, but the distribution or equity. Since the stakes are high, the interests of bargaining parties are in conflict and their justice perceptions differ widely, the principal challenge before the global negotiators is not to find an efficient instrument, but to harmonize these diverse perceptions and arrive at a widely acceptable mitigation arrangement.
Justice, from developing country perspective, is thus the primary concern of climate change mitigation negotiations. Its aim - to arrive at a “fair and impartial” distribution of mitigation burden. The developing country position on the neo-classical approach to the climate change problem can be succinctly summed up by reiterating the observation made by Rawls (1971): *A theory however elegant and economical must be rejected or revised if it is untrue; likewise laws and institutions no matter how efficient and well-arranged must be reformed or abolished if they are unjust.* An efficient world order for climate change mitigation, if unjust, would need alterations.

### 9.6.1 Equity in the UNFCCC

Varied equity criteria are explicitly considered in the principles of the UNFCCC (see UNFCCC, 1992). The special consideration for developing countries such as articulated through the “*common but differentiated responsibilities*” (Article 3.1) clause requires the leadership, i.e. greater acceptance of burden, by the developed countries in combating the climate change. Strong equity concerns are also reflected in the special attention and considerations proposed for the developing country parties, which are particularly “*vulnerable to the adverse effects of climate change*” and those who have “*to bear disproportionate or abnormal burden under the convention*” (Article 3.2). The exclusion of developing countries from any binding emissions limitation commitments in the present negotiations culminating in the Kyoto Protocol (see UNFCCC, 1997) reaffirms these equity concerns enunciated in the UNFCCC.

### 9.6.2 Procedural and Consequential Equity

The equity concerns are of two kinds (see Banuri et al, 1996), the procedural and the consequential. Procedural equity refers to the “impartiality and fairness” in the process of delivering and administering the justice. Consequential equity relates to assessing and remedying the consequences arising from climate change and the mitigation actions. The principles such as the participation of the affected parties in the justice procedure or equal treatment of all before the law belong to the notion of procedural equity. The specific procedural equity problems for developing countries in the global climate change regime arise from their poor information base, weak bargaining strength and inferior capacity to deal with the climate change.

The consequential equity addresses the sharing of the climate change burden. Various approaches to consequential equity such as parity, proportionality, priority, utilitarianism and distributive justice exist (see Banuri et al, 1996), however there is no consensus on the superiority of any single approach. The concerns relating to the consequential equity from the developing country perspective arise from:

1. their low historical contribution to the existing stock of greenhouse gases in the atmosphere (Table 1),
ii) their very low per capita emissions which are only a fraction of that in developed countries (see Banuri et al, 1996),

iii) high risk from climate change impacts (e.g. small island nations) compared to the size of their economy, and,

iv) lack of resources, technologies and capabilities to mitigate the impacts.

The rest of the discussion in the paper focuses on these consequential equity concerns.

9.7 Emissions from Developing Countries

The current per capita emissions (Figure 1) and historical contribution of developing countries to the existing emissions stock in the atmosphere is very small compared to the industrialized nations (Table 1). It is argued however that the rapidly rising emissions from developing countries shall reverse this position in a few decades. While the emissions from developing countries are growing at rates higher than those for developed countries, the per capita emissions of developing countries shall continue to remain substantially lower throughout the next century in absence of climate change interventions. This is evident from the analysis of per capita emissions for three well known emission scenarios proposed by the Intergovernmental Panel on Climate Change (IPCC), namely the IS92a, c and e scenarios (Table 2). These scenarios assume no climate change interventions and cover a full range of possible future emissions (see Legget et al, 1992; Pepper et al, 1992; Alcamo et al, 1995).

For each scenario, the per capita emissions in developing countries shall be below a third of the developed country emissions even in the year 2100 (Table 2). It is likely that some developing countries may reach the emissions level of developed countries before the end of the next century. Yet, even after a century, the per capita emissions in most developing countries shall remain far below those in industrialized countries. While the income gap is expected to narrow, the per capita incomes in developing countries shall remain a fraction of developed country incomes throughout the next century. Hence, the population of most developing countries will bear only marginal mitigation burden during the next century under a welfare loss minimization regime.

9.7.1 Future Global Emissions and Mitigation Needs

The IPCC emissions scenarios suggest that in absence of climate change mitigation interventions, the emissions during the next century shall result into very high concentrations of greenhouse gases by the end of the century (see Wigley et al., 1997). The IS92a scenario, often considered a mid-emissions scenario, would cause the carbon concentration from the fossil emissions alone to exceed 700 ppmv. The high emissions IS92e scenario would lead to an alarmingly high concentration of 950 ppmv. In these
scenarios, the rising emissions from the developing countries are a substantial fraction of global emissions. Thus, the concentrations shall reach alarming levels even if developed countries would drastically reduce their emissions throughout next century. The developing country participation therefore will be essential to keep the “greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with climate system” - the ultimate objective of the UNFCCC. The global climate policy needs to decide the acceptable stabilization levels to minimize the total climate burden, as well as an equitable burden sharing arrangement.

The cumulative emissions for the period 1991 to 2100 for different IS92 emissions scenarios are shown in Table 3. Two well-known stabilization trajectories are those proposed by the IPCC (see Schmiet et al, 1995) called “S” trajectories and by Wigley et al. (1996) called “WRE” trajectories. The cumulative emissions for these trajectories are shown in Table 4. A comparison of emissions from these trajectories with IS92 emissions suggests that stabilization 750 ppmv shall require substantial mitigation throughout the next century. Cost effectiveness apart, the substantial mitigation needs shall necessitate the early participation of developing countries. The pertinent question in the negotiation therefore is not whether or when the developing countries shall join the regime, but how the mitigation burden shall be shared. A just burden sharing regime is vital to ensure the wide participation from developing countries, which is a necessary condition for cost-effectiveness and stabilization of concentrations.

9.8 Equity Perspectives and Principles

Diverse equity perspectives and principles are debated in the context of climate change (see Rose, 1990; Rose and Stevens, 1993; Banuri et al, 1996). The central ones are - i) per capita entitlements (see Grubb, 1989; Agarwal and Narain, 1991), or egalitarian principle (see Rose, 1990), ii) historical responsibilities (see Hyder, 1992), iii) basic needs, iv) obligation to pay - a composite criteria that combines historical responsibility and basic needs (see Hayes, 1993), v) Rawlsian criteria (see Benestad, 1994), vi) ability to pay (see Smith et al., 1993), vii) “grandfathered” emissions (see Bodansky, 1993), and viii) utility maximization (see Chichilinsky and Heal, 1994). The present emissions limitations negotiations, leading to the Kyoto Protocol, have been centered around the “grandfathered” emissions criterion. The mitigation burden is distributed among developed nations as a percentage reduction from their current emissions. Developing countries are excluded from the binding commitments, keeping in view the historical responsibility and ability to pay criteria.

The “grandfathered” emissions criterion gives higher entitlements to present polluters. This distribution inherently disfavours developing countries since their current emissions are very low, but are rising rapidly. Since developing countries are excluded for the present from binding commitments under Kyoto protocol, the “grandfathered” criterion is not contested. The need in future to move away from the “grandfathered” criterion towards an equal per capita emissions is articulated through the “convergence”
framework. This framework proposes to begin at present with “grandfathered” emissions entitlements, which in future can converge to an equal per capita entitlements that can match the desired stabilization trajectory. While the convergence framework is a practical negotiation instrument, the equity considerations are still needed to determine the “convergence target” level and the timing of the entry of developing countries into the protocol.

### 9.8.1 Equity and the Convergence Criteria

The convergence framework proposes to bridge the gap in per capita emissions between developed and developing nation within a few decades. Prima facie, the compromise appears favourable to developing countries and also balanced for the developed countries. The “grandfathered” emissions criterion suits well the present needs of developed nations. Equal per capita emissions entitlements fits well with the developing country demands. The convergence framework has limitations and unless it is designed with strong equity concerns, it shall contravene several accepted equity criteria like the obligation to pay, Rawlsian criteria and utility maximization.

The per capita emissions gap between developed and developing nations today is manifold (Figure 1). Under the business-as-usual, the trajectories of many developing countries will cross the target, thus making them the net buyers of entitlements after a few decades. An early entry of developing countries into a convergence protocol which uses “grandfathered” allocations in the early decades and equal per capita emissions later can be doubly inequitable. This is likely to happen under the conventional conception of convergence (see Jepma and Munasinghe, 1998), illustrated in Figure 2a, unless the entry of developing countries and their entitlement allocation are decided based on equity criteria like historical responsibility, ability to pay and Rawlsian philosophy. The presumption that the per capita emissions trajectories of developed and developing nations shall converge without crossing the target makes developed nations the net gainers of emissions entitlements (Area A: Figure 2a) and developing countries the net contributors (Area B: Figure 2a) for all times - past and future.

The income effect (see Kuznet, 1955) is likely to cause the per capita emissions from developed countries to transit to a declining trajectory earlier than in developing countries. In later periods, the developing countries will experience a rising burden of buying the entitlements or incurring mitigation costs. For instance, the present per capita carbon emissions from China are 0.6 ton of carbon. These are rising rapidly. The stabilization trajectories (see Wigley et. al, 1997) would require the convergence to be below 0.7 tons of carbon per capita later in the next century. Even if the targets in earlier periods are set at higher levels, say at around 1 ton of carbon per capita, China shall become a net buyer of entitlements within a decade or shall have to incur significant emissions mitigation costs for transiting to a lower carbon emissions trajectory. This can be unfair from the historical responsibility and ability to pay perspectives.
A more equitable convergence scheme, from developing countries perspective, may follow the trajectories as shown in Figure 2b. The developing country per capita emissions can first cross and then converge to the target level, while on a downward path following the Kuznet curve. Alternatively, the equity criteria would recommend a changing target level that at first follows a rising and then a declining trajectory, together with an early entry of developing countries so that they earn and bank the entitlements for later use.

9.8.2 Technology Protocol with Income based Entry

Edmonds and Wise (1997) propose a different equity criteria that considers an income based entry for developing countries into a technology oriented mitigation protocol. The protocol is proposed in three parts.

1. Any new fossil fuel electric power capacity in Annex I nations installed after the year 2020 must scrub and dispose of the carbon from its exhaust stream;
2. Any new synthetic fuels capacity must capture and dispose of carbon released in the conversion process; and
3. Non-Annex I nations which participate must undertake the same obligations that Annex I nations undertake when their per capita income, measured by purchasing power parity, equal to the average for Annex I nations in 2020.

The global analysis based on the model runs shows that the protocol is adequate to stabilize the CO2 concentrations below the 550 ppmv level. The developed countries (Annex I) join the protocol after 2020, but their effective contribution in the analysis begins after 2035 due to - i) the slow change in technology stock due to lower growth rates, and ii) long time periods used for the model analysis. The additional cost of carbon removal technologies is thus small in early decades. As per the part 3 of the proposal, most developing countries would enter the protocol during the second half of the next century. Prima facie, the income clause in the protocol seems fair to the developing countries. In reality however, that developing countries like China would enter the protocol around 2040, i.e. just a decade after the developed countries have begun implementing the protocol.

While the protocol demonstrates the feasibility of stabilizing the concentrations through a strong technology push, it is neither cost-effective nor does it ensure an equitable distribution of mitigation burden. The merit of the protocol is that it directly integrates technology strategy with the equity criteria and the mitigation strategy. The protocol has strong technology assumptions which may not be attainable at reasonable costs. The sense of security promised by the results that a strict stabilization trajectory, such as 550 ppmv, can be attained by mitigation programmes which can begin as late as in 2030 to 2040 may prove false if these strong technology related assumptions do not materialize.
The income based “graduation clause”, which decides the entry of developing countries within the protocol, is an indirect equity measure. Since the rest of the technology conditions are presumed identical for all entrants, the protocol gives a sense of “fairness”, which is illusive since the nations have different economic structures, resource endowments, technological capabilities and emissions profiles.

9.9 Conclusions

The three important attributes, the long time horizon, global nexus and the need for wide participation, make the climate change mitigation a truly complex problem. Success of the regime depends on the robust foundations built early (see Toman and Burtraw, 1991; Kverndokk, 1995; Rayner et. al, 1997). Justice, equity and efficiency are the three pillars of climate mitigation regime. While the efficiency concerns are amply addressed in climate debate, the justice and equity has received meager attention. The future emission scenarios developed by the IPCC suggest that the ultimate objective of the UNFCCC, i.e. the stabilization of greenhouse gas concentrations, can not be achieved without participation of developing countries in mitigation. The economic efficiency studies also indicate that the global cost-effectiveness shall require sizable emissions mitigation and adaptation actions in developing countries. Participation of developing countries in climate regime is therefore necessary and cost-effective.

The basic concern of developing countries is not whether or when to initiate the mitigation actions, but how the mitigation burden shall be distributed among the nations. This is a justice issue, concerned with an equitable distribution. The unfavorable bargaining position has contributed to myriad apprehensions about the procedural and consequential equity in the negotiations. The concerns on the matter arose in the developing countries even before the Framework Convention was drafted (see Agarwal and Narain, 1991). The climate mitigation policy studies have shown that the economic implications of alternate allocation are substantial (see Manne and Richels, 1996; Richels et al., 1996). Results of studies for developing countries are even more striking. For instance, the “grandfathered” and “equal per capita” entitlement schemes for India lead to substantial losses or gains respectively, amounting to several percent of India’s GDP (see Shukla, 1996; Fisher-Vanden et al., 1997). Equity therefore is vital, and yet not trivial to achieve.

The present climate negotiations, culminating into the Kyoto Protocol, are restricted to the emissions mitigation. Equity therefore is viewed within a narrow context of emissions entitlements, the distribution of which is an indirect equity criteria. An appropriate direct criteria is the minimization of global welfare losses resulting from mitigation and adaptation actions and impacts. The per capita income and emissions in developing countries, under a business-as-usual scenario, are expected to remain substantially below those in the developed countries throughout the next century. A welfare loss minimizing mitigation regime is therefore unlikely to allocate a substantial climate mitigation burden to developing countries. The alternate equity proposals, like the convergence framework.
or the income based entry, rest on indirect equity criteria. Ultimately, all such proposals shall need to be endorsed by the three touchstones - justice, equity and efficiency. An efficient climate change mitigation regime would require an early entry of developing countries. This shall happen only if the post-Kyoto phase of climate negotiations would quickly move towards addressing the justice and fairness issues.
References


Table 1: Historic CO₂ and Methane Contribution by Region, 1800-1988 (in percentages)

<table>
<thead>
<tr>
<th>Region</th>
<th>Industrial CO₂</th>
<th>Total CO₂</th>
<th>CO₂ + CH₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD North America</td>
<td>33.2</td>
<td>29.7</td>
<td>29.2</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>26.1</td>
<td>16.6</td>
<td>16.4</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>5.5</td>
<td>4.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Former USSR</td>
<td>14.1</td>
<td>12.5</td>
<td>12.4</td>
</tr>
<tr>
<td>Japan</td>
<td>3.7</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Oceania</td>
<td>1.1</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>China</td>
<td>5.5</td>
<td>6.0</td>
<td>6.3</td>
</tr>
<tr>
<td>India</td>
<td>1.6</td>
<td>4.5</td>
<td>4.8</td>
</tr>
<tr>
<td>Other Asia</td>
<td>1.5</td>
<td>5.0</td>
<td>5.2</td>
</tr>
<tr>
<td>N. Africa &amp; Mid-East</td>
<td>2.2</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Other Africa</td>
<td>1.6</td>
<td>5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.7</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Other Latin America</td>
<td>3.2</td>
<td>6.5</td>
<td>6.5</td>
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<tr>
<td>Developed Countries (1-6)</td>
<td>83.8</td>
<td>67.8</td>
<td>66.9</td>
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<td>Developing Countries (7-13)</td>
<td>16.2</td>
<td>32.2</td>
<td>33.1</td>
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<tr>
<td>World</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
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</table>

Source: Grubler and Nakicenovic, 1991

Table 2: Per capita emissions (Ton of Carbon/yr.) for IS92a, c and e

<table>
<thead>
<tr>
<th>Region</th>
<th>Year</th>
<th>IS92a</th>
<th>IS92c</th>
<th>IS92e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed Countries</td>
<td>1990</td>
<td>3.63</td>
<td>3.63</td>
<td>3.63</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td>4.20</td>
<td>3.28</td>
<td>5.11</td>
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<tr>
<td></td>
<td>2100</td>
<td>4.87</td>
<td>1.96</td>
<td>7.93</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>1990</td>
<td>0.39</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td>0.73</td>
<td>0.53</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>2100</td>
<td>1.36</td>
<td>0.57</td>
<td>2.49</td>
</tr>
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</table>
Table 3: Cumulative Carbon Emissions for the period 1991 to 2100 for IS92 Emission Scenarios

<table>
<thead>
<tr>
<th>Emission scenario</th>
<th>Cumulative Emissions: 1991 - 2100 (Giga Ton Carbon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS92a</td>
<td>1500</td>
</tr>
<tr>
<td>IS92b</td>
<td>1430</td>
</tr>
<tr>
<td>IS92c</td>
<td>785</td>
</tr>
<tr>
<td>IS92d</td>
<td>975</td>
</tr>
<tr>
<td>IS92e</td>
<td>2187</td>
</tr>
<tr>
<td>IS92f</td>
<td>1845</td>
</tr>
</tbody>
</table>

Table 4: Cumulative Carbon Emissions (1991 to 2100) for “S” and “WRE” Emissions Trajectories for Stabilization of CO₂ Concentrations

<table>
<thead>
<tr>
<th>Stabilization Target</th>
<th>Cumulative Carbon Emissionsa (Giga Ton Carbon)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“S” Trajectory</td>
</tr>
<tr>
<td>450 ppmvb</td>
<td>628</td>
</tr>
<tr>
<td>550 ppmv</td>
<td>872</td>
</tr>
<tr>
<td>650 ppmv</td>
<td>1038</td>
</tr>
<tr>
<td>750 ppmv</td>
<td>1194</td>
</tr>
</tbody>
</table>

a: Cumulative emissions vary due to different emissions trajectories (Wigley et. al, 1996)
b: ppmv: parts per million volume
Figure 1: Carbon Emissions per Capita (1993)

Source: Adapted from Banuri et al. (1996)
Figure 2: Trajectories for Convergence of Per Capita Emissions

**Figure 2a: Conventional Convergence Concept**

- Industrial Countries Emission Profile
- Developing Countries Emission Profile
- Convergence Target

**Figure 2b: Just and Equitable Convergence Profiles**

- Industrial Countries Emission Profile
- Developing Countries Emission Profile
- Convergence Target