

## **Session 5: Are regional characteristics well-developed within IAMs?**

Paper 1- Representation of Value Systems in Developing Countries

M. Munasinghe

Nominated Discussion

R. Tol

Paper 2- Reflection of Indigenous Culture in Developing Countries

W. Chantanakome

Rapporteur's Summary

R.Helten

## **Representation of Value Systems in Developing Countries**

**M. Munasinghe**

## **A Framework for Climate Change Decisionmaking: The Crucial Role of Values<sup>1</sup>**

**Mohan Munasinghe**

Distinguished Visiting Professor of Environmental Management, University of Colombo, Colombo, Sri Lanka, and Convening Lead Author, IPCC Second Assessment Report (1996).

The threat of global climate change poses an unprecedented challenge to humanity. While climate change is potentially important, it is crucial to also recognize that (especially for the developing countries), there are a number of other priorities that affect human welfare more immediately -- such as hunger and malnutrition, poverty, health, and pressing local environmental issues. In this context, better predictions about climate change, its impacts, and the costs of mitigation are important for the policymaking dimension, because climate change issues reside within broader questions about sustainable development. Furthermore, decisionmaking about climate change and sustainable development are crucially influenced by fundamental human values, which determine the weights that are applied to various decision criteria.

The first section of this paper describes the three main elements of sustainable development -- economic, social and environmental -- each of which has a different value system and approach. The relevance of climate change is analysed within this context. Section 2 describes the main causal links, policy issues and complications involved in climate change. In Section 3, a comprehensive framework for decisionmaking is set out, based on three stages. The first stage involves global optimization, which relies heavily on economic values and efficiency criteria. Second, the collective decisionmaking process places greater weight on social aspects and equity principles. The third stage involving procedures and mechanisms focuses on institutional issues and pragmatic approaches for implementing decisions. Finally, Section 4 contains some concluding remarks, including an overview of estimates of the costs and benefits of climate change mitigation options, the particular relevance of Asian values for addressing climate change issues, and a summary of the paper.

### **1. Climate Change and Sustainable Development**

The state of the environment is a major worldwide concern today. Pollution is perceived as an especially serious threat in the industrialized countries, where the quality of life had hitherto been measured mainly in terms of growth in material output. Meanwhile, environmental degradation has become a significant impediment to economic development and the alleviation of poverty in the developing world. In this context, sustainable development (SD) is an overarching objective for human society that has emerged at the end of the twentieth century (*WCED 1987*). The interaction between SD and global climate change is especially important, in view of the wide ranging impacts that the latter is likely to have. Furthermore, the UNFCCC has recognized this relationship explicitly in Article 2, which states (inter alia) that the stabilization of greenhouse gas concentrations ".....should be achieved within a time-frame sufficient to.....enable economic development to proceed in a sustainable manner" (*UNFCCC 1993*).

#### **1.1 The Economic, Social and Environmental Dimensions of Sustainable Development**

The world is currently exploring the concept of sustainable development: an approach that will permit continuing improvements in the present quality of life at a lower intensity of resource use, thereby leaving behind for future generations an undiminished or even enhanced stock of natural resources and other assets. While no universally acceptable practical definition of sustainable development exists as yet, there is increasing agreement

that it should incorporate, in a balanced manner, three critical elements based on economic, social and environmental value (see Box 1).

Current approaches to the concept of sustainable development draw on the experience of several decades of development efforts. Historically, the development of the industrialized world focused on material production. Not surprisingly, therefore, the model followed by the developing nations in the 1950s and the 1960s was output and growth dominated, based mainly on the concept of economic efficiency. By the early 1970s the large and growing numbers of poor in the developing world, and the lack of "trickle-down" benefits to them, led to greater efforts to directly improve income distribution. The development paradigm shifted towards equitable growth, where social (distributional) objectives, especially poverty alleviation, were recognized as distinct from, and as important as, economic efficiency.

Protection of the environment has now become the third major objective of development. By the early 1980s, a large body of evidence had accumulated that environmental degradation was a major barrier to development. The concept of sustainable development has, therefore, evolved to encompass three major points of view: economic, social and environmental, as shown in Figure 1 (Munasinghe 1993).

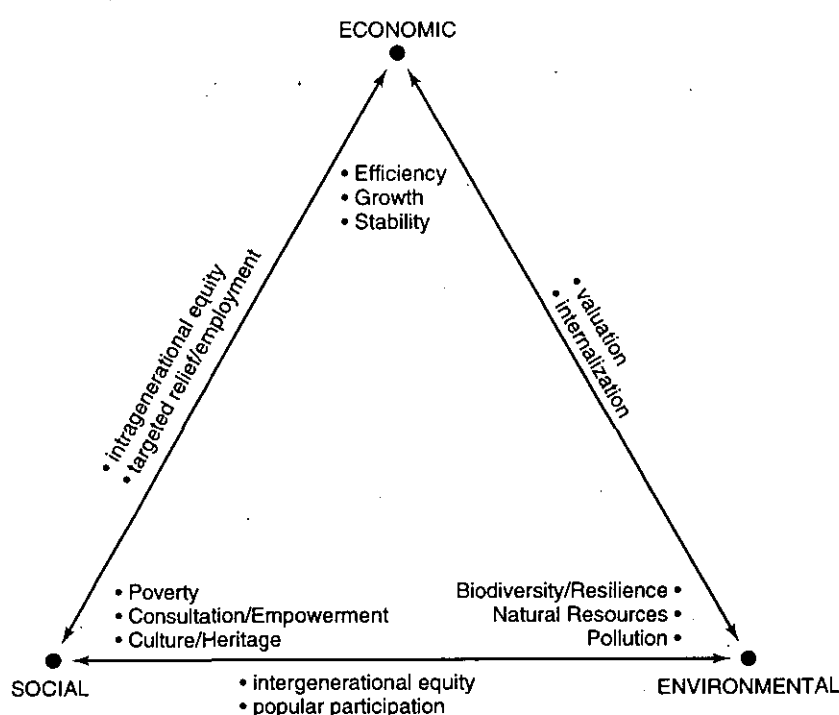


Figure 1: Elements of sustainable development. From Munasinghe (1993).

### Box 1. Approaches to Sustainable Development

The economic approach to sustainability is based on the concept of the maximum flow of income that could be generated while at least maintaining the stock of assets (or capital) which yield these benefits (this concept is attributed to Lindahl and Hicks -- see Solow 1986, Maler 1990). There is an underlying concept of optimality and economic efficiency applied to the use of scarce resources. Problems of interpretation arise in identifying the kinds of capital to be maintained (for example, manufactured, natural, and human capital) and their substitutability,

as well as in valuing these assets, particularly ecological resources. The issues of uncertainty, irreversibility and catastrophic collapse pose additional difficulties.

The social concept of sustainability is people-oriented, and seeks to maintain the resilience of social and cultural systems and their ability to withstand shocks. Greater equity and the reduction of destructive conflicts are important aspects of this approach. Preservation of cultural diversity and cultural capital across the globe, and the better use of knowledge concerning sustainable practices embedded in less dominant cultures, are desirable. Modern society would need to encourage and incorporate pluralism and grass-roots participation into a more effective decision making framework for socially sustainable development.

The environmental view of sustainable development focuses on the resilience of biological and physical systems. Of particular importance is the viability of subsystems that are critical to the global stability of the overall ecosystem. Furthermore, "natural" systems and habitats may be interpreted broadly to also include man-made environments like cities. The emphasis is on preserving the resilience and dynamic ability of such systems to adapt to change, rather than conservation of some "ideal" static state. Natural resource degradation, pollution and loss of biodiversity reduce system resilience.

Reconciling these various concepts and operationalizing them as a means to achieve sustainable development is a formidable task, since all three elements must be given balanced consideration. The interfaces among the three approaches are also important (see Figure 1). Thus, the economic and social elements interact to give rise to issues such as intra-generational equity (income distribution) and targeted relief for the poor. The economic-environmental interface has yielded new ideas on valuation and internalization of environmental impacts. Finally, the social-environmental linkage has led to renewed interest in areas like inter-generational equity (rights of future generations) and grassroots participation.

In seeking to integrate the economic, social and environmental approaches in a practical way, it is useful to recognize that most development decisions continue to be based on the economic efficiency criteria. Thus, it is useful to turn to the relatively new area of environmental economics as a starting point for developing a broader conceptual framework that integrates the economic, socio-cultural and ecological approaches (*Munasinghe 1993*). For example, economists attempt to incorporate environmental concerns into decision making by valuing environmental resources in monetary terms, and ensuring that resource prices reflect their scarcity values. Similarly, economists have addressed social-equity concerns by placing special emphasis on costs and benefits accruing to the poor, by ensuring that those who impose costs on others pay commensurate charges and, more recently, by seeking to protect productive assets for future generations.

The foregoing suggests a broad integrated conceptual approach in which the net benefits of economic activities are maximized, subject to maintaining the stock of productive assets over time, and providing a social safety net to meet the basic needs of the poor. Some analysts support a "strong sustainability" rule which requires the separate preservation of each category of critical asset (for example, manufactured, natural, socio-cultural and human capital), assuming that they are complements rather than substitutes. Other researchers have argued in favor of "weak sustainability," which seeks to maintain the aggregate monetary value of the total stock of assets, assuming a high degree of substitutability among the various asset types. At the same time, the underlying basis of economic valuation, optimization and efficient use of resources may not be easily applied to ecological objectives like protecting biodiversity, or to social goals such as promoting public participation and empowerment — thereby forcing reliance on non-economic indicators of social and environmental status, as well as on techniques like multi-criteria analysis to facilitate trade-offs among a variety of such non-commensurable objectives. Furthermore, uncertainty about the future will require the use of methods based on decision analysis.

## **1.2 The Potential Impacts of Climate Change on Sustainable Development**

The climate change problem fits in quite readily within the conceptual framework for sustainable development described above. Box 2 provides a summary of the main facts about climate change, including likely impacts.

### **Box 2. Summary of Climate Change**

#### **1. Present State of Knowledge**

***The balance of evidence suggests a discernible human influence on global climate.***

During the past hundred years, the global mean surface air temperature has increased between 0.3 and 0.6°C, while the mean sea level has risen between 10 and 25 cm. Both the horizontal and vertical variations in the patterns of global temperature change, as well as seasonal climate changes, are consistent with the trends of increasing human intervention over time. Nine of the warmest years in the past century have occurred after 1980, and glaciers are retreating worldwide. Accumulation of atmospheric GHGs (chiefly CO<sub>2</sub>) make the earth a less efficient emitter of energy back into space. Therefore, the atmosphere tends to warm through the greenhouse effect, in order to maintain the essential balance between solar radiation absorbed and radiation re-emitted. Aerosols have an opposite (cooling) effect in more localised regions. Energy and land use patterns are the main human activities which contribute to emissions of GHGs.

#### **2. Potential Future Climate Scenarios**

***If present trends continue, both GHG concentrations and the likely climate change impact will increase significantly in the next century.***

If there is no specific human strategy to mitigate climate change, typically the atmospheric concentration of CO<sub>2</sub> will increase from the present 360 ppmv to between 500 and 900 ppmv by 2100 -- depending on the rates of global economic and population growth, energy prices, and application of new technologies. Consequently, the global mean surface temperature will increase between 1 to 3.5°C, and the mean sea level will rise between 15 and 95 cm, during the same period. Because of the thermal inertia of the oceans and the century long lifetimes of atmospheric GHGs, both the temperature and sea level will continue to rise, long after the GHG concentration in the atmosphere has stabilised. Precise predictions are difficult to make because of the complexity of analysing interlinked geophysical, ecological and socioeconomic systems on a planetary scale over very long periods of time. Uncertainty, irreversibility and non-linear phenomena further complicate matters.

#### **3. Impact on Ecological and Socioeconomic Systems**

***Widespread and significant effects are likely, with the most severe effects occurring in the tropics.***

The impact on ecological systems will be significant, because the projected rate of global mean temperature change will be the fastest observed in the past 10,000 years. Typically, forest zones are likely to shift poleward between 150 and 650 km, causing short term die-back, and coral reefs will suffer severe adverse effects. Flooding of coastal areas due to sea level rise will lead to forced displacement of tens of millions of people, with small island states and river deltas being most severely impacted. Increases in vector borne diseases, particularly malaria, will affect tens of millions of people in the tropics. Changes in global aggregate food production are uncertain, but agriculture in the tropics and sub-tropics will suffer adverse impacts. Changes in the worldwide hydrological cycle will reduce the

availability of freshwater in water-scarce regions. Financial, institutional and human resource shortages will make the developing countries most vulnerable to climate change impacts. Globally, a doubling of atmospheric CO<sub>2</sub> equivalent by 2100 may cause annual damages of between 1-2% of GDP, but damages in some developing countries could be as high as 10% of GDP.

#### 4. Implementing Mitigation Measures

***Balanced use of technological and policy options is desirable within an emerging global institutional framework for collective decisionmaking.***

The precautionary principle indicates that uncertainty about the future climate does not constitute valid grounds for delay or inaction. "No regrets" technological and policy measures are presently available worldwide that could significantly reduce GHG emissions in a cost-effective manner, especially in relation to energy and land use. However, achieving even a modest target for stabilisation of atmospheric GHG levels within the next 150 years will require significant expenditures of resources and firm political commitment, to accelerate the development and application of new technologies and policies. A collective global decisionmaking process is required which will incorporate both efficiency and equity considerations. At present, the main institutional framework for addressing climate change issues is the UNFCCC, currently ratified by 164 nations. The Annex 1 countries may agree to more stringent GHG emission reduction targets at the UNFCCC COP3 meeting in Kyoto in December 1997.

First, global warming poses a significant threat to future economic activities and the well being of large numbers of human beings. The economic viewpoint will seek to maximize the net benefits from use of the global resource represented by the atmosphere. The stock of atmospheric assets, which provide a sink function for GHGs, needs to be maintained at a level which ensures future benefits (in terms of avoided climate change damage) that equal or just exceed the costs of measures required to restore the sink function to that level. The underlying principles are based on optimality and the economically efficient use of a scarce resource, i.e., the global atmosphere.

Second, climate change could also undermine the social elements of sustainable development -- which tend to value equity highly. Both intra- and inter-generational equity (i.e., spatial and temporal fairness) could be worsened, due to the uneven distribution of the costs of climate change damage as well as of required adaptation and mitigation efforts. Some social aspects worth considering include: (a) the establishment of an equitable and participative global framework for making and implementing collective decisions about climate change; (b) reducing the potential for social disruption and conflicts arising from climate change impacts; and (c) protection of threatened cultures and preservation of cultural diversity (particularly in small islands where the impact of a sea level rise will be greatest).

Third, the ecological viewpoint relies heavily on the principle of risk avoidance, to ensure the stability and viability of ecosystems. Increasing anthropogenic emissions and accumulations of GHGs will significantly perturb one of the subsystems (the atmosphere), to the point where the global mean temperature and climate will change at a rate that might threaten the stability of many critical ecosystems. Thus, an important goal would be to determine the limits of climate change within which the resilience of the global system could be maintained at an adequate level. In turn, the accumulations of GHGs in the atmosphere would have to be constrained to a point which prevented climate change from exceeding the safe margins.

Thus, the different approaches to SD employ different criteria and values, which in turn could result in potentially conflicting decisions. In the context of SD, both public and private sector decisionmakers in most countries still rely on a basically economic-financial framework to manage their activities and make development decisions. Furthermore, the

techniques of environmental economics, that focus on impacts of human activities on natural resources, ecosystems and social systems, provide an important bridge among the three approaches to SD (for details, see *Munasinghe 1993*).

These considerations suggest that an integrated and comprehensive framework for analysing the climate change problem might begin with the concept of maximization of net benefits of development, subject to maintaining the services provided by the stock of economic, social and environmental resources, over time. In this context, net benefits are defined as the benefits derived from development activities minus the costs incurred to carry out those actions (see below). This approach implies that wastes should be generated at rates less than or equal to the assimilative capacity of the environment -- in particular, the global atmosphere. Renewable resources, especially if they are scarce, should be utilized at rates less than or equal to the natural rate of regeneration. The efficiency with which non-renewable resources are used should be optimized subject to substitutability between these resources and technological progress. Finally, both intra- and intergenerational equity (especially poverty alleviation), as well as a pluralistic and consultative social framework, are important additional considerations. Such an integrative framework would also help to incorporate climate change response measures within a national sustainable development strategy (see below).

In the developing world, economic growth and poverty alleviation carry great weight, and any climate change mitigation strategy must fit within this context. In particular, developing country decisionmakers need to be persuaded that it is possible to devise policies that address climate change issues that are aimed chiefly at restructuring growth, rather than at restricting the magnitude of growth. Figure 2(a) shows how the human socioeconomic subsystem produces goods and services by drawing energy, raw materials and environmental services from, and discharging waste products into, the larger ecological system. The dotted lines indicate that the socioeconomic subsystem could eventually expand until it begins to infringe on the ecosystem boundaries. In the case of climate change, it is the uncontrolled emission of GHGs which is overloading the absorptive capacity of the atmosphere.

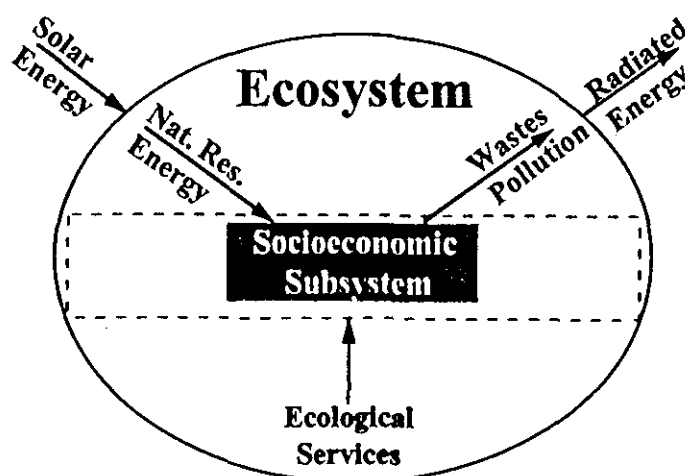
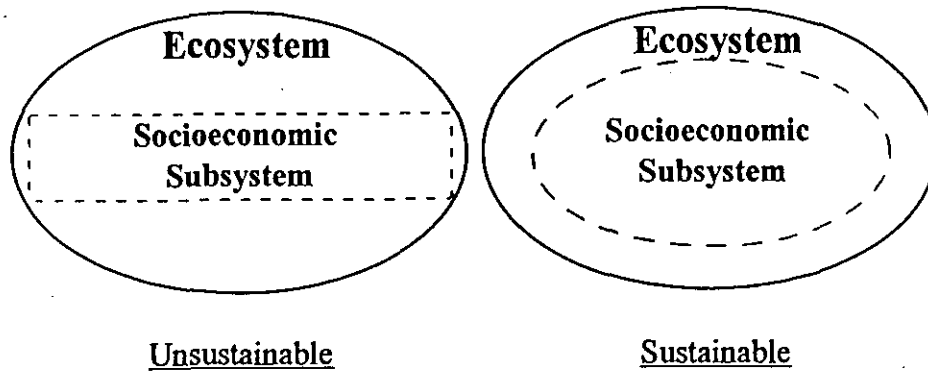


Figure 2(a): The capacity of the ecosystem may become overloaded by the growing socioeconomic subsystem (broken lines).

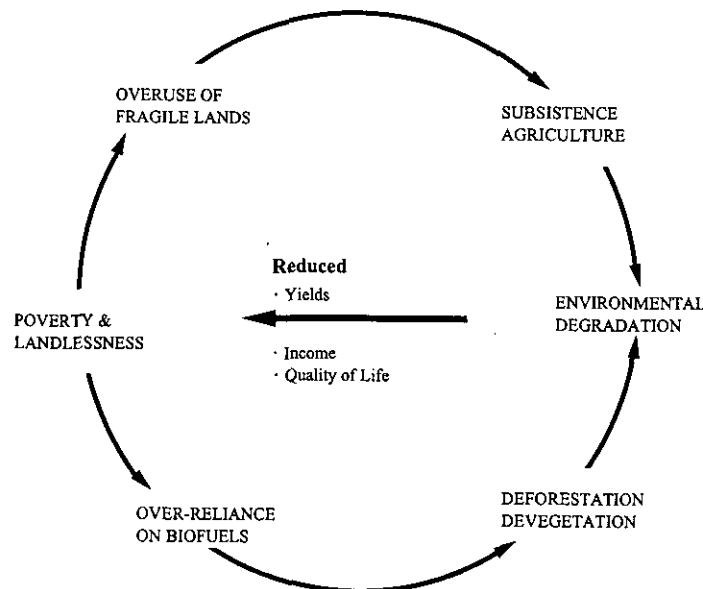


## Restructuring Growth



**Figure 2(b):** Indicates symbolically, that growth might be restructured so that it is not unduly restricted (especially in the case of low income countries), by natural resource constraints. A related consideration is the need to shift the conventional paradigm of material intensive economic growth to the more modern concept of sustainable development -- which has social and environmental dimensions as well.

For consistent policy analysis, country level models designed to study climate change strategies must be integrated with existing models that deal with economic growth, poverty and human wellbeing. For example, Figure 3 shows how environmental degradation reduces crop yields and income, ultimately lowering the quality of life of the poor. Unfortunately, there is a feedback loop whereby poverty and landlessness also lead to overuse of fragile lands, reliance on subsistence agriculture, and further land degradation. Moreover, over-reliance on bio-fuels might exacerbate devegetation and deforestation, causing even more environmental harm. In this case, the linkages between land, energy and climate need to be integrated consistently.



**Figure 3: Links Between Rural Poverty and The Environment**

## 2. Policy Issues and Complications

All approaches to understanding and dealing with climate change policy issues are hampered by formidable complications which are explored below.

### 2.1 *The Causal Chain*

The chain of causality which is associated with global climate change is a convenient starting point to understand the magnitude of the climate change phenomenon, attendant complications, and how human values might influence a response strategy. As shown in Figure 4 (on the following page), the causal chain leads from GHG emissions and concentrations to damages caused by climate change impacts, followed by the succeeding set of linkages from proposed abatement measures to net reductions in GHG emissions. Some feedback mechanisms are not included in the diagram, to retain clarity.

In the figure, linkage 1 (which connects modules A and B) shows how net emissions of GHGs lead to increasing atmospheric concentrations. There are major scientific uncertainties associated with determining the quantitative relationship between emissions and concentrations, including the multitude of sources and sinks and their interactions, and the number of different GHGs with varying lifetimes and global warming potentials (for details, see *IPCC 1996a*). The second link (connecting modules B and C) relates atmospheric concentrations of GHGs to geophysical effects such as changes of temperature and precipitation, soil moisture content, sea level rise, and the frequency and severity of extreme weather events. Once again, there are formidable problems of accurately predicting such effects -- for large and complex systems, over long periods of time, and in specific regions and locations of the world.

Linkage 3 (which connects modules C and D) in the figure explores the extent of economic, social and ecological damage caused by geophysical changes. While Article 2 of the UNFCCC has highlighted potential impacts on ecosystems and food production, the full range of such impacts is much larger and difficult to enumerate taxonomically. The broadest categories of impacts concern ecosystems and natural habitats, hydrology and water resources, food and agriculture, human infrastructure and habitats, and human health (for details, see *IPCC 1996b*). The complexity of relatively unknown relationships within and among large and often closely linked physical, ecological and socioeconomic systems, as well as the multidisciplinary nature of the required analysis, poses great problems. Economic valuation of the many potential impacts, or assigning comparative weights to such impacts, is important in establishing both the overall magnitude of damages and relative priorities. This step also has many theoretical and practical pitfalls.

The fourth link (connecting modules D and E) is the critical one which determines the response strategy that will address the potential damage from global climate change. Before this step, however, the range of feasible technological options, policy instruments, and adaptive responses must be identified and well understood. The costs of implementing such measures also need to be determined. Linkage 5 (which connects modules E and F) helps to establish how responsibilities for abatement measures are assigned, how emissions rights are allocated, and what the international and national implementing mechanisms might be. A related question involves the extent to which those responsible for GHG emissions (both past and present) might compensate others who suffer the costs of climate change impacts, and how such transfers could be ensured. The implementing mechanisms will have a feedback effect on the response strategy, as shown by the reverse link 5. The main difficulties associated with decisionmaking process related to links 4 and 5 have to do with sociopolitical and equity issues. While there are scientific and technical questions at this stage too, the uncertainty and lack of knowledge associated with them is significantly less than in the earlier stages.

The sixth and final link closes the chain in two ways, through the implementation of the response strategy. First it results in the abatement of GHG emissions which will eventually reduce future global climate change. Second, the response strategy will lead to the adoption of adaptive measures which directly reduces vulnerability to climate change. There will be many uncertainties (both scientific and socioeconomic) at this stage, as relatively new and untried policies and technologies are implemented. Typical questions include: how well technological options might work; how quickly GHG emissions will respond to abatement measures; and how human beings will respond to policies.

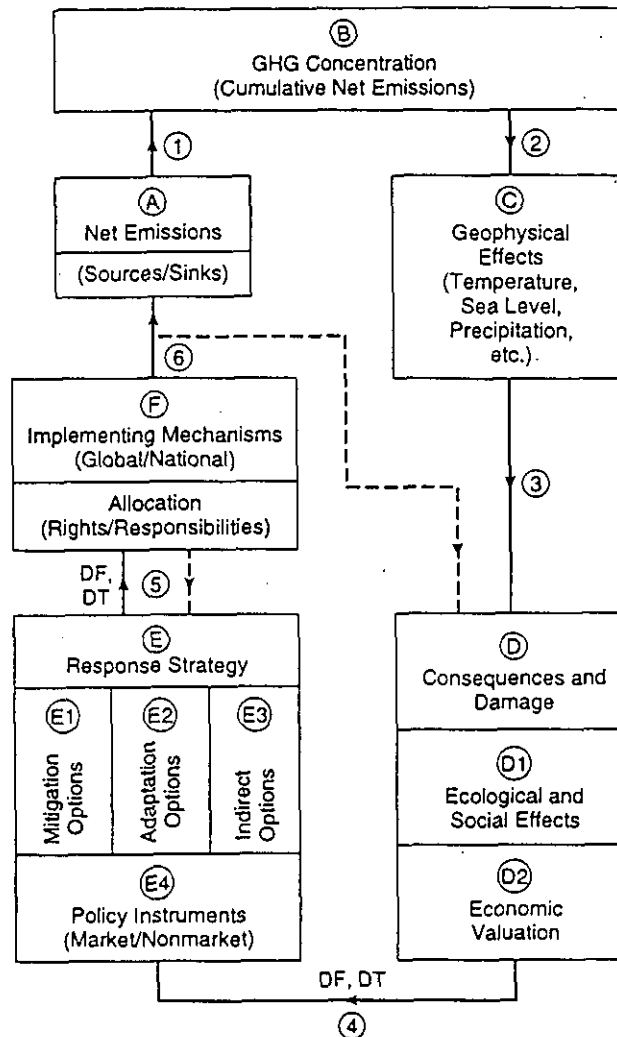


Figure 4: Casual links that characterize the global climate change phenomenon (DF denotes decision framework; DT, decision tools). From Munasinghe (1996).

## 2.2 Generic Complications and Uncertainty

For better comprehension, it is useful to group, into several categories, the multitude of difficulties identified in the foregoing discussion. We begin below, with an explanation of several generic issues which complicate climate change policy analysis. These generic

problems are further compounded by uncertainty. Issues arising from equity and social values are described in the subsequent sections.

## Generic Issues

The generic problems which are pervasive in climate change analysis include the very large spatial and temporal scale of events, complexity, irreversibility, non-linear behaviour and catastrophic collapse.

Both the worldwide spatial extent and centuries-long temporal dimension are considerably bigger than the normal range of magnitudes for which conventional techniques of analysis have been designed. The physical, ecological, economic and social systems and subsystems involved are extremely large and complex. Their interactions are not well known and require multidisciplinary analysis. Another unprecedented complication is the fact that every human being on the planet, present and future, has a stake in the outcome. Determination of who bears the costs and who benefits, allocation of rights and responsibilities for damages and abatement, and establishment of collective decisionmaking procedures and implementation mechanisms for agreed response strategies, are typical examples of tasks to be undertaken on a global scale. At the same time, every link in the causal chain from emissions to impacts involves decade or century long physical and ecological processes and corresponding time lags. Predictions about the structure of socioeconomic systems and human behaviour for at least the next hundred years is equally problematic, but essential to assess climate change impacts and responses.

The potential irreversibility of some effects is another major complication, especially in the context of the long gestation periods and inertia of systems involved. For example, since the effective agent is the cumulative stock of GHGs, past emissions may have committed us already to an unacceptably high risk of global warming. Furthermore, we could well discover too late that the consequences of ongoing or future emissions have irreversible consequences. Thus, the failure to reduce emissions in the short to medium term may be irreversible in the sense that once the effects of climate change become apparent, it will then be too late to do anything about it. If some of these consequences turn out to be catastrophic as well, human beings literally have no other place or planet to migrate to. Catastrophic outcomes are more likely if there are potential non-linearities involved in the entire causal chain -- i.e., the responses of systems are not proportional to the stimuli to which they are subjected. If global-scale systems (climate, ecological or social) are perturbed outside their normal or stable states of equilibrium, positive feedbacks could lead to instability and unpredictable "flipping" of these large systems to new states which may have unpleasant consequences for humanity. In other words, we are dealing with planetary scale mechanisms which are little understood and may become uncontrollable. The foregoing indicates the merits of a cautious approach, especially if humanity is averse to risks on a global scale (see below, for a related discussion of the precautionary principle).

## Uncertainty

We discuss below, the different forms of uncertainty in two broad categories: (a) scientific uncertainty which arises due to limited knowledge, mainly in the case of physical and natural systems; and (b) socioeconomic and technological uncertainty that is inherent in future predictions about human systems and infrastructure. Many of these uncertainties are linked to the generic issues mentioned earlier, i.e., the large spatial and temporal scale, as well as the complexity of the systems involved. Key related concepts such as aversion to risk, the precautionary approach, and the importance of robust policies which are sound under a variety of circumstances, are discussed later in Section 3.

**Scientific Uncertainty:** To begin with, the processes involved in the biological and geochemical cycling of GHGs, aerosols and aerosol precursors, as well as their rates of accumulation, are all uncertain. Since there are many GHGs and multiple sources and sinks spread across the world, GHG emissions are subject to much uncertainty (except for a few cases like CO<sub>2</sub> from fossil fuel use). Moreover, the separation of anthropogenic and natural causes of GHG emissions is more difficult than in the case of other important local or global pollution issues (such as nuclear wastes or CFC's).

Next, the link between emissions and ambient concentrations of most GHGs is far from clear, because of complex chemical transformations in the atmosphere. Even the relatively better understood case of CO<sub>2</sub> is complicated by the operation of several processes that remove this gas from the atmosphere over a range of timescales. There are many poorly understood interactions. For example, the presence of CFCs could affect climate change not only directly through its greenhouse warming potential, but also indirectly by its impact on biota like nanoplankton -- which in turn influence oceanic CO<sub>2</sub> uptake. Similarly, the degree of reliance on fossil fuels would affect CO<sub>2</sub> and SO<sub>2</sub> emissions directly, and CO<sub>2</sub> absorption indirectly -- via the effects of acid rain on forests and biomass.

The impact of atmospheric GHG concentrations on climate is subject to even greater scientific uncertainty. Currently available climate models do not adequately capture the effects of clouds, sea ice, vegetation and oceans. Some of these key feedbacks involve changes in albedo or reflection of solar radiation (e.g., from clouds or ice), while others concern long term equilibrium exchanges of GHGs and heat (e.g., between the atmosphere and oceans). Other uncertainties, that affect greenhouse warming, include variations in solar output, hydrological cycles, and ecosystem changes. Present models are even less well equipped to predict how regional precipitation patterns might change, including the spatial and temporal distribution of rainfall. Uncertainty about changes in the patterns of extreme weather events will be of even greater concern, especially to developing countries which are vulnerable.

Quantifying the impacts of climate change on flora, fauna and human beings is another area of great scientific uncertainty. Problems arise in analysing such responses, because of the sheer number of impacts to be considered, the complexity of biological and ecological systems and subsystems, and the existence of many non-linear feedbacks. Disentangling the effects of climate change on these systems, from the impacts of other non-climatic factors, will be especially difficult.

**Socioeconomic and Technological Uncertainty:** The future emissions of GHGs, aerosols and aerosol precursors from anthropogenic sources are subject to significant uncertainty, because they depend on human actions and policies which are themselves unpredictable. This form of uncertainty compounds the problems raised by scientific uncertainty associated with predictions about such gases (see previous section). Another major source of economic uncertainty stems from the inability to estimate the magnitude of certain types of impacts in terms of monetary value, especially those involving assets that are not valued directly in markets. For example, the loss of rainforests will entail a reduction in biological diversity and the degradation of ecological functions like watershed protection, which are very difficult to value. Another problem concerns the valuation of impacts on human health, especially the loss of life. Both ethical and equity issues add to the complications of determining the value of a human life.

The manner in which human communities will adapt to climate change is not well known. Simple extrapolation of existing information, based on the impact of disasters on social systems, will be inadequate, because the scale of global climate change is so much greater. For example, the destabilising effects due to impoverishment and displacement of large numbers of environmental refugees are not well known, including the potential for destructive conflicts over diminishing resources. Another source of uncertainty is the reaction of individual human beings and economic agents to some of the strategic response options.

Finally, there is considerable uncertainty concerning the availability, reliability and costs of various technological options now under review. Timing is particularly important, and the long lead times required for the development of new technologies will influence decisions regarding response strategies. The interactions among new inventions, markets, venture capital, and government incentives for R&D, are also critical.

### 2.3 *Equity and Social Values*

Equity in the context of a social decision means that the outcome is fair and just. It is an important element of the collective decisionmaking framework needed to respond to the challenge of global climate change (see Box 3 for details).

#### **Box 3. Why Is Equity Important?**

Equity considerations are important in addressing global climate change for a number of reasons, including: (a) moral and ethical concerns; (b) facilitating effectiveness; (c) sustainable development; and (d) the UNFCCC itself.

First, the principles of justice and fair play are important in themselves, in all types of human interactions. In particular, practically all modern international agreements, including the UN Charter, enshrine moral and ethical concerns relating to the basic equality of all human beings and the existence of inalienable and fundamental human rights. Equity is also embodied explicitly or implicitly, in many of the decisionmaking criteria used by policymakers.

Second, equitable decisions generally carry greater legitimacy and encourage parties with differing interests to cooperate better in carrying out mutually agreed actions. The successful implementation of a collective human response to the problem of global climate change will require the sustained collaboration of all sovereign nation states and many billions of human beings over long periods of time. While penalties and safeguards will play a role, decisions that are widely accepted as equitable are likely to be implemented with greater willingness and goodwill than those enforced under conditions of mistrust or coercion. In other words, cooperative and effective outcomes are more likely when all parties to the decision feel that it is fair.

Third, as explained in Box 1, equity and fairness are extremely important elements of the social dimension of sustainable development. Thus the impetus for sustainable development provides another crucial reason for finding equitable solutions to the problem of global warming.

Fourth, the UNFCCC has several specific references to equity in its substantive provisions. To begin with, Article 3.1 states that "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof." Other equity-related principles emphasised in Article 3 include: (a) the right to promote sustainable development; (b) the need to take into account the specific needs and special circumstances of developing country and vulnerable parties; (c) the commitment to promote a supportive and open international economic system; and (d) the precautionary principle (to protect the rights of future generations).

According to Article 4.2(a), all developed country Parties, including those with economies in transition, are required to take the lead in mitigating climate change. Furthermore they are required to transfer technology and financial resources to developing country parties that are particularly vulnerable to the adverse effects of climate change in meeting the costs of adaptation (Article 4.4). Another reference to equity in Article 4.2 (a) requires developed country parties to commit themselves to: "adopt national policies and take corresponding measures on the mitigation of climate change.... These policies and measures

will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention...taking into account the difference in the Parties' starting points and approaches, economic structures, available technologies and other individual circumstances, as well as the need for equitable and appropriate contributions by each of the Parties to the global effort regarding that objective." Finally, Article 11.2 requires the Convention's financial mechanism to "have an equitable and balanced representation of all Parties within a transparent system of governance."

### **Procedural and Consequential Equity**

The requirements of the UNFCCC place great weight on equity principles, to: (a) procedural issues -- how decisions are made; and (b) consequential issues -- the outcomes of those decisions. Both aspects are important because equitable procedures need not guarantee equitable decisions, and conversely, equitable outcomes could well arise from quite inequitable decision making processes. Support for the convention and acceptance of its recommended course of action will depend largely on widespread participation by the global community and on how equitable it is perceived to be, by all participants.

Procedural equity itself has two components. First, pertaining to participation, equity implies that those who are affected by decisions should have some say in the making of these decisions, either through direct participation or representation. Second, relating to the process, equity must ensure equal treatment before the law -- similar cases must be dealt with in a similar manner, and exceptions must be made on a principled basis.

Consequential equity also has two elements, relating to the distribution of the costs and benefits of: (a) impacts and adaptation to climate change; and (b) mitigating measures (including the allocation of future emissions rights). Both the elements (a) and (b) have implications for burden sharing among and within countries (intragenerational and spatial distribution); and between present and future generations (intergenerational and temporal distribution). The equity of any specific outcome may be assessed in terms of a number of generic approaches, including parity, proportionality, priority, classical utilitarianism, and Rawlsian distributive justice. Societies normally seek to achieve equity by balancing and combining several of these criteria. Self interest also influences the selection of criteria and the determination of equitable decisions. Consequential equity as applied in the international arena, is derived largely from these principles which were developed originally in the context of human interactions within specific societies.

A human response to climate change requires the application of equity at an even more elevated (global) level, where there is far less practical experience. Cultural and societal norms and views about ethics, the environment, and development, complicate efforts to achieve a worldwide consensus on matters of both procedural and consequential equity. Even the urgency of a response to climate change is subject to dispute. Given the different meanings, philosophical interpretations, and policy approaches associated with equity, judgement plays an important role in resolving potential conflicts. Ultimately, any global response strategy will be a compromise between different world views, each of which is also influenced by self interest and attempts to shift the compromise in one's own favour.

Nevertheless, from a pragmatic viewpoint significant progress towards a global consensus would be made if the decisionmaking framework could harness economic self-interest to support equitable or ethical goals (see Box 4). For example, developed countries are likely to have a self-interest in taking the lead and shouldering the major burdens of addressing climate change issues because their own citizens have shown greater willingness to pay to solve environmental problems. Similarly, developed nations would enjoy greater opportunities for trade and export if developing country markets grew without being disrupted by climate change, and the former could also avoid the significant negative spillover impacts of worldwide instability arising from disasters associated with climate

change. At the same time, the higher risks and vulnerability faced by developing countries provides them an incentive to seek common solutions to the climate change problem.

#### **Box 4. Equity and Economic Efficiency**

While the previous section reviewed some arguments for reconciling equity and economic self interest, among nations, conflicts between economic efficiency and equity may arise due to assumptions about the definition, comparison and aggregation of the welfare of different individuals or nations. For example, efficiency often implies maximisation of output subject to resource constraints. This approach can potentially result in an inequitable income distribution. Overall welfare could drop depending on how welfare is defined in relation to the distribution of income. Conversely, total welfare might increase if appropriate institutions can ensure appropriate resource transfers -- usually from the rich to the poor.

In the same context, aggregating and comparing welfare across different countries is a disputable issue. Gross National Product (GNP) is simply a measure of the total measurable economic output of a country, and does not represent welfare directly. Aggregating GNP across nations is not necessarily a valid measure of global welfare. However national economic policies frequently focus more on the growth of GNP rather than it's distribution, indirectly implying that additional wealth is equally valuable to rich and poor alike, or that there are mechanisms to redistribute wealth in a way that satisfies equity goals. Attempts have been made to incorporate equity considerations within a purely economic framework, by the weighting of costs and benefits so as to give preference to the poor. Although systematic procedures exist for determining such weights, often the element of arbitrariness in assigning weights has caused many practical problems. At the same time, it should be recognised that all decisionmaking procedures do assign weights (arbitrarily or otherwise). For example, approaches based on economic efficiency which seek to maximize net benefits (see Box 5) assign, the same weight of unity to all monetary costs and benefits -- irrespective of income levels. More pragmatically, in most countries the tension between economic efficiency and equity is resolved by keeping the two approaches separate, e.g., by maintaining a balance between maximising GNP, and the establishment of institutions and processes charged with redistribution, social protection, and provision of various social goods to meet basic needs.

The lack of proper institutions to carry out such a redistributive role on an international scale, raises concerns over how -- if at all -- national welfare levels can be compared internationally. The extreme viewpoints are that: (a) welfare levels should be compared as though all countries value each others' welfare equally (i.e., equivalent welfare functions exist across countries, and equal weights might be assigned to each); and (b) that each country is concerned primarily with its own welfare and bears no responsibility for the welfare of any other (i.e., welfare cannot be aggregated and compared across countries). Since climate change constitutes situations where the activities of one country affect others, a convention on climate change must arrive at some compromise between these two extremes.

## **2.4 Value Placed on Intragenerational and Intergenerational Equity**

### **Intragenerational (Spatial) Equity**

While equity is not synonymous with equality, differences between countries clearly affect issues of international equity. International response strategies will eventually translate into actions adopted at the national level, and therefore should reflect equity concerns within countries as well. Several categories of differences between countries that are relevant to the question of equity, are discussed next.



**Wealth and Consumption:** Wealth is perhaps the most obvious and prevalent difference between (and within) countries. Measured in terms of GNP, the World Bank's 1994 World Development Report (*World Bank 1994*) states that more than half the world's population (58.7 percent) live in countries classified as "low income". These countries have an average per capita GNP of \$390. In contrast, 15.2 percent of the world's population live in 'high income economies' which have an average per capita GNP of \$22,160. The remaining 26.1 percent of the population live in the "middle income economies" which have an average per capita GNP of \$2,490. Such wide variations in per capita income between countries imply that simply comparing this measure of welfare may be inappropriate (as explained in the previous section)<sup>2</sup>.

These differences have direct implications for the way climate change is addressed. For instance, activities in developing countries that produce greenhouse gases are generally related to fulfilling "basic needs". They may result from generating energy for cooking or keeping tolerably warm, engaging in agricultural practices, consuming energy to provide barely adequate lighting, and occasionally for travel by public transport. In contrast emission of greenhouse gases in developed countries is likely to result from activities such as operating personal vehicles and central heating or cooling, and energy embodied in a wide variety of manufactured goods and the use of such goods. Therefore, the level of personal wealth is directly related to the welfare impacts of reducing greenhouse gas emissions (WCED, 1987). Furthermore, wealth has a direct bearing on the vulnerability to the impacts of climate change. By virtue of being richer, some countries will be able to adapt more effectively to climate change. A similar relationship between the poor and the rich also prevails within countries.

Poorer countries may be less prepared to adopt mitigation and adaptation strategies due to several reasons. First, poverty has implications for the urgency of other national priorities and of time scales used in policy planning. Wealth has a direct correlation to personal discount rates (i.e., discount rates decline with rising wealth). The more affluent have a greater share of disposable wealth to invest in the future, and therefore are able to conceptualize longer planning time horizons. The poor are forced to focus on shorter term objectives such as basic survival necessities.

A similar phenomenon applies to national level economic and political systems as well. Consequently, interest rates are higher in poorer countries, capital is more scarce, and the emphasis of policy planning is on the short term needs, such as poverty alleviation, and employment generation. The focus of government may be to keep up with infrastructure needs due to rapidly rising demands. They may not have the luxury to consider optimal development strategies as some richer countries may be able to. Thus national wealth affects both actual investment decisions as well as broader public policy planning capability.

The IPCC Special Report on Developing Countries addresses this concern by stating that, "the priority for the alleviation of poverty continues to be an overriding concern of the developing countries; they would rather conserve their financial and technical resources for tackling their immediate economic problems than make investments to avert a global problem which may manifest itself after two generations." Similarly, Article 4.7 of the FCCC states that, "economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties" and thus their commitments to implementing climate change responses will be influenced by these considerations. Even though concerns about climate change are likely to grow in the developing countries (especially those who consider themselves the most vulnerable), they are likely to lack the resources to address the issue.

**Contributions to Climate Change:** Countries vary in the nature and degree of contribution to climate change. Many different gases and sources contribute towards climate change. The capacity of sinks to absorb carbon emissions also differs widely between countries. The range of sources and sinks may not be an issue of equity, but different ways of aggregating and

presenting the data can have implications for equity considerations. In particular, developing countries emit much less per capita and have contributed less to past emissions. In this context, some authors have argued that the industrialized countries owe the developing world a "carbon debt", due to disproportionately high GHG emissions in the past (see for example, *Jenkins 1996*, and *Munasinghe 1990*). The developing countries also need considerable "headroom" to allow for the growth of future economic output and energy consumption, since they are starting from a much lower base (see also Box 4). At the same time, there are many variations within developed and developing countries which must be acknowledged as well. Simply differentiating along the lines of developed and developing countries will exclude many important issues from the analysis. As discussed later, the incorporation into the decisionmaking process, of equity issues associated with variations in the contributions to climate change, would be critical both in facilitating the reaching of a worldwide consensus on burden sharing, and in subsequently implementing difficult mitigation and adaptation measures.

**Incidence of and Vulnerability to Impacts:** The incidence of impacts may bear no relationship to the pattern of GHG emissions, which violates equity principles and is inconsistent with the "polluter pays" and "victim is recompensed" approach that has been applied already to more local environmental pollution problems. In particular, the negative effects of climate change are likely to be most pronounced in tropical regions typically occupied by developing countries. In addition to asymmetries in the incidence of impacts, many developing countries are more vulnerable to the effects of global warming, because of fewer resources, weaker institutional capacity, and smaller pools of skilled human resources, to draw on in times of crisis. The plight of poor and subsistence level communities, or low lying small island nations subject to sea level rise, will be quite bleak. Therefore, both humanitarian and equity principles need to be invoked to provide them some relief, along the lines of the principles and procedures established during the United Nations international decade for natural disaster relief or IDNDR (see for example, *Munasinghe and Clarke 1995*).

**Equity Within Countries:** Almost all the arguments mentioned above in the context of equity across countries, also apply to equity within individual nations. Fortunately, there are many existing mechanisms within countries (such as subsidized food, healthcare and schooling, social security, or progressive taxation) to ensure action consistent with what is considered acceptable and proper, and achieve proper redistribution of resources. Equity issues, especially in the form of views about what constitutes justice, will influence the formation, decisions and credibility of these institutions. Although the capacity and legitimacy of these institutions may vary, they provide a useful framework within which climate change issues can begin to be addressed at the national and sub-national levels.

### **Intergenerational (Temporal) Equity and Discounting**

Most of the points enumerated earlier with respect to spatial equity also affect equity across time, and in very similar ways. First, future generations may be richer or poorer than the present generation. Second, those living in the past and the present would undoubtedly be the contributors to future climate change impacts. Third, while future generations will have to bear the consequences of GHG emissions made in the past, they will also benefit from sacrifices and investments made by their forbears. At the same time, it is unclear whether our descendants will be more or less vulnerable to the effects of climate change.

At the same time, there are two fundamental issues that require us to pay special attention to intergenerational equity. First, all decisions relating to climate change are made

by the generation living at that time. To the extent that future generations are not represented in the ongoing decisionmaking process, particular care needs to be exercised to ensure that their rights are protected. Second, once a chain of events unfolds, it will be difficult to compensate future generations for past mistakes or miscalculations. Once again, extra prudence is required to avoid imposing future burdens that are both irreversible and impossible to compensate. Nevertheless, generations do overlap in practice (e.g., parents and children), and this is likely to result in the automatic incorporation of some intergenerational concerns into the discount rate and decisionmaking in general.

**Social Rate of Discount:** There are various equity-related mentioned earlier that may be used to ensure a desirable measure of temporal equity. From an economic viewpoint, one of the principle instruments available to influence the allocation of resources across time is the social rate of discount (see Box 5). Indeed, the conclusions derived from any long term analysis of climate change policy will depend crucially on the numerical value of discount rate that is selected. It is important to bear in mind that we are discussing the real discount rate where the effects of inflation are netted out. Furthermore, conceptually the interest rate (at which present day capital will grow into the future) is the exact mirror image of the discount rate (at which future expenditures should be discounted to the present date).

Since discounting is a method for comparing economic costs and benefits that occur at different times, it will have a direct bearing on intergenerational equity. In the case of climate change analysis, the effects of discounting will be especially pronounced for two reasons: (a) the relevant time horizons are extremely long; and (b) many of the costs of mitigation occur relatively early, while potential benefits lie in the distant future. In brief, as far as present-day decisions are concerned, a higher discount rate will reduce the importance of future benefits (of avoided climate change damages) relative to the near term costs (of mitigation measures).

### **Box 5. Discount Rate**

#### **Basic Concepts**

The social rate of discount (SRD) is defined as the one used by decisionmakers in determining public policy. The main text indicates that some fundamental issues of value and equity are involved in the choice of such a social discount rate. In addition to the technical aspect of comparing economic costs and benefits over time, the sustainable development dimension described earlier provides a more overarching guideline -- that each generation has the right to inherit a set of economic, social and environmental assets that are at least as good as the one enjoyed by the preceding generation (see Box 1). In subsequent discussions, mention of the discount rate refers to the social rate of discount, unless otherwise specified.

Even in traditional cost benefit analysis used in project evaluation, which is far less complicated than climate change decisionmaking, the choice of a discount rate is not clear cut (see for example, *Munasinghe 1993*). Discount rates vary across countries, depending on behavioural preferences and economic conditions. Furthermore, it is considered prudent to test the sensitivity of the results by using a range of discount rates (usually about 4 to 12 percent per annum), for a project within a given country.

Starting from the theoretically ideal (or first best) situation of perfectly functioning, competitive markets and an optimal distribution of income, it is possible to show that the discount rate should be equal to the marginal returns to investment (or marginal yield on capital) which will also equal the interest rate on borrowing by both consumers and producers (*Lind 1982*). More specifically, there are three conditions to ensure an efficient (or optimal) growth path. First, the marginal returns to investment between one period and the next should equal the rate of interest (i) charged from borrowing producers. Second, the rate of change of

the marginal utility of consumption (or satisfaction derived from one extra unit consumed) from one period to the next should be equal to the interest rate ( $r$ ) paid out to lending consumers. Third and finally, the producer and consumer rates of interest are equal (i.e.,  $i = r$ ), throughout the economy and over all time periods.

As we deviate from the ideal market conditions and optimal income distribution, the determination of the discount (or interest) rate becomes less clear. For example, taxes (subsidies) may increase (decrease) the borrowing rate to producers above (below) the interest rate paid to consumers on their savings (i.e.,  $i$  unequal to  $r$ ). More generally, if the three conditions do not hold because of economic distortions, then efficiency may require project or sector specific discount rates that would include so-called second-best corrections to compensate for the various economic imperfections. In extreme cases, there is no theoretical basis for linking observed market interest rates to the social rate of discount. Nevertheless, market behaviour would still provide useful information on the social rate of discount.

There are two main approaches to practically determining a value of the social rate of discount (SRD) for climate change analysis -- one based on the social rate of time preference (SRTP), and the other on market returns to investment (MRI). While the concepts underlying the two approaches may appear to be divergent, when practical adjustments are made, they tend to produce estimates for the social discount rate that are comparable -- typically with SRTP varying from 1 to 4 percent and MRI lying in the range 3 to 6 percent.

**Social Rate of Time Preference (SRTP):** This parameter is defined as follows:  $SRTP = a + (b.g)$ . Here,  $a$  is the pure rate of time preference which basically reflects the impatience of consumers and is normally positive. In other words, individuals will tend to value consumption today more highly than consumption next year, simply because current consumption is preferred (myopia), while future consumption may be considered less certain (risk aversion). In the second term,  $g$  represents the growth rate of per capita consumption which is normally positive. The parameter  $b$  is the "elasticity of marginal utility", which is also a positive number that reflects how rapidly the welfare (or satisfaction) provided by each successive unit of consumption declines, as the consumption level rises. To summarize, even if individuals were not impatient (i.e.,  $a = 0$ ), the term  $(b.g)$  tells us that one unit of current consumption will still provide greater satisfaction than a unit of future consumption, to the extent that succeeding generations are likely to be richer and more satiated.

Since  $a$  and  $b$  are both normally positive, if the growth rate ( $g$ ) is high, then SRTP will also be large. This is consistent with an optimistic scenario where technological and other advances will ensure high levels of future per capita consumption. Therefore, future benefits will carry a smaller weight relative to current costs. On the other hand, if we assume a gloomy future where global climate change has depressed production and consumption levels,  $g$  might become sufficiently negative to make SRTP zero or even negative. In this case future benefits would have exaggerated importance compared to present-day costs. The main conclusion is that the choice of a discount rate will depend also on the future scenario that is assumed (*Munasinghe 1993*). Given the uncertainties indicated earlier, it would be rather difficult to predict which type of outcome will predominate.

When comparing competing investment alternatives, all expenditures should be converted to the same numeraire or yardstick -- based on consumption equivalents (i.e., the value of consumption that could be provided by a given expenditure). Environmental impacts also would be valued in units of this agreed consumption-based numeraire, and discounted at the SRTP. This approach obviates the need to have a special (lower) discount rate for environmental impacts. In other words, to the extent that environmental assets become scarcer in the future, their value will tend to rise faster than the SRD, which is equivalent to using a lower discount rate for environmental assets while keeping relative prices unchanged. Uncertainty about future impacts needs to be handled by converting the value of such impacts into certainty equivalents -- that is the certain result which would be equivalent in value to

the uncertain actual outcome. Finally, in GHG mitigation projects, the opportunity cost of capital needs to be taken into account to adjust costs, which reflect the forgone benefits from alternative uses of the same investment resources.

**Market returns to investment (MRI):** This approach focuses explicitly on the opportunity costs of capital (OCC), adjusted for risk (i.e., the marginal returns to investment capital measured in terms of the certainty equivalents mentioned above). The basic argument is that investments in GHG mitigation measures could well have been applied to other projects (both public and private) which would themselves have yielded returns in the future. Therefore, a discount rate that reflects the yields on such alternative projects (i.e., the opportunity cost of capital), provides a good basis for comparing whether future generations would be better off with or without climate change response measures. Furthermore, returns to current projects and yields in financial markets reveal the actual preferences of society today, concerning tradeoffs between current and future consumption.

One criticism of the MRI approach is that some alternative schemes may in fact ignore climate change impacts. For example, investments in coastal zones that are normally expected to provide high yields (based on present day conditions), may not be feasible if there is a major rise in future sea levels. More broadly, if the impacts of global warming are severe enough to significantly disrupt human society, then the general instability of national economies and the business climate may undermine returns to all activities.

Additional problems arise in attempting to deal with taxes and uncertainty. Thus, the extent to which the MRI should reflect the producer rate of interest (or returns to private investment before taxes) or the consumer rate of interest (or returns to private investment after taxes), will depend on the extent of distortion introduced by the tax system. Uncertainty has to be dealt with by adjusting gross yields according to risk. While this is routinely done in financial markets for short to medium term investments (e.g., the risk rating system for bonds), the long term perspective required in the context of climate change decisions poses additional problems. The yield on a longer term government guaranteed bond is often used as an example of a relatively risk-free rate of return on investments.

**Practical Estimates:** While actual estimates of SRTP are scarce, it is possible to begin with the assumption that the pure rate of time preference is rather low (say  $0 < a < 2$ ). Reasonable estimates for the elasticity of marginal utility  $b$ , might be in the range 1 to 1.5. The long term growth rate of per capita consumption is likely to be rather modest (say  $0.5\% < g < 1.5\%$ , where the higher figure is close to the value of 1.6% used in the IPCC IS92 emissions scenarios). After adjusting for foregone investments and depreciation, it is possible to arrive at a range of about 1 to 4 percent for the SRTP.

A logical first step in estimating the MRI is to review current returns to various types of market investments. Adjustment for risk will tend to lower expected returns. Furthermore, historic rates of economic growth may have been higher than those expected for the long run future, which could reduce projected yields on investment. Taking these considerations into account, a range of 3 to 6 percent appears reasonable for the MRI, which is also consistent with the long term returns on risk free public investments.

### 3. Framework for Decisionmaking

One logical starting point for making decisions about the global climate change problem is the wording in Article 2 of the UNFCCC, which seeks "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". To begin with, an effective decisionmaking framework should provide policymakers with the means to assess the available scientific, technical, economic and social information, and thereby determine what

range of future human activities might constitute such “dangerous anthropogenic interference”, and how remedial steps could be identified.

Unfortunately, the complications set out earlier, especially uncertainty, sets limits on the precision of long term optimizing solutions. However, uncertainty is not a valid reason for inaction -- given the seriousness of the potential impacts of global climate change. Therefore, the decisionmaking framework should facilitate consensus building on prudent short term responses (e.g., the ‘no regrets’ measures like energy conservation, which are robust over a wide range of future scenarios). At the same time, the longer term strategy should ensure the consistency and smoothness of the near term decisions already under way. It must certainly be flexible in the face of uncertainty, and contain “heuristic” elements that permit the systematic future revision of both decisionmaking processes and objectives, in keeping with the most recent knowledge that may emerge periodically.

### **3.1 Decision Objectives and Elements of the Framework**

Within the broader objective of the UNFCCC--which seeks to “stabilize the concentrations of GHGs”--more specific decisionmaking objectives may be defined in the form of the following questions that need to be faced in common, by all humankind:

1. Determining the acceptable concentrations of GHGs in the atmosphere, at different times in the future.
2. Determining the target levels for reduction of GHG emissions that are necessary to achieve the desired atmospheric concentrations, including the future time path of such emissions.
3. Identifying the combination of measures that will bring about the desired reductions of emissions, and consequently the ambient concentrations of GHGs.
4. Allocating the appropriate distribution of emission reduction responsibilities among different nations, taking into consideration their past emissions and future development needs.
5. Establishing mechanisms and institutions (both international and national) to make collective decisions and implement them effectively.
6. Formulating measures that also meet the criteria for sustainable development.
7. Developing methods of dealing with the special difficulties, especially the issue of uncertainty which manifests itself in different forms with respect to each of the earlier questions.

The questions set out above indicate that the decisionmaking framework must encompass three complementary elements. While values based on economic efficiency and equity are often intertwined and difficult to separate, we seek a practical decisionmaking framework that might initially separate these two issues and allow us to proceed in a stepwise fashion.

The first element in such a framework addresses questions of *global optimization*. More specifically, the desirable overall target levels of GHG concentrations and net emissions need to be determined on a global basis, since the total accumulation of GHGs is far more important than the location of specific sources and sinks. As explained below, for this type of decision, “economically efficient” solutions carry greater weight. This approach maximizes net benefits (i.e., benefits minus costs, broadly defined) for all of humanity, without necessarily being concerned about the incidence or allocation of such costs and benefits. However, the correspondence between global optimisation and efficiency is not necessarily absolute. Equity-based values could be important also, to the extent that costs and benefits, as well as income levels, are unequally distributed. In the final analysis, it is more practical to bring in equity issues after both scientific and efficiency criteria have been used to arrive at a broad global consensus concerning desirable levels of GHG concentration and emission.

The second element focuses on the *collective decisionmaking* process required to provide “socially equitable” solutions to climate change problems -- where greater weight is

placed on equity and the analysis of the distribution and allocation of costs and benefits associated with global climate change. Questions such as who should bear differentiated responsibilities for commonly agreed abatement response measures, fall into this category. The key complication arises from the fact that the entire global population is potentially at risk. Thus, the stakeholders (or those who have an interest in the outcome) who need to be involved in decisions range from single individuals and small firms to nation states and multinational groupings (for example, the small island nations who are particularly concerned with inundation of land due to a rise in sea levels). Furthermore, many selection criteria may be applied, including those concerning social equity, economic efficiency, sovereignty, ethics, and ecology. Clearly, a widely participative process is essential to determine acceptable answers to this type of question.

The third and final element concerns *procedures and mechanisms* for addressing climate change issues. Rules governing decisionmaking processes and behaviour, as well as implementing mechanisms and structures, fall within this category in which equity and pragmatic values come into play. The UNFCCC has already provided many of the initial rules and mechanisms in this category. The procedural element will be strongly influenced by the framework adopted for the global optimization and collective decisionmaking elements, and vice versa. Procedures also should facilitate the program of abatement actions. Such a set of response actions is likely to be: (a) sequential (or step-by-step); (b) based on a pre-identified portfolio of the most desirable mitigation, adaptation and research measures (e.g., first adopt "win-win" strategies or measures you would have taken anyway--even in the absence of global warming); (c) able to provide a hedge against uncertainty and risk; and (d) adjusted and updated systematically to take new knowledge into account. The decisionmaking process must reflect these requirements. Finally, the process of formulating and implementing globally agreed abatement decisions inside a specific country, needs to take place within a national framework for sustainable development.

### 3.2 Global Optimisation and Efficient Solutions

Global optimization is based on the rather basic concept of maximizing the net benefits (NB) of emissions reduction -- i.e., finding a strategy which maximizes the benefits (B) of reduced climate change, net of the costs (C) associated with GHG abatement efforts. This approach is based on cost-benefit analysis (CBA). When such costs and benefits may be valued economically, the quantity to be optimized or the "objective function" is definable in monetary units (ignoring distributional aspects). The resulting solution is termed economically "efficient".

Basic arithmetic indicates that we are seeking to maximize the quantity:  $NB = B - C$ . If we measure benefits in terms of the avoided costs (D) of greenhouse damages, then maximizing net benefits is equivalent to minimizing total costs (TC) or the sum of the costs of damages and abatement. In other words, since we can also write:  $NB = -D - C = -TC$ ; then maximizing net benefits is equivalent to minimizing total costs. Introducing the symbol R to represent the level of emissions reduction, we may write:  $TC(R) = -[C(R) + D(R)]$ . In terms of simple calculus, TC is minimized when its first derivative equals zero, or  $[dTC/dR] = [(dC/dR) - (dD/dR)] = 0$ .

We might identify  $(dC/dR)$  and  $(dD/dR)$  respectively, as the marginal abatement cost (MAC) or change in C per additional unit of GHG abated, and the marginal avoided damages (MAD) or change in damages per unit of GHG abated. We would expect that MAC increases and MAD decreases with higher levels of abatement. TC is minimized at the point where the slope of the abatement cost (or MAC) curve equals the negative slope of the damage cost (or MAD) curve -- i.e., GHG abatement efforts should be pursued up to the level where  $MAC = MAD$  or  $(dC/dR) = -(dD/dR)$ .

## Setting Targets

An important practical handicap is the likelihood that the costs and benefits curves may exhibit great uncertainty (for the reasons set out earlier) -- especially the marginal avoided damage costs (MAD). Figure 5 indicates how such uncertainty will affect the global optimisation process. In Figure 5(a), both the marginal avoided damages and the abatement costs are economically undefined. Nevertheless, it may be possible to use scientific judgement to determine the target level of emissions reduction  $R_{AS}$ , beyond which the risk of damage is unacceptably high. The cross hatching shows the extent of uncertainty in defining the two zones. Indeed, the dividing line at  $R_{AS}$  has been drawn closer to the error margin on the right, to indicate a cautious viewpoint (see also, the discussion below on the *precautionary* approach). The target level  $R_{AS}$  is based on an *absolute standard*, because the obligation to avoid harm is absolute. It implies that the underlying MAD curve (if available) would have been quite low in the acceptable risk zone to the right of  $R_{AS}$ , but rising sharply in the zone of unacceptable risk. In other words, the potential damages are so high within the unacceptable risk zone, that the cost of abatement carries very little weight in this decision.

In Figure 5(b), the marginal abatement costs (MAC) are available while the marginal avoided damage costs are still undefined. The cross-hatching on the MAC curve indicates the degree of uncertainty on either side of its expected (or mean) value. In this case, the target level of emissions reduction  $R_{AM}$ , reflects the judgemental balance between the affordable level of abatement costs and the acceptability of damage risk. This approach is termed the *affordable safe minimum standard*. The relevant total affordable cost is the area under the MAC curve, up to the vertical line. One of the difficulties is that affordability is a concept that is not well defined and subject to different interpretations. There is an implication also that the underlying MAD curve is still quite low in the zone to the right of  $R_{AM}$ .

Finally in Figure 5(c), the optimal level of emissions reduction is defined in terms of the CBA framework presented earlier in the box. In this case, either both the marginal avoided damage cost and abatement cost functions are known with certainty, or the expected values of these curves are used (in the absence of risk aversion) -- with the cross hatching again indicating the margin of error around the mean value. Then the globally desirable degree of emissions reduction is indicated by  $R_{OP}$ , at the point where  $MAC = MAD$ .

The benefits of greater information are apparent, to the extent that the abatement target may become less stringent as the decisionmaking progresses through the three cases, in which (a) both MAC and MAD are undefined; (b) only MAD is undefined; and (c) both curves are defined. In other words, since  $R_{AS} > R_{AM} > R_{OP}$ , the level and costs of abatement would be progressively reduced as one approached the optimal point--reflecting greater confidence in the information available.

## Attitude to Risk and Precautionary Approach

The attitude to risk plays a key role in decisionmaking under uncertainty. Great weight is placed on the *precautionary* approach to decisionmaking (which is in fact endorsed by the UNFCCC), when *risk aversion* interacts with the uncertainty associated with potentially irreversible and catastrophic climate change impacts. More specifically Article 3.3 of the UNFCCC seeks to provide guidance to decisionmakers when uncertainty is present -- through the 'precautionary principle'. The article states that the Parties to the UNFCCC should: "take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be



comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors. Efforts to address climate change may be carried out cooperatively by interested Parties.”

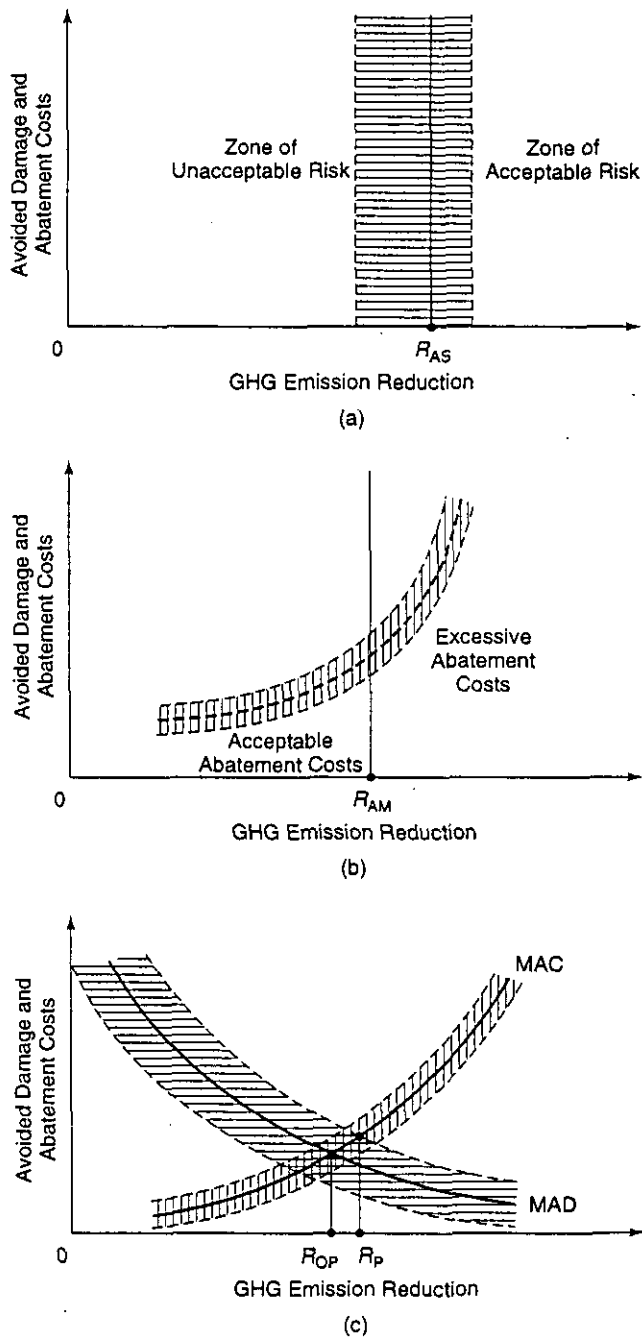


Figure 5: Determining abatement targets: (a) absolute standard; (b) affordable safe minimum standard; (c) cost-benefit optimum.

As an example of the precautionary approach, consider Figure 5(c). Here, although the uncertainty in the avoided damages curve is likely to be large, the decision need not be delayed. A risk-averse decisionmaker would select the more stringent target emissions reduction level  $R_p$  (lying to the right of  $R_{op}$  -- which is presently unknown). The relevant point B is determined roughly by the intersection of the MAC curve and some estimate of the upper envelope of the avoided damages (MAD) line. Furthermore, in the face of the greater level of uncertainty shown in Figure 5(a), a precautionary approach might result in the even more stringent emissions reduction target  $R_{AS}$ , leaving a smaller margin for error on the right side.

### Some Observations

The foregoing analysis gives rise to several corollaries: (a) uncertainties in determining costs and benefits would require a great deal of judgement to be used in determining target emissions reduction levels; (b) the decision criterion could progressively evolve as the quality of information improved--from the absolute standard, through the affordable safe minimum standard, to the precautionary and optimal approaches; and (c) there may be significant returns to investing in better research and information gathering on climate change.

The many difficulties mentioned earlier, that would complicate the analysis, are briefly recapitulated below. For example, the emission of a unit of GHG may give rise to a varying stream of environmental costs which must be discounted over time to yield a present value aggregate. The environmental damage function may be discontinuous and non-linear. Abatement costs may change over time, depending on when the technologies are applied--because of technological progress. Similarly, abatement costs may exhibit economies of scale (e.g. mass production of solar photovoltaic cells), resulting in a marginal cost curve that actually declines beyond a certain point. Such costs may also differ across countries, for various reasons. Moreover, the abatement costs are net costs, to the extent that certain technologies (e.g. renewables) may produce other (non-climate related) benefits and costs--this is the so-called joint products complication discussed below.

Finally, costs and benefits accrue to so many diverse individuals, groups and nations, that simple aggregation raises equity issues. It is possible to incorporate elements of "equity" into the globally optimal solution--for example, by weighting costs and benefits in inverse proportion to the income levels of the respective victims and beneficiaries. However, determining such weights has proved to be highly contentious, even in the much simpler context of development projects. To conclude, it is more practical to focus on the efficient solution (subject to some judgement) at the global optimization stage, and introduce equity in the collective decisionmaking stage, discussed next.

### Problems of Economic Valuation

An important reason for avoiding climate change is that it will give rise to significant damages. As explained earlier in the context of Figure 5, it is necessary to estimate both the marginal avoided damage (MAD) and marginal abatement cost (MAC) curves, to determine an economically optimal response. In fact, if  $MAD > MAC$ , it is possible to infer that further abatement is desirable (since severe marginal damage (high willingness to pay) could be avoided at low emissions curtailment costs -- and vice-versa. Valuation of environmental effects in cost-benefit analysis (CBA) may be helpful also in attaining cost-effective decisions. However it is difficult to assess these values. Furthermore, the valuation should be based on a reasonably well founded methodology, since speculative assumptions could well confuse decisionmakers. An action which yields negative net benefits may yet be worthwhile accepting, especially if some important beneficial effects could not be explicitly valued in the calculation but were nevertheless well documented. Different types of costs and benefits require somewhat different approaches to quantification and valuation.

A fundamental concept underlying valuation is that of the total economic value (TEV) of a resource. TEV consists of its use value (UV) and non-use value (NUV) [see for example, *Munasinghe 1993*]. Use values may be broken down further into the direct use value (DUV), the indirect use value (IUV) and the option value (OV) or potential use value (see for example, *Arrow and Fischer 1974*; and more recently *Chichilinsky and Heal 1994*). One needs to be careful not to double-count both the value of indirect supporting functions and the value of the resulting direct use. One major category of non-use value is existence value (EV). Thus, we may write:

$$\begin{aligned} \text{TEV} &= \text{UV} + \text{NUV} \\ \text{or} \\ \text{TEV} &= [\text{DUV} + \text{IUV} + \text{OV}] + [\text{NUV}] \end{aligned}$$

Figure 6 shows this disaggregation of TEV in schematic form. Below each valuation concept, a short description of its meaning and a few typical examples (based on a tropical rainforest) are provided, of the environmental resources underlying the perceived value. Option values and non-use values and existence values are shaded, to caution the analyst concerning some of the ambiguities associated with defining these concepts -- as shown in the examples, they can spring from similar or identical resources, while their estimation could be interlinked also. However, these concepts of value are generally quite distinct. Option value is based on how much individuals are willing to pay today for the option of preserving the asset for future direct and indirect use. This concept is very similar to that of holding a financial asset in the expectation of making some future capital gain. In the presence of uncertainty, quasi-option value is said to define the value of preserving options for future use in the expectation that knowledge will grow over time -- about the potential benefits or costs associated with the option (see *Pearce and Turner, 1990*, and *Fisher and Hanneman, 1987*). The latter approach may be quite relevant, given the great uncertainties associated with climate change, as elaborated below in the section on decision analysis. Existence value is a more altruistic concept, based on the perceived value of the environmental asset unrelated either to current or optional future use, i.e., the value arising simply because it exists.

A variety of valuation techniques may be used to quantify the above concepts of value (for methodological details, see *Freeman 1993*; and for some applications, see *Munasinghe 1993*). As shown in Box 5, valuation methods can be categorized according to which type of market they rely on, and by considering how they make use of actual or potential behaviour.

#### Box 6. Techniques for Valuing Environmental Impacts

TYPE OF BEHAVIOUR	TYPE OF MARKET		
	Conventional market	Implicit market	Constructed market
Based on actual behaviour	Effect on Production	Travel Cost	Artificial market
	Effect on Health Defensive or Preventive Costs	Wage Differences Property Values  Proxy Marketed Goods	
Based on intended behaviour	Replacement Cost  Shadow Project		Contingent Valuation

**Effect on Production.** An investment decision often has environmental impacts, which in turn affect the quantity, quality or production costs of a range of productive outputs that may be valued readily in economic terms.

**Effect on Health.** This approach is based on health impacts caused by pollution and environmental degradation. One practical measure related to the effect on production is the value of human output lost due to ill health or premature death. The loss of potential net earnings (called the human capital technique) is one proxy for foregone output, to which the costs of health care or prevention may be added.

**Defensive or Preventive Costs.** Often, costs may be incurred to mitigate the damage caused by an adverse environmental impact. For example, if the drinking water is polluted, extra purification may be needed. Then, such additional defensive or preventive expenditures (ex-post) could be taken as a minimum estimate of the benefits of mitigation.

**Replacement Cost and Shadow Project.** If an environmental resource that has been impaired is likely to be replaced in the future by another asset that provides equivalent services, then the costs of replacement may be used as a proxy for the environmental damage -- assuming that the benefits from the original resource are at least as valuable as the replacement expenses. A shadow project is usually designed specifically to offset the environmental damage caused by another project. For example, if the original project was a dam that inundated some forest land, then the shadow project might involve the replanting of an equivalent area of forest, elsewhere.

**Travel Cost.** This method seeks to determine the demand for a recreational site (e.g., number of visits per year to a park), as a function of variables like price, visitor income, and socio-economic characteristics. The price is usually the sum of entry fees to the site, costs of travel, and opportunity cost of time spent. The consumer surplus associated with the demand curve provides an estimate of the value of the recreational site in question.

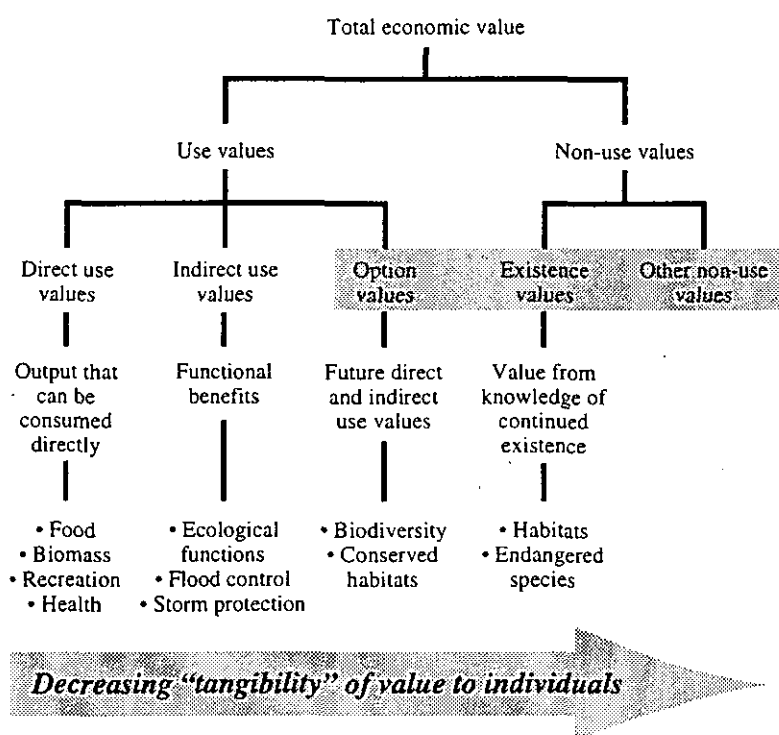


Figure 6: Categories of economic values attributed to environmental assets (with examples from a tropical rainforest). From Munasinghe (1993).

**Property Value.** In areas where relatively competitive markets exist for land, it is possible to decompose real estate prices into components attributable to different characteristics like house and lot size, air and water quality. The marginal WTP for improved local environmental quality is reflected in the increased price of housing in cleaner neighborhoods. This method has limited application in developing countries, since it requires a competitive housing market, as well as sophisticated data and tools of statistical analysis.

**Wage Differences.** As in the case of property values, the wage differential method attempts to relate changes in the wage rate to environmental conditions, after accounting for the effects of all factors other than environment (e.g., age, skill level, job responsibility, etc.) that might influence wages.

**Proxy Marketed Goods.** This method is useful when an environmental good or service has no readily determined market value, but a close substitute exists which does have a competitively determined price. In such a case, the market price of the substitute may be used as a proxy for the value of the environmental resource.

**Artificial Market.** Such markets are constructed for experimental purposes, to determine consumer WTP for a good or service. For example, a home water purification kit might be marketed at various price levels, or access to a game reserve may be offered on the basis of different admission fees, thereby facilitating the estimation of values.

**Contingent Valuation.** This method puts direct questions to individuals to determine how much they might be willing-to-pay (WTP) for an environmental resource, or how much compensation they would be willing-to-accept (WTA) if they were deprived of the same resource. The contingent valuation method (CVM) is more effective when the respondents are familiar with the environmental good or service (e.g., water quality) and have adequate information on which to base their preferences. Recent studies indicate that CVM, cautiously and rigorously applied, could provide rough estimates of value that would be helpful in economic decisionmaking, especially when other valuation methods were unavailable.

**Source:** Munasinghe 1993.

The basic concept of economic valuation underlying all these methods is the willingness to pay (WTP) of individuals for an environmental service or resource. (for an up-to-date exposition, see *Kolstad and Braden, 1991*). Willingness to pay itself is based on the area under the demand curve.

When economic valuation is difficult to carry out or estimated values are highly uncertain, other techniques such as multicriteria analysis (MCA) and decision analysis need to be used for policymaking (see for example, *Munasinghe 1993*). An application of the MCA approach to global optimization is summarized later, in Section 4.

More broadly, at the macroeconomic level, standard national income accounting techniques must be re-examined, and improved measures of environmental and social progress developed. Gross domestic product (GDP), the commonly used growth measure, relies on transactions in markets, and is the basis on which many aspects of national policy are determined. However, its shortcomings include neglect of income distributional concerns and non-market activities. Furthermore, from the environmental viewpoint, there are weaknesses in the current national accounting framework because the depreciation of natural resource stocks (like deforestation) is ignored, and harmful outputs like pollution are overlooked, while beneficial inputs related to environmental needs are implicitly undervalued (*Munasinghe 1994, Atkinson et al. 1996*). Currently, several countries are exploring different types of environmental adjustments to the conventional system of national accounts (SNA). Some promising new measures of sustainability such as "genuine savings" and "total wealth" have emerged recently (*Munasinghe 1997, World Bank 1997*). Non-monetary measures of ecological and social sustainability are being explored (*Munasinghe and Shearer 1995, Hanna and Munasinghe 1995a & 1995b*)

### 3.3 *Collective Decisionmaking and Equitable Solutions*

One collective decisionmaking framework that already exists at the political level is the Conference of Parties (COP) to the UNFCCC, which could evolve into an effective 'apex forum' responsible for formulating global environmental policies. Another international group set up before the COP, primarily to make scientific assessments about climate change, is the Intergovernmental Panel on Climate Change (IPCC). The IPCC has been quite successful in reaching a worldwide consensus among scientists and experts working on the climate change problem. Currently, the COP are discussing the structure of a Subsidiary Body on Science and Technology Advice (SBSTA), under Article 9 of the UNFCCC. Meanwhile, the COP will continue to rely on the IPCC for scientific inputs that could facilitate their negotiations. Ultimately, a comprehensive collective decisionmaking framework, whose characteristics are discussed below, may be the most appropriate setting for formulating practical climate change policies. While this section focuses on decisionmaking at the global level, primarily among sovereign nation states, many of the arguments are equally applicable to decisionmaking and implementation at various levels within countries (as discussed in the next section).

First, the requirements of procedural equity (introduced earlier) suggest that most of the key questions set out at the beginning of Section 3 should be resolved preferably through a collective process with fair representation and treatment of all parties (mainly sovereign nations), and transparent procedures. The global optimization approach helps to establish the desirable future GHG concentration levels and emission profiles. However, other questions that are more equity-dependent, such as the allocation of emissions rights and abatement responsibilities among countries, require special attention in the collective decisionmaking process. Thus, to the extent that the developing countries feel that they have not had adequate influence in past international negotiating processes, special attention needs to be paid to procedural equity in the COP. In particular, the developing countries are seeking to make the case that they ought to be entitled to special considerations because they: (a) historically have contributed less towards the problem; (b) have fewer resources; and (c) are more vulnerable to the impacts of global warming.

In international fora, the developing countries have shown a distinct preference for the one country - one vote system used in the United Nations. The OECD countries have traditionally wielded more influence in organizations where voting rights are weighted by country financial contributions -- e.g., in the world Bank and IMF where the OECD controls the majority of shares. More recently, in institutions like the Global Environment Facility (GEF), a double weighted voting system has emerged, in which all decisions are subject to both the above systems. Clearly, such a process could result in deadlock, but so far most GEF decisions have been reached by consensus.

Collective decisions should be especially sensitive to international distributive issues. Thus, when responsibilities for implementing abatement measures are assigned, an individual country would be concerned about how emissions from other countries would affect it, and how the benefits from its own emissions reduction measures might accrue to all countries. More generally, climate change has different implications for different nations, raising issues of consequential equity (as outlined earlier). Annex 1 countries which will bear the major financial burden would be more concerned about the cost of abatement. At the same time, non-Annex 1 countries which are poorer, are more likely to worry about the impacts of climate change on economic growth and development, the costs of adaptation, vulnerability to changes, increase in the frequency of extreme events, and irreversible damage. Meanwhile, more specific groups like the island states have already expressed fears about inundation of land due to sea level rise, while the oil exporting countries are particularly concerned about the effects of potential carbon taxes on their oil incomes, and the drop in the demand for petroleum fuels.

Second, the decisionmaking process needs to incorporate mechanisms to meet the criteria of both equity and efficiency. Geographic or intragenerational equity is a prime concern. For example, the poorer nations require sufficient freedom to expand economic activities. They are unwilling to curtail their development due to constraints imposed by emissions reduction strategies. More generally, the welfare of poorer communities must be especially protected--even in industrialised countries. Another important example involves intergenerational equity. To paraphrase the Brundtland Commission--the interest of future generations must be considered, but without significantly compromising the well-being of present generations (WCED 1987).

The application of cost-benefit or utility based decisionmaking techniques to climate change decisions would adequately cover mainly the efficiency aspects, but leave the bulk of the equity issues unaddressed. As described earlier, such approaches could help determine global optima for collective action, such as target levels for GHG concentrations. However using cost-benefit based methods to deal with equity questions (e.g., allocate responsibilities, and distribute costs and benefits associated with climate change), would require a comprehensive global welfare function with equity weighting, that fairly incorporates the well-being of all stakeholders (i.e., affected parties). Such an objective function is virtually impossible to formulate.

Delays in the collective decisionmaking process also have equity implications. Typically, international negotiations and agreements take a long time to be implemented, and may not be adopted by all parties. These 'slippages' occur at the expense of increasing cumulative concentrations, thus reducing availability of emission potential for the future. For instance, since ratifying the UNFCCC, Annex 1 countries will emit 40 to 50 billion tonnes of CO<sub>2</sub> during the nineties. This would have been sufficient for the South to continue development activities for a quarter of a century. In the absence of consensus on an abatement strategy, Annex 1 countries could well be held accountable for emissions since 1990<sup>3</sup>.

### **Allocation of Emissions Rights**

As mentioned earlier, an explicit or implicit allocation of emissions rights does raise significant equity related concerns. Once the desired global concentration levels are established (using global optimization principles discussed above), the permissible volume of emissions can be distributed among the sovereign states in an equitable manner as decided by collective choice. Annex 1 countries which have historically emitted more GHGs than developing countries, may feel entitled to a larger share of the rights -- for example, by relying on a "grandfathering" allocation rule which used existing country emissions as the starting point. Developing countries however would prefer an allocation rule based on an equal worldwide per capita emission rate weighted by population. The implications of the foregoing allocation approaches are explored in Box 7. Meanwhile, the UNFCCC provides only general guidance on selecting an equitable allocation, by suggesting that nations act to protect the climate system in accordance with their "common but differentiated responsibilities".

The allocation of emissions rights will affect the level of emissions reduction that a country must adopt. Monitoring and enforcement are critical requirements for implementing any agreement on allocation of emissions (see next section on procedures and mechanisms). If rights to emit are clearly defined and enforceable, nations that wish to exceed their allocated emissions rights could do so by agreeing to purchase or lease rights allocated to another nation -- for example, by using a mechanism for trading emissions quotas. This concept is discussed further in the section below on 'North South transfers'. Here it is sufficient to note that the adoption of such measures impose additional responsibilities on the collective decisionmaking process (i.e., in resolving issues such as how contracts might be

arranged and implemented, how much should be paid, and how the revenues should be allocated).

### **Box 7. How Might GHG Emissions Rights be Allocated Fairly?**

Suppose that the analysis of climate change yielded a target level of desirable worldwide GHG emissions in the future (e.g., see the section on the global optimisation process). To illustrate the issue more clearly, we will take a single constant level of emissions that will achieve some desired stabilization case (e.g., S550 or stabilisation of atmospheric GHG concentrations at 550 ppm of CO<sub>2</sub> equivalent before year 2150). The principles of allocation discussed below would apply in exactly the same way to any other case involving an alternative emissions profile such as IS92c (see *IPCC 1996a*). One method of allocating constant emissions might be based on ethics and basic human rights -- i.e., equal per capita (EPC) emission rights for all human beings. The total national "right to emit" would then be the product of the population and the basic per capita emissions quota.

Figure B.7 illustrates the dynamics of this allocation issue in simplified form. The line EPC indicates the constant level of per capita emissions, if the total global emissions target were allocated equally to all human beings during the decisionmaking time horizon. If we assume a total permissible accumulation of 800 GtC during the 100 year period 2000-2100 corresponding to the S550 case (see *IPCC 1996a*), shared equally among the global population of about 6 billion persons (in 2000), then the constant average per capita emission right would amount to 1.33 tonnes of carbon (TC) per year, up to 2100 -- as shown by the solid line EPC in the figure. A more precise calculation might seek to aggregate both past and future emissions (using discounting techniques that further penalize near term emissions which would cause damage over a longer period), to yield the grand total over any given period of time.

The points IC and DC represent the average current per capita GHG emissions of the industrialised (i.e., OECD nations, Eastern Europe and former Soviet Union), and developing countries, respectively. Although the figure is not exactly to scale, IC (about 3.5 TC per capita per year) is both above EPC and considerably larger than DC (about 0.5 TC per capita). Thus, the industrialised countries would need to cut back GHG emissions significantly if they were to meet the EPC criterion -- which would entail economic costs (depending on the severity of the curtailment in each country). On the other hand, the developing countries have considerable room to increase their per capita emissions, as incomes and energy consumption grow.

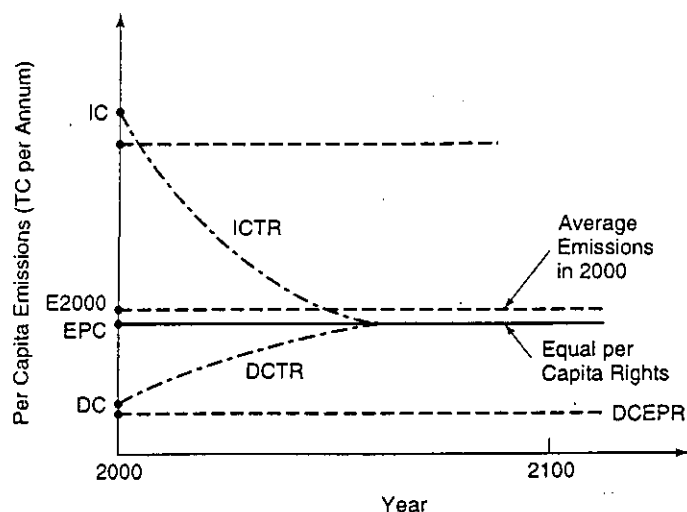


Figure B7 : Allocating emission rights. From Munasinghe (1996).



An alternative allocation rule is based on equi-proportional reductions (EPR) of emissions. In this case, all countries would reduce emissions by the same percentage amount relative to some pre-agreed baseline year, to achieve the desired global emissions target. Assuming a global average emission rate of about 1.47 TC per capita per year in 2000 (indicated by the broken line E2000 in the figure), this implies that all countries would need to curtail carbon emissions by about 10% to meet the EPR criterion (as shown by the broken lines ICEPR and DCEPT in the figure). Clearly, given the primary impetus provided by energy to economic development, such a solution would severely restrict growth prospects in the developing world -- where per capita energy consumption is low, to begin with (*Munasinghe, 1995*).

Thus the EPC and EPR approaches would result in some hardship and inequity to the developed and developing countries, respectively. Another related equity issues is whether past emissions should be considered also or ignored in deciding the current and future quotas. Suppose we assume that the future global atmospheric concentration of CO<sub>2</sub> must be stabilised at 550 ppmv. Over 80% of carbon accumulated up to 1990 have resulted from fossil fuel use in the industrialized world. Clearly the industrialized countries have used up a significant share of the "global carbon space" available to humanity while driving up atmospheric CO<sub>2</sub> concentrations from the pre-industrial norm of 280 ppmv to the current level of about 360 ppmv. Therefore, the developing countries argue that responsibility for past emissions should be considered when future rights are allocated. Correspondingly, it would be in the industrialized countries interest to use a fixed base year population (e.g., in the year 2000) as the multiplier of the per capita emissions right (e.g., EPC) in determining total national emission quotas. This would effectively penalise those countries which had high population growth rates, since their allowed national quota (determined by the base year population) would have to be divided up among more people in the future.

In practice, it is possible that some intermediate requirement which falls between EPC and EPR might emerge eventually from the collective decisionmaking process. For example, EPC may be set as a long term goal. In the shorter run, pragmatic considerations suggest that both the industrialised and transition countries be given a period of time to adjust to the lower GHG emissions level, in order to avoid undue economic disruptions and hardship -- especially to poorer groups within those countries (see transition emissions paths ICTR and DCTR in the figure). Even if some industrialised nations might argue that the goal of EPC emissions rights for all individuals is too idealistic or impractical, the directions of adjustment are clear. Net CO<sub>2</sub> emissions per capita in industrialised countries should trend downwards, while such emissions in developing countries will increase with time. This result emerges even if the objective is a more equitable distribution of per capita emissions, rather than absolute equality of per capita emissions.

Another adjustment option might be the facilitation of an emissions trading system. For example, once national emissions quotas have been assigned, a particular developing country may find that it is unable to fully utilize its allocation in a given year. At the same time, an industrialised country might find it cheaper to buy such 'excess' emissions rights from the developing nation, rather than undertake a much higher cost abatement program to cut back emissions and meet its own target. More generally, the emissions trading system would permit emissions quotas to be bought and sold freely on the international market, thereby establishing an efficient current price and even a futures market for GHG emissions (burden reallocation is also possible through activities implemented jointly).

**Note:** Numerical values in this box have been chosen for illustrative purposes only.

## Response Strategies

Identifying the relevant portfolio of options and instruments that form the basis for a response strategy, is also an important requirement of collective decisionmaking. Once globally

efficient concentration levels are decided, the decision process and analytical tools (discussed in the next section) may be to determine a range of response strategies. We briefly summarize the most important measures below under four broad categories: mitigatory, adaptive, indirect, and cooperative responses. The joint implementation approach is presented as a hybrid response involving both technical and policy elements. These response options may be implemented through an appropriate mix of economic and non-economic policy instruments.

**Mitigatory responses:** These include technological measures to reduce sources of GHG emissions into the atmosphere, as well as measures that increase the sink capacity to absorb CO<sub>2</sub> and other GHGs. Given that the great bulk of total CO<sub>2</sub> emissions originates from the burning of fossil fuels, energy efficiency and fuel switching are important options, while removal of CO<sub>2</sub> from the atmosphere is also a priority through carbon sinks such as new forests. A range of technical responses can be adopted both collectively at a global level and also individually at the level of sovereign nations.

Another key element of mitigation measures is the transfer of technology and training to developing countries. This objective is expressly spelled out in the UNFCCC. It embodies both efficiency as well as equity criteria. Efficiency is achieved by first selecting emissions reduction strategies with higher marginal returns to the investment, that is, greater emissions reduction per dollar of investment. Such opportunities are more likely to be found in developing countries and economies in transition, where technological improvements would be more cost effective. Technology cooperation can be equitable when the social welfare of such countries is improved by assistance from developed countries. Ideally, the type of technology cooperation selected could achieve both efficiency and equity goals (a "win-win" outcome).

**Adaptive responses:** In the absence of mitigation measures, countries must adapt to deal with the effects of climate change. Thus, the cost of delay in dealing with the problem are externalized in the form of various adaptation measures that would have to be implemented. In general the negative effects of adaptation are most strongly felt by the South and particularly by the poor within these countries. Many developing countries are ill equipped to adapt to climate change. Adaptive responses generally result in increased human misery—for example, in terms of the homeless and poor who suffer and even die from starvation, heat exhaustion, or extreme weather events. It is fair to suggest that the cost of adaptation measures should be internalized by nations that have contributed towards the problem. To some extent, the cost should also be internalized to parties that obstruct corrective measures from being adopted. However it must also be noted that adaptive responses are not a solution to the problem. They serve as a corrective policy measure based on the polluter-pays principle, to the extent that affected parties are compensated for the costs of forced adaptation.

**Indirect (or other) responses:** These are measures designed to address priority development issues other than climate change, but which give rise to indirect results that help to reduce climate change impacts. Among the more important indirect responses are economic policies aimed at realigning resource allocation that has been distorted due to market and institutional failures, and making it consistent with the broad objective of improving social well-being. In general, economic measures serve several functions which include: 1) correcting market distortions; 2) encouraging cost minimization; and 3) providing flexibility in selecting strategies. A larger menu of instruments also provides more flexibility to encourage economic adjustments in the face of changing environmental conditions.

**Cooperative responses and activities implemented jointly:** Some of these approaches may be implemented at the global level whereas others are more appropriate for adoption at the level of sovereign states. Cooperative programs (such as the activities implemented jointly or AIJ)

are encouraged in the UNFCCC (for example, in Article 4.2(a)). One such global policy instrument currently undergoing pilot testing, are the activities implemented jointly (AIJ). It is a generic approach that provides opportunities for interactions between countries -- especially between North and South. In particular, the North is encouraged to invest in emissions reduction strategies in the South (through the process of AIJ), if this is less costly than adopting equivalent abatement measures in the North (see Box 8 for details). Therefore, AIJ is a hybrid mechanism which essentially includes both technical and policy elements discussed above.

### **Box 8. Economic Rationale for North-South Transfers**

The coordinated implementation of financing and technical cooperation mechanisms is essential to reduce GHG emissions from the developing countries (see Munasinghe and Munasinghe 1993, for details). Figure B.8.1 clarifies the basic economic rationale for greater North to South resource transfers and technical cooperation, and also highlights the complex interplay of efficiency and equity considerations in addressing the climate change problem. The curve ABCDE indicates the combined marginal abatement costs (MAC) for a pair of countries (one developing or southern and the other industrialised or northern). In other words, the graph shows the additional costs (over and above the costs of conventional technologies) of adopting various GHG reducing schemes, plotted against the amount of avoided emissions. The portion AB indicates negative costs, to represent so called 'win-win' or 'no regrets' options like energy efficiency schemes for which CBA will show a net economic gain even before GHG abatement benefits have been considered (i.e., where the value of conventional energy savings exceed project costs). Other measures like fuel switching, new and renewable technologies, carbon sinks, and advanced energy technologies are likely to appear on the rising part (BCDE) of the curve. Most of the lower cost options for GHG emissions reduction, such as CF, would be in the developing country, whereas the more costly alternatives would lie in the industrialised nation.

Ideally, all options should be pursued in both countries, up to the point E, where the additional costs (MAC combined) of the marginal unit of emissions curtailed are equal to the corresponding benefits (MAD) of avoided global warming impacts. First, we explore the broad rationale for northern assistance to the south. In this context, consider the representative project (e.g., wind power generation) in the developing country, with additional costs CF. It would be *economically efficient* for the global community to finance these costs (on a grant basis) in the developing country, because they will thereby realize the global net benefits HC (i.e.,  $HC = HF - CF$ ). Without such a transfer, the developing country would be willing to pursue abatement measures only up to the point K -- where MAC is equal to the benefit of avoided climate change costs or MAD (DC) accruing purely to that country. Second, we make the case for a bilateral transfer of resources from the industrialised to the developing country. Consider the cost of the project DR which seeks to reduce GHG emissions in the industrialised country. This country could realize a cost saving GC by transferring an amount CF to the developing country, while still achieving the same emissions reduction. This would be the basis for so called "activities implemented jointly" and similar bilateral cooperative schemes. To the extent that net benefits HC, and cost savings GC are significant, it would be both *equitable* and *efficient* for the developing country to be given more resources than the bare breakeven reimbursement CF.

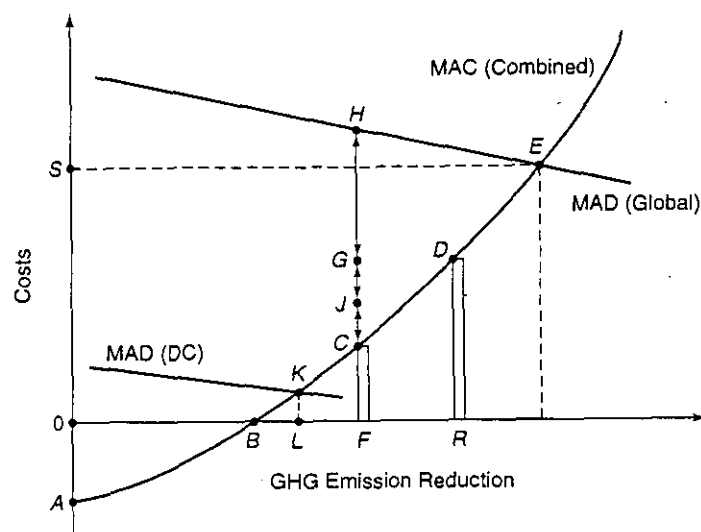


Figure B8.1: Economic rational for north-south transfers and interplay of efficiency and equity. From Munasinghe and Munasinghe (1993).

Thus, a share of the net profit (e.g., JC) would act as an incentive that would encourage the developing country to accelerate its GHG emissions reduction activities. Basically the same argument has been made to accelerate implementation of the Montreal Protocol to reduce emissions of ozone depleting substances (Munasinghe and King 1992).

Third and finally, we examine how north to south transfers might help to overcome barriers to pursuing 'win-win' options in developing countries. Consider the portion of the cost curve AB in Figure B.8.1 -- where one might expect the developing country to undertake measures (such as 'energy conservation') without external inducements, because they are economically justified in themselves. Figure B.8.2 shows the cash flow pattern over time, for a typical energy saving project. Although the net present value of benefits will be positive (i.e., negative costs, as shown in Figure B.8.1), the initial investment costs I (horizontal stripes) are quite high, while energy cost savings or benefits occur only in the future (vertical stripes). As indicated earlier, investment funds are scarce in developing countries, while perceived opportunity costs are high because of other uses for such funds (e.g., to overcome poverty, malnutrition, ill-health etc.). Therefore, unless external funds are provided to surmount this initial investment barrier, many such cost effective (or 'win-win') GHG abatement reduction schemes will not be undertaken.

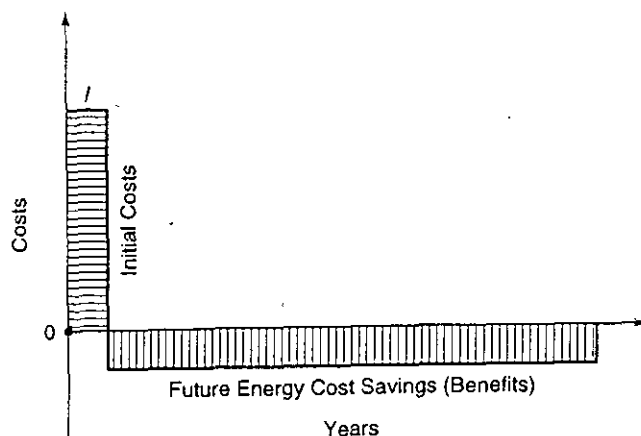


Figure B8.2: The barrier of initial costs. From Munasinghe and Munasinghe (1993).

The question of whether the North 'earns' additional emission rights in exchange for emission reduction strategies that they promote in the South is yet to be determined. Even if this principle was agreed, negotiations would be necessary to determine the amount of such credits and methods for monitoring JI schemes. Clearly these issues should be discussed in a collective decision making forum.

There are a series of related issues that must also be resolved. For instance, if developing countries are granted very large GHG emissions rights (in recognition of their lesser contribution towards the problem in the past), the industrialised nations may find it difficult to justify such investments to tax payers or share holders who perceive the South to be receiving too much of a free deal. Nevertheless, it is possible for the North to devise methods to grant incentives or credits internally, to recognize JI contributions--for example, in the form of carbon tax rebates. In the event that carbon taxes are not recognized by a country, rebates can be issued for other categories (such as R&D or charity). Even if international credits are not established, the North may benefit from participating in JI. Doing so would enhance the mitigation capacity of the South and reduce the pressure for mitigation in the North, in the long term.

**Policy instruments:** A range of both non-economic and economic policy instruments. are available to implement the response strategies discussed above. Non-economic policies are primarily of the command and control type, involving standards, regulations and legislation. Economic policy instruments suitable for addressing climate change can be categorized according to the type of response generated by their implementation. These include: 1) defining and allocating property rights (ownership rights, rights to use and develop resources); 2) creating new markets (to trade or exchange scarce environmental resources); 3) providing economic incentives (such as taxes on polluting emissions); 4) designing financial instruments (to make additional funds available for environmental protection); and 5) making better use of liability instruments (environmental damage liability, liability standards, liability insurance, etc.).

### **North to South Transfers and Technology Cooperation**

A related issue that must also be considered under the collective decisionmaking framework is that of North-South transfers. The same arguments apply to West-East transfers. The joint implementation approach discussed above provides opportunities for North to South transfers of resources. The tradable emissions permit mechanism also shows similar promise, and we discuss some key issues concerning this approach.

If national 'rights to emit' can be defined, a mechanism may be developed to enable nations to transfer or trade such rights. For example, Southern countries which have more rights than they can presently utilize, may decide to sell or lease them to Northern countries which may wish to exceed their allocated rights. One argument advanced by Southern nations is that many Northern countries currently utilize a larger share of the scarce global atmospheric commons or 'environmental space' than can be justified by their size (either geographical or human population). Furthermore the use of environmental space for emission of greenhouse gases today, has implications for intergenerational equity as well (see earlier discussion). Under the "polluter pays principle", countries (or communities) whose use of 'environmental space' exceeds their fair share would be required to pay,

Poor nations may be forced to spend an increasing share of their resources to undertake adaptation measures against climate change symptoms. This may serve to constrain development in these countries. Transfer of financial and technical resources to affected countries could be justified on these grounds. Countries that have emitted more than their fair share of greenhouse gases may become liable to other countries for the damage that may result from climate change. Finally, delay in adopting abatement strategies has implications

for the South, in terms of lost opportunities for development of alternative energy sources, land use, and crops. The South may wish to be compensated for these foregone development opportunities.

Technology cooperation between North and South is a key complement to financial transfers. While additional funds can enable developing countries to utilize the latest technologies, the long-term effectiveness of such investments will depend crucially on improved knowledge and skill development that is an essential element of technology cooperation. Over the past decades, many studies of industrial productivity (including the efficiency of energy use), have sought to isolate the critical factors underlying long-term efficiency improvements. In particular, researchers have shown that less than 20% of productivity gains have resulted from "embodied technical change" (i.e., mainly improvements in the physical capital stock or machines themselves). The great bulk (over 80%) of efficiency increases may be attributed to "disembodied technical change" (i.e., basically the aspects linked to increased skills and knowledge of human beings). The key conclusion for those seeking to improve energy management and reduce GHG emissions in the developing world is that the *financing* of new investments must be synchronised with *human resource development*, and *institution building*, to achieve maximum effectiveness. Important barriers to improving the application of technology for environmental protection include: (a) economic problems like capital shortages and policy distortions; (b) inadequate environmental regulations and weak enforcement; (c) insufficient technological skills and knowledge; and (d) poor decisionmaking and lack of political will. The implementation of a climate change response strategy will have to address these difficulties.

### 3.4 Procedures and Mechanisms

The UNFCCC broadly outlines some procedural guidelines to be adopted in addressing climate change at the global scale. These pertain primarily to the collective decisionmaking framework--especially to the negotiation and arbitration processes. At the outset, the UNFCCC states that collective decisionmaking (i.e., the steps in negotiating treaties and agreements) must be based on 'procedural rationality', which places emphasis on the manner in which decisions are made. This is in contrast to 'substantive or consequential rationality' where the emphasis is on the outcome of the choice, irrespective of the decisionmaking process. A collective decisionmaking process is essential for negotiating international treaties and agreements, establishing decision procedures, and determining appropriate weights, decision criteria or rules to apply.

The significant scientific, economic, and policy uncertainties surrounding the climate change problem compel international negotiators to first initiate environmental treaties on a more general basis and then further develop the details incrementally. Thus, once the broad outline of a treaty (like the FCCC) is agreed upon during the main negotiation phase, additional and specific details are addressed in the post-negotiation stage. Such discussions can be time consuming, due to the difficulty of arriving at a consensus among such a large number of stakeholders. Environmental negotiations are also becoming more complex because other policy concerns need to be incorporated into the process, such as international competitiveness and trade, as well as different opinions about what constitute fair and equitable solutions (particularly between developed and developing countries). Therefore, new and innovative approaches are required to improve the effectiveness, and enforceability of international environmental negotiations.

Further work on procedural issues is going on in view of the following factors pertaining to the climate change problem. Post-agreement negotiation processes, which will critically influence the success of GHG abatement implementation efforts, need to be strengthened further. In particular, following some basic guidelines may be useful -- such as involving domestic or local stakeholders and eventual implementers (including firms, consumer representatives and energy producers) from the earliest stages of negotiations;

restructuring agreements to reflect simplicity and transparency; and improving processes to educate the public about international environmental problems which generally tend to be more abstract than local environmental issues.

In the absence of a global social welfare function which could be maximized using methods of economic analysis (see the earlier discussion), emphasis for resolution of global environmental problems falls squarely on the ability to reach consensus through a negotiation process, and on the political will within countries to implement agreed measures. The UNFCCC recommends a flexible procedure for collective decisionmaking. Governments are requested to submit national communications which will ensure that they comply with their commitments. Flexibility also facilitates modifying and changing the agreement subject to availability of new information.

Countries are also required by the Convention to co-ordinate their economic and administrative instruments. Co-ordination between countries is also necessary to ensure that measures adopted under international treaties are not misused to reinforce protectionist measures and other trade distortions, or negatively affect third parties.

### **Financing Mechanisms for Climate Change Responses**

Climate change impacts and consequences are marked by great uncertainty, which will affect the nature and scale of technical and economic response strategies, and ultimately determine the extent of financial resources required. One primary objective of the international climate change mitigation effort is to provide financial and other incentives to both developing and industrialized countries to implement agreed measures that will reduce emissions and increase the absorption capacity of GHGs. Activities implemented jointly, an approach which was described earlier, is just one example of a cooperative mechanism to provide such financial incentives.

Given the massive potential costs of future GHG abatement measures worldwide (ranging from tens to hundreds of billions of US dollars), a variety of avenues are being explored to secure funding for such programs. Specific mechanisms include general taxes and other sources of revenue not usually associated with climate change, as well as specific taxes targetting activities that discharge GHGs (for example, taxes or fees on those using fossil fuels, like the carbon tax mechanism).

The trading of emissions rights among nations (through a system for trading marketable emissions permits), is another source of financing discussed in the previous section. Other creative methods to secure funding are also being explored. Using undisbursed funds left over from dormant projects or overestimated budget items, cost savings from increased energy efficiency, additional taxes on airline tickets, or introducing a worldwide lottery, are some suggestions. Another possibility is to impose a non-compliance fee on countries that are unable to meet their GHG abatement obligations -- this may not be appropriate for non-Annex 1 countries (i.e., developing nations), especially since they have no binding commitments at present.

In the shorter term, multilateral development banks, bilateral assistance programs, United Nations organizations (especially those concerned with development, science and technology), and other research and academic foundations, are being encouraged to expand their capacity for addressing climate change issues. More specifically, such institutions are expected to provide incentives, in the form of external assistance, to those developing countries who will adapt their national development priorities to accommodate climate change considerations. "Win-win" strategies that simultaneously achieve internal sustainable development goals, as well as GHG emissions abatement objectives, have the highest priority. Additional and complementary actions by groups of nations are being similarly promoted at the regional level. Regional development banks are already ensuring that their projects are environmentally sound. To the extent possible, such projects could also be made

more compatible with the climate change decisions that would emerge from the UNFCCC negotiations.

On matters such as assessing the financial assistance for climate change strategies, cooperation between nations, and development of mechanisms to be utilized as climate change strategies, a progressive approach is recommended. This mirrors the process described earlier in the development of international treaties. One example is the Global Environment Facility which went through a five year pilot phase before being accepted as an 'interim' financing mechanism to support GHG mitigation efforts. Another case is the step by step approach being adopted in implementing the Montreal Protocol for reducing emissions of ozone depleting substances like chlorofluorocarbons and halons.

Initially, a "twin response track" could help to ensure well coordinated and cost effective disbursement of resources to address climate change. The first track focuses on existing institutions such as the World Bank, UN organizations, multilateral organizations and some regional banks. Global climate change issues are being integrated into the agendas of these institutions, and they will each develop action plans while also identifying opportunities for future action. These organizations will re-examine the nature of ongoing development assistance in the context of this integration process. Funding priorities may be altered to reflect a greater emphasis on environmental programs.

The second 'response track' refers to a parallel development of new institutional mechanisms, expressly created to facilitate the implementation of climate change conventions and related protocols. The Global Environment Facility is such an initiative.

The IPCC has discussed the merits of individual developing countries developing country specific studies on current and projected emission levels along with estimates of financial and technical resources required to meet objectives of GHG mitigation or sink enhancing strategies. Energy, forestry and agriculture are the most important sectors to be examined in this regard. Such studies are to be conducted expeditiously, in order to determine the magnitude of the financial needs of developing countries. A similar approach was adopted in addressing issues and needs faced by countries in adhering with the Montreal Protocol.

## **Insurance and Related Mechanisms**

Insurance is a mechanism closely linked with financial markets, that provides an important method of dealing with risk and uncertainty, using information derived from such markets. It provides a mechanism to share the risk of adverse climate change outcomes between agents (i.e., both among and within countries). In general, the literature indicates that risk sharing through insurance tends to improve social welfare in an economy (see for example, *Eeckhoudt and Gollier 1995*). The concern about global climate change is not merely concentrated in the rich nations, but in the upper income groups in those nations, which are the very same groups that already purchase insurance to protect themselves against other losses like health, flood, earthquake. Persuading poor people to make cash outlays for flood or earthquake insurance can be much more difficult even in the industrialized countries. However, less formal insurance schemes have developed even in simple economies. For example, peasant farmers reduce their individual exposure to misfortune (e.g., bad weather or ill health), by collectively sharing farm work and outputs. In summary, to the extent that the lack of information about the impacts of climate change constitute a risk to society, this risk could be spread more widely through markets for securities that pay off contingent on the probability of such risk.

Insurance schemes at the global level need to take some special concerns into account. These issues are linked to the "polluter pays" and "victim is compensated" principles. First, relating to the extent that the bulk of past and present contributions to carbon emissions has been by industrial countries, the developing countries feel that the industrialized nations should bear a special responsibility for the costs of uncertainty imposed on the rest of the



world. Second, developing countries are likely to be less able to protect themselves from potential impacts of climate change, and more vulnerable to the risks.

Financial markets and private economic agents could serve as a useful mechanism to assess the true importance that individual countries place on the climate change issue, and on the publicly-stated position taken by them (Chichilnisky and Heal 1993). When countries express their estimates of climate change risk through market commitments or payments, the latter are more likely to reflect actual views than the mere public pronouncements of these governments.

A community's willingness to pay to reduce risk from climate change depend on two factors: the degree of risk aversion and the discount rate. Differences in policy positions among countries can be attributed to these two causes and also to varying interpretations of the available evidence. The efficient global solutions mentioned earlier, do not necessarily have to be compromised on account of such differences in perceptions among countries. The differences in the degree of risk aversion, discount rate, and seriousness of the perceived outcomes, can be addressed by creating markets in which the different risk positions can be traded, leading to a more efficient outcome.

Creating financial markets can be justified from an ecological-economic standpoint as well. Thus, the uncertainty over (a) the regional distribution; and (b) the overall intensity of impacts, merits examining two broad categories of financial instruments as a means of sharing the risks to both biological and cultural diversity. For example, the alliance of small island states (AOSIS) has proposed a *mutual insurance* scheme to deal with the regional variations in climate change impacts. The AOSIS proposal first pools together nations (or communities) who face somewhat similar risks, and then provides pay-offs to the more adversely affected regions from those who suffer lesser impacts. More specifically, AOSIS envisages an "International Insurance Pool" consisting of two groups: (a) low lying coastal nations and small island states -- who would receive insurance cover from the pool; and (b) industrialised, donor countries -- who would contribute funds to the pool. The size of the transfers between the two groups would depend on the relative magnitudes of adverse impacts. In contrast to the above approach based on regional variations, the overall or global incidence of impacts may be insured against by so-called 'Arrow securities'. Such an instrument would pay off only if the worldwide intensity of negative impacts reached a pre-determined trigger level.

Clearly, the insurance industry and financial community needs to adopt new analytical methods and explore new instruments to deal with climate change risks, especially since past experience is no longer a helpful guide for the future. One encouraging sign is the innovative reaction of some members of the insurance industry, towards recent extreme weather events (see for example, *Munasinghe and Clarke 1995*). It is only in the 1990s that insurance losses associated with natural disasters have exceeded the US\$1 billion mark -- the most costly up to now being Hurricane Andrew in August 1992 which resulted in US\$15.5 billion in insurance payouts.

### **Making and Implementing Decisions Within Countries**

Any GHG reduction measures have to be designed and implemented within a national framework. Thus individual projects must be generally consistent with the national economic and energy strategy, and also fit more specifically within the investment program of the energy system. It is necessary to briefly review and understand the complexity of the overall energy decisionmaking process, in order to identify barriers and opportunities for GHG emission reductions.

More effective policies may be designed by using a holistic framework that fully accounts for key macroeconomic and intersectoral linkages as well as energy-environmental interactions--an approach that is more comprehensive than the narrower, intrasector analysis used in conventional approaches. Whatever the prevailing political system, there are market

failures and policy distortions that give rise to unsustainable practices. The decisionmaking framework described below helps formulate policies and provide decentralized market signals and information to economic agents that will encourage more sustainable energy production and use.

Climate change decision making is an iterative process. Figure 7 shows how the globally collective decisionmaking process is linked with national policies through the collective decisionmaking process to achieve sustainable energy development (SED) inside a country. An effective SED process must deal with a multiplicity of actors, criteria, levels, policy tools, and impediments. Turning to the first column in the figure, there is an increasing need to ensure multi-actor participation in energy decisionmaking (especially of the environmentally concerned public), but this involvement must be effectively structured to avoid a paralysis of decisionmaking in the sector which could result in costly energy shortages. The existence of many traditional and often conflicting policy criteria or goals

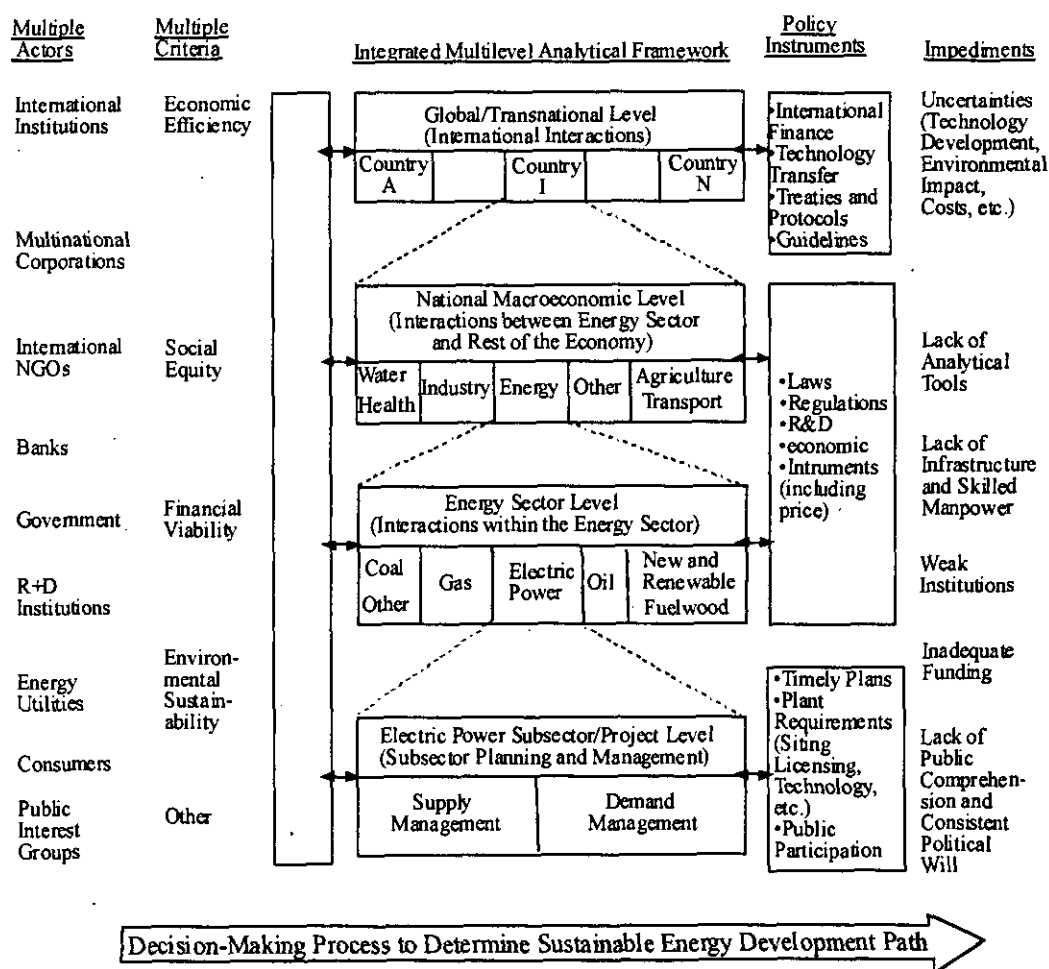


Figure 7: Conceptual framework for sustainable energy development. From Munasinghe (1991).

(shown in the second column) is now complicated further by pressing new environmental considerations--both of a local and global nature. The core of the decisionmaking process is the integrated multilevel analysis shown in the middle column. Within a given country, such an analysis may be carried out using a hierarchical framework for integrated national energy planning (INEP), policy analysis and supply-demand management (*Munasinghe 1990*).

Although the INEP framework is primarily country focused, we begin at the global level by recognising that there are many transnational energy-environmental issues. Thus individual countries are embedded in an international matrix, and economic and environmental conditions (e.g., global warming) at this level will impose a set of exogenous inputs or constraints on decisionmakers within countries. The next hierarchical level in the figure focuses on the multisectoral national economy, of which the energy sector is a part. Therefore, energy planning requires analysis of the links between the energy sector and the rest of the economy. The intermediate level of the integrated approach treats the energy sector as a separate entity composed of sub-sectors such as electricity, petroleum, coal, and so on. This permits detailed analysis, with special emphasis on interactions among the different energy subsectors, substitution possibilities, and the resolution of any resulting policy conflicts. The final or micro-level pertains to analysis within a given subsector. It is at this most disaggregate level that most of the detailed energy resource evaluation, planning and implementation of projects is carried out.

In practice, the many levels of INEP merge and overlap considerably. Thus the interactions of electric power problems and linkages at every level need to be carefully examined. Energy-environmental interactions (represented by the vertical bar) tend to cut across all levels and need to be incorporated into the analysis. Finally, regional and spatial disaggregation may be required also, especially in larger countries.

To reach the desired goals of sound energy management, a variety of policy instruments are available to decisionmakers, as summarised in fourth column of the figure. Since these tools are interrelated, their use should be closely coordinated for maximum effect. Finally, column five indicates the most important impediments that limit effective policy formulation and implementation. The practical application of the SED framework is described in *Munasinghe 1996*, for the case of Sri Lanka.

The above conceptual framework facilitates policymaking and does not imply rigid centralized planning. Thus, such a process should result in the development of a flexible and constantly updated energy strategy designed to meet the national sustainable development goals. This national energy strategy (of which the investment program and pricing policy are important elements), may be implemented through a set of energy supply and demand management policies and programs that make effective use of decentralized market forces and incentives. In particular, the implementation of climate change measures within countries could be made far more effective by incorporating them within the strong current trends towards privatization and decentralization of the energy sector.

## 4. Concluding Remarks

### 4.1 Preliminary Assessment of Abatement Costs and Damages

As indicated earlier, both abatement costs and climate change damage estimates have been estimated on a rather indicative and preliminary basis in the IPCC Second Assessment Report (*IPCC 1996c*). Damages involve more uncertainties (on the ecological and social side) and are more difficult to estimate than costs (which are relatively technology dependent). Thus, the former are assigned wider error bars (see for example, Figure 5). Damages involve valuation of ecological impacts such as biodiversity loss which are very difficult to estimate and have a much higher order of uncertainty. Also, damages involve potential social impacts which may be so severe in some places that they damage the whole

social fabric -- causing mass migrations, conflicts, and civil strife that are impossible to quantify.

Table 1 summarizes the monetary damage estimates for a doubling of CO<sub>2</sub> on an annual basis. Ranges are upper and lower bounds based on the existing literature -- no error bars are assigned. A GHG concentration of 560 ppmv CO<sub>2</sub> equivalent and moderate (2.5°C) climate sensitivity, are assumed.

**Table 1. Annual Economic Damage for Doubling of Pre-industrial CO<sub>2</sub> Concentrations**

<b>Region</b>	<b>Nominal</b>	<b>Adjusted</b>
OECD	1-2%	1-4%
Others (developing and transition)	2-9%	0-7%
World	1.5-2%	1-2%

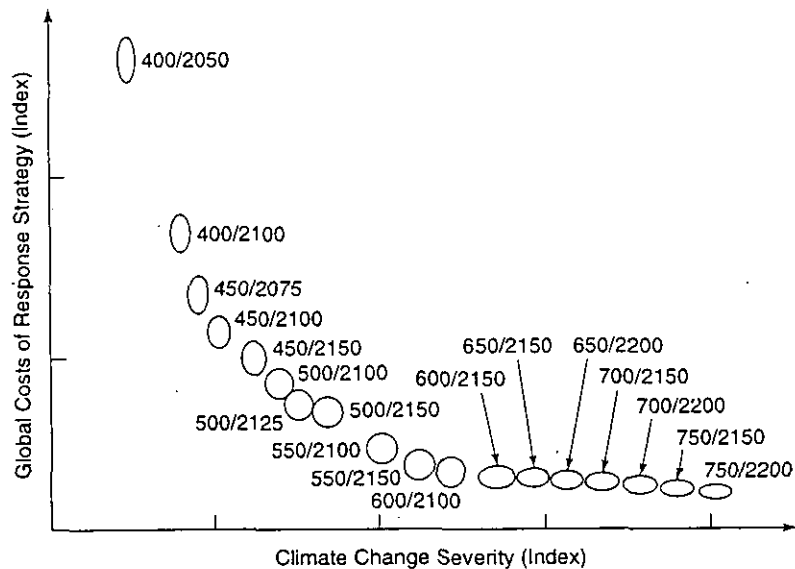
The damage costs range from \$5 to \$125 per ton of carbon emitted. Different values of discount rate (based on the notion that costs in the future should carry less weight than costs borne today), which is used in various calculations, cause damage costs to vary substantially. If a uniformly high discount rate is used, say 5%, the range of damage costs narrows to \$5-\$12 per ton of carbon. However, environmentalists and others argue that with a problem like climate change, we should use a very low discount rate -- implying that future damages should weigh heavily in the calculus today. While the choice of a discount rate is a source of dispute and not another cause of uncertainty, it does influence estimated damage costs significantly.

Regarding mitigation costs, some experts believe that CO<sub>2</sub> could be reduced to 1990 levels at negligible costs -- using "bottom up" models which deal with individual behavior. Conversely, the top down, macroeconomic models project the costs of mitigation to be much higher, up to several percentage points of GDP. Nevertheless these top-down models give answers for different countries that vary quite widely.

Although the foregoing numerical results are too imprecise to provide definite targets, some policy guidance may be derived using the multicriteria analysis (MCA) approach mentioned earlier. Figure 8, on the following page, is a (hypothetical) MCA-based, tradeoff curve of the costs of alternative abatement responses (e.g., measured as the average percentage of GDP lost per year) plotted against a climate change severity index (e.g., the global mean temperature rise at equilibrium in the distant future)<sup>4</sup>. To simplify the presentation, we will specify alternative abatement paths in terms of the target concentration and the earliest date of stabilization. Thus, a point such as 450/2100 indicates that the atmospheric GHG CO<sub>2</sub> concentration will be stabilized at a CO<sub>2</sub> equivalent concentration of 450 ppmv from 2100 onwards. For a given stabilization date, lower target concentrations would imply higher abatement costs (e.g., 450/2100 versus 500/2100), and vice versa. Furthermore, for a given target concentration, an earlier stabilization date would be associated also with greater abatement costs (e.g., 500/2100 versus 500/2150), and vice versa. The data in the figure are illustrative only, and plotted as ellipses -- to indicate the considerable margin of uncertainty. Preliminary information about such a tradeoff curve suggests that abatement costs might rise rather slowly with decreasing concentration levels up to about 600 or 650 ppmv, and then begin to increase more steeply -- especially for concentrations below about 450 ppmv.

Even with rather uncertain estimates about damages and imprecise knowledge of what might constitute "dangerous anthropogenic interference with the climate system", the shape of the tradeoff curve may help to develop a better climate change strategy -- especially if this curve exhibits a sharp bend or "knee".

First, the hypothetical numbers suggest that aiming for a stable concentration less than about 500 ppmv could become prohibitively costly. At the same time, adopting a target level above 600 ppmv is unlikely to reduce abatement costs significantly relative to the sharply rising risk of damage. This aspect resembles the discussion earlier in the context of Figure 5(b) and the affordable safe minimum standard. Second, delaying the stabilization date may not decrease abatement costs a great deal, except for the lower concentration targets (below about 500 ppmv). The latter conclusion has important implications for the debate regarding "putting off" decisions. Another relevant factor is that monetary damages are likely to be an exponentially increasing function of the climate change damage index (e.g., global mean temperature rise). The foregoing information, combined with affordability, risk aversion and the precautionary principle, suggest a reasonable concentration target in the range 450 to 650 ppmv, and little justification for unduly delaying the stabilization date.



**Figure 8:** Hypothetical trade-off curve of an index of response costs versus an index of climate change severity. The pairs of numbers (m/n) represent the stable atmospheric GHG concentration (m) and the year of stabilization (n).

## 4.2 Role of Asian Values

Countries in the Asian region share an ancient and common heritage which has given rise to value systems, modes of social conduct, and relationship with nature, which will prove very useful in climate change decisionmaking.

Asian values place great emphasis on the family as a unit, and on community relations. Recent experience has thrown up a number of examples in the region that harmoniously combine traditional and modern (technology-based) values.

Social decisionmaking in the region has traditionally relied on consensus rather than confrontation. There are many practical examples of consultative and participatory approaches, especially in rural communities. Governance is often informal rather than formal, and disagreements tend to be settled through discussion rather than legal action. Pragmatism, often based on traditional values, has held its own against ideological approaches often introduced from outside.

The high population densities and frequent scarcities of natural resources have encouraged a frugal and sustainable lifestyle, although high levels of consumption and consumerism have emerged among urban groups who mimic Western lifestyles. The bulk of

the population, who are still rural-based tend, to focus on meeting needs rather than artificially created wants. Furthermore, the ancient spiritual and religious roots of the region have emphasised harmonious co-existence with nature rather than dominance over the earth.

### 4.3 Summary

Human values will continue to play a critical role in decisionmaking. Climate change has to be analysed within the broader context of sustainable development, which has three main elements based on economic, social and environmental value systems. Our understanding of the chain of causality from emissions of GHGs to ultimate impacts on natural and human systems is hampered by the large spatial and temporal scale of events, their complexity and irreversibility, and the risks of non-linear responses and catastrophic collapse. Both scientific uncertainty arising from lack of knowledge about natural systems, and socioeconomic and technological uncertainty associated with human systems, are difficult to deal with. Furthermore, equity and social values merge in many forms and often complicate efficiency issues. In decisionmaking, both the procedures and their consequences must be equitable to all stakeholders. Intragenerational equity involves tradeoffs among affected groups, especially between the richer and poorer nations. Intergenerational equity also requires a careful balance to be maintained between the rights of current and future generations, with the discount rate playing a crucial role. Two different estimates of the social rate of discount -- based on the social rate of time preference and the market rate of interest -- yield comparable results of 1 to 4 and 3 to 6 percent, respectively.

A specific set of key questions was posed to decisionmakers seeking to formulate policy responses to address global climate issues. The framework for decisionmaking includes three main elements. First, the global optimization step places a high value oneconomically efficient solutions to determine the desirable GHG concentrations levels. However, while the ideal approach would be to reduce emissions up to the point where the marginal costs of mitigation are exactly equal to the marginal benefits of avoided climate change damages, uncertainties in knowledge suggest that a more basic precautionary rule be used -- i.e., adopting a safe minimum standard for future GHG emissions and concentrations. Second, the collective decisionmaking step puts more emphasis on both procedural and consequential equity. Response strategies consist of mitigatory, adaptive, other policy, and cooperative approaches. Financial transfers and technology cooperation (especially North to South) are also discussed. Third, the procedures and mechanisms step pragmatically explores how the UNFCCC process might be developed to create new and innovative financing mechanisms, insurance schemes and in-country policy application frameworks to implement the international agreements that might emerge from the negotiations.

The decisionmaking framework seeks to be both flexible and heuristic, given that a conventional approach based on deterministic optimization in the long term is not possible in the face of high levels of uncertainty. At the same time, uncertainty should not be used to justify inaction, since a business-as-usual scenario results in a high level of climate change risk which is unacceptable according to the "precautionary principle". The framework facilitates the making of short term decisions (such as 'no regrets' measures) which are sensible and robust, but adjustable in the longer term -- as more accurate information becomes available.

Preliminary and indicative numerical results of both the costs and benefits of GHG abatement were summarized. While it is not possible to set precise targets on the basis of information available today, some broad policy directions are emerging. For decisions that must be made today, we should strive to give decisionmakers information on what is currently known, and at the same time seek to improve the state of our knowledge for future assessments. Climate change decisionmaking is not a single event, but rather a process based on a heuristic approach which makes use of continuing improvements in human knowledge.

The values that we use to assess climate change responses must be clearly defined and understood, to improve the sustainability of the outcomes. Asian value systems in particular -- many of which have emerged from ancient traditions -- will prove very helpful in making and implementing climate change decisions.

## END NOTES

<sup>1</sup>This paper is based mainly on material in the IPCC Working Group III (IPCC 1996c) report on the economic and social dimensions of climate change.

<sup>2</sup>One method of comparing incomes across countries is to use purchasing power parities (PPPs) instead of market exchange rates. PPPs are used to adjust exchange rates, such that the monetary value of a standard basket of commodities (typically including food, clothing and shelter) is equalized across all countries. Such a correction tends to provide a better assessment of the ultimate welfare provided by income levels in different nations. However even when incomes are adjusted based on purchasing power parities, wide differences in real per capita income are still evident among countries.

<sup>3</sup>That is, in any global agreement, the share of emission rights assigned to Annex 1 countries might be adjusted accordingly (see earlier discussion on "contributions to climate change"). Holding countries accountable for emissions after baseline year (say 1990) could help to reduce wasteful consumption, in the scramble to beat regulations or manipulate rules.

<sup>4</sup>Preliminary evidence tends to indicate that the actual economic damages will rise more than linearly with the target level of stable GHG concentration.

## References

- Arrow, K.J. and A. Fischer. 1974. "Environmental Preservation, Uncertainty, and Irreversibility." *Quarterly Journal of Economics*, 88: 312-19.
- Atkinson, G., R. Dubourg, K. Hamilton, M. Munasinghe, D. Pearce, and C. Young. 1997. *Measuring Sustainable Development*, London, UK: Edward Elgar.
- Chichilinsky, G and G. Heal. 1993. Global environmental risks. *Journal of Economic Perspectives*, 7 (4), 65-86.
- Eeckhoudt, L. and C. Gollier. 1995. *Risk evaluation, management and sharing*, translated by V. Lambson. New York: Harvester Wheatsheaf.
- Fisher, A.C. and W.M. Hanneman. 1987. "Quasi Option Value: Some Misconceptions Dispelled." *Journal of Environmental Economics and Management* 14: 183-190.
- Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values*. Washington, DC: Resources for the Future.
- Hanna, S and M.Munasinghe. 1995a. *Property Rights and the Environment*. Stockholm and Washington, DC.: Beijer Institute and the World Bank.
- Hanna, S and M.Munasinghe. 1995b. *Property Rights in Social and Ecological Context*. Stockholm and Washington, DC.: Beijer Institute and the World Bank.
- IPCC. 1996a. *Climate Change 1995: The Science of Climate Change*, (J.T. Houghton et al. eds.), London, UK: Cambridge Univ. Press.
- IPCC. 1996b. *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change*, (R.T. Watson et al. eds.), London, UK: Cambridge Univ. Press.

- IPCC. 1996c. *Climate Change 1995: Economic and Social Dimensions of Climate Change*, (J.P. Bruce et al. eds.), London, UK: Cambridge Univ. Press.
- Jenkins, T.N. 1996. "Democratising the global economy by ecologising economics: The example of global warming." *Ecological Economics* 16 (3): 227-39.
- Kolstad, C.D. and J.B. Braden (eds). 1991. *Measuring the Demand for Environmental Quality*. New York: Elsevier, 1991.
- Lind, R.C. 1982. *Discounting for Time and Risk in Energy Policy*. Baltimore, MD.: Johns Hopkins University Press.
- Maler, K-G. 1990. "International Environmental Problems". *Oxford Review of Economic Policy* 6 (1): 80-108.
- Munasinghe, M. 1990. *Energy Analysis and Policy*. London: Butterworth Press.
- Munasinghe, M. 1991. "Sustainable Energy Options for Developing Countries." *World Energy Council Journal* 1 (December):69-87.
- Munasinghe, M. 1992. "Environmental Challenges Facing the Developing Countries, *EPA Journal* 16 (March-April): 52-4.
- Munasinghe, M. 1993. *Environmental Economics and Sustainable Development*. Washington, DC: World Bank.
- Munasinghe, M. 1995. *Sustainable Energy Development: Issues and Policy*. Environment Paper No. 16. Washington, DC: World Bank.
- Munasinghe, M., (ed). 1996. *Environmental Impacts of Macroeconomic and Sectoral Policies*, Washington DC and Solomons MD: World Bank, UNEP and ISEE.
- Munasinghe, M. 1997. "The Sustainability of Countrywide Policies", Paper presented at the Latin American Ministers of Finance Meeting on Sustainable Development and Growth, Santiago, Chile, 14-16 May.
- Munasinghe, M., and C. Clark. 1995. *Disaster Prevention for Sustainable Development*. Geneva and Washington, DC: International Decade for Natural Disaster Reduction and World Bank.
- Munasinghe, M., et al. 1996. "Applicability of Techniques of Cost-Benefit Analysis to Climate Change", in IPCC. 1996c. *Climate Change 1995: Economic and Social Dimensions of Climate Change*, op. cit.
- Munasinghe, M and K. King. 1992. "Accelerating Ozone Layer Protection in Developing Countries," *World Development* 20 (April): 609-18.
- Munasinghe, M., and S. Munasinghe. 1993. "Enhancing South-North Cooperation to Reduce Global Warming", Paper presented at the IPCC Meeting on Global Warming, Montreal, May.
- Munasinghe, M., and W. Shearer (eds). 1995. *Defining and Measuring Sustainability*. Tokyo and Washington, DC: United Nations University and World Bank.
- Pearce, D. and R.K.Turner. 1990. *Economics of Natural Resources and the Environment*. London: Harvester-Wheatsheaf.
- Solow, R. 1986. "On the Intergenerational Allocation of Natural Resources." *Scandinavian Journal of Economics* 88 (1):141-49.
- UNFCCC. 1993. *Framework Convention on Climate Change: Articles*. New York: United Nations.
- WCED (World Commission on Environment and Development). 1987. *Our Common Future*. London: Oxford University Press.
- World Bank. 1994. *World Development Report*. Washington, DC: World Bank.
- World Bank. 1997. *Measuring Environmental Progress*, Washington DC: Environment Department, The World Bank.