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ANALYSING THE NEXUS OF SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE: AN OVERVIEW

by

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FOREWORD

This document is an output from the OECD Development and Climate Change project, an activity being jointly overseen by the (Environment Policy Committee) Working Party on Global and Structural Policies (WPGSP), and the DAC (Development Assistance Committee) Working Party on Development Co-operation and Environment (WPENV). The overall objective of the project is to provide guidance on how to mainstream responses to climate change within economic development planning and assistance policies, with natural resource management as an overarching theme. Insights from the project will be shared with the development assistance community in OECD countries, and national and regional planners in developing countries.

The paper served as a basis for discussions in an initial OECD expert meeting, held in March 2002, aimed at constructing a framework for future OECD work on development and climate change. It therefore outlines key concepts, relevant principles, and tools for analysis that could support OECD work on this theme.

Partly drawing on this report, a subsequent Concept Paper (Agrawala and Berg 2002) outlined a more specific framework for launching and structuring case studies that are now being carried out under the project. These case studies are focusing on adaptation, to develop an understanding of how climate change adaptation policies in various natural resource management sectors (e.g. coastal zone, water resource and forestry management) can be mainstreamed into economic development planning and assistance policies. Although the case studies are principally addressing adaptation policies, they are also considering opportunities for combined adaptation-mitigation and development outcomes (for example, in the areas of land use and forest management).

Mitigation is also recognised by the international community as a key connection between economic development and climate change policies. Future work in this project may wish to consider mitigation connections more specifically or, drawing on the results of the adaptation and natural resource management case studies, begin to assess the appropriate balance between investment in adaptation and mitigation options in different national contexts. Mitigation is, therefore, also discussed in this document, alongside vulnerability and adaptation issues. Ultimately, climate change solutions will need to identify and exploit synergies, as well as seek to balance possible trade-offs, among the multiple objectives of development, mitigation, and adaptation policies.

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The views expressed in the paper are those of the author alone, and do not necessarily reflect the positions of either the OECD or its Member countries. The report is published under the responsibility of the Secretary-General.

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1. INTRODUCTION

World decision makers are looking for new solutions to traditional development issues such as economic stagnation, persistent poverty, hunger, malnutrition, and illness, as well as newer challenges like environmental degradation and globalisation. One key approach that has received growing attention is the concept of sustainable development or 'development which lasts' (WCED 1987). Following the 1992 Earth Summit in Rio de Janeiro and the adoption of the United Nations' Agenda 21, the goal of sustainable development has become well accepted world-wide (UN 1993).

Meanwhile, the threat of global climate change poses an unprecedented challenge to humanity. While climate change is important in the long run, it is crucial to recognise that (especially for the developing countries) there are a number of other development issues that affect human welfare more immediately – such as hunger and malnutrition, poverty, health, and pressing local environmental issues. Seen from the development viewpoint, climate change vulnerability, impacts and adaptation are the main elements of the climate change problem that resonate. Development pathways also determine emission levels, and they have implications for mitigation strategies as well.

Climate change and development interact in a circular fashion. Alternative development paths will certainly affect future climate change, and in turn, climate change will have an impact on prospects for sustainable development (for details, see IPCC, 2001). In the same context, climate change may endanger the success of some development co-operation efforts and vice versa, *i.e.*, some development assistance efforts could (unintentionally) have repercussion's for a country's emission levels or mitigation options, as well as exacerbate its vulnerability to climate change (Klein 2001).

This paper sketches out a broad framework to address the nexus of sustainable development and climate change. It also draws out some implications for the preparation of future case studies aimed at exploring the dynamics of climate change vulnerability and adaptation – especially when one goes beyond simple win-win outcomes, and confronts difficult trade-off situations among conflicting objectives (Burton and van Aalst 1999, Klein 2001).

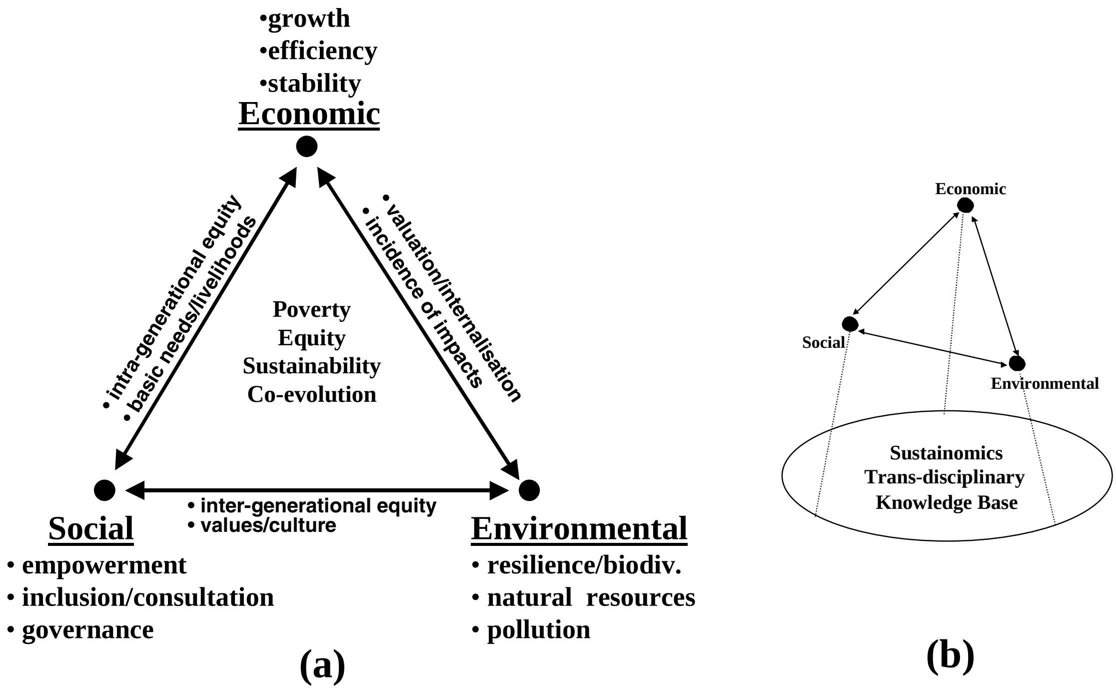
The paper is organised as follows: Section 2 introduces the concept of sustainable development; Section 3 links that concept to climate change. In section 4, tools and methods of integrating and analysing the social, economic, and environmental dimensions of this nexus are briefly presented. These ideas are illustrated in section 5, by applying them to specific examples involving climate-related problems across the full range of spatial scales - at the global, national-economy-wide, sub-national-sectoral, and local-project levels. Section 6 contains some concluding thoughts and a discussion of implications for case studies.

2. OVERVIEW OF KEY CONCEPTS

2.1 Sustainable development concepts

While no universally acceptable practical definition of sustainable development exists, the concept has evolved to encompass three major points of view: economic, social and environmental (Figure 1[a]). Each viewpoint corresponds to a domain (and a system) that has its own distinct driving forces and objectives. The economy is geared mainly towards improving human welfare, primarily through increases in the consumption of goods and services. The environmental domain focuses on protection of the integrity and resilience of ecological systems. The social domain emphasises the enrichment of human relationships, achievement of individual and group aspirations, and strengthening of values and institutions.

Figure 1. Sustainable development triangle supported by a trans-disciplinary framework



Source: adapted from Munasinghe 1992, 1994.

Figure 1(b) indicates how an emerging 'sustainomics' framework (i.e., science of sustainable development), and associated trans-disciplinary knowledge base, would support comprehensive and balanced assessment of the trade-offs and synergies that might exist between the economic, social and environmental dimensions of sustainable development (as well as other relevant disciplines and paradigms) [Munasinghe 1994, 2001; OECD 2001]. Balance is also needed in the relative emphasis placed on traditional development (which is more appealing to the South) versus sustainability (which is emphasised by the North) (Munasinghe1992). The optimality and durability approaches described in Box 1 (below) play key roles in integrating economic, social and environmental issues (Munasinghe 2001).

Current approaches to sustainable development draw on the development experience of the 20th century. For example, the dominant development paradigm during the 1950s was growth, focusing mainly on increasing economic output and consumption. In the 1960s, development thinking shifted towards equitable growth, where social (distributional) objectives, especially poverty alleviation, were recognized to be as important as economic efficiency. Since the 1970s, environment has emerged as the third key element of (sustainable) development.

Broadly speaking, sustainable development may be described as “a process for improving the range of opportunities that will enable individual human beings and communities to achieve their aspirations and full potential over a sustained period of time, while maintaining the resilience of economic, social and environmental systems” (Munasinghe 1994). In other words, sustainable development requires (i) opportunities for improving economic, social and ecological systems; and (ii) increases in adaptive capacity (Gunderson and Holling 2001). Expanding the set of opportunities for system improvement will give rise to development, while increasing adaptive capacity will improve resilience and sustainability. The evolving behaviour of individuals and communities facilitates learning, the testing of new processes, adaptation, and improvement.

The precise definition of sustainable development remains an ideal, elusive (and perhaps unreachable) goal. A less ambitious, but more focused and feasible strategy would merely seek to ***‘make development more sustainable’***. Such an incremental (or gradient-based) method is more practical, because many unsustainable activities can be recognised and eliminated. This approach seeks continuing improvements in the present quality of life at a lower intensity of resource use, hopefully, leaving behind for future generations an undiminished stock of productive assets - manufactured, natural and social capital - that will enhance opportunities for improving their quality of life (Munasinghe 1992).

2.2 Economic, environmental and social sustainability

Economic progress is often evaluated in terms of welfare (or utility) – measured as willingness to pay for goods and services consumed. The modern concept underlying economic sustainability seeks to maximise the flow of income or consumption that could be generated while at least maintaining the stock of assets (or capital) which yield these beneficial outputs (Hicks 1946). Economic efficiency plays a key role in ensuring both efficient allocation of resources in production, and efficient consumption choices that maximise utility. Problems arise in the valuation of non-market outputs (especially social and ecological services), while issues like uncertainty, irreversibility and catastrophic collapse pose additional difficulties (Pearce and Turner 1990).

The *environmental* interpretation of sustainability focuses on the overall viability and health of ecological systems – defined in terms of a comprehensive, multiscale, dynamic, hierarchical measure of resilience, vigour and organisation. Natural resource degradation, pollution and loss of biodiversity are detrimental because they increase vulnerability, undermine system health, and reduce resilience (Perrings and Opschoor 1994; Munasinghe and Shearer 1995) The notion of a "safe threshold" (and the related concept of "carrying capacity") are important, *e.g.*, to avoid catastrophic ecosystem collapse (Holling 1986).

Social sustainability seeks to reduce vulnerability and maintain the health (*i.e.*, resilience, vigour and organisation) of social and cultural systems, and their ability to withstand shocks [Chambers 1989; Bohle et al. 1994; Ribot et al. 1996]. Strengthening social values and institutions (like trust and behavioural norms), and enhancing human capital (through education) will increase social capital – typically, the accumulation of capabilities for individuals and groups of people to work together to achieve shared objectives. Weakening social values, institutions and equity will reduce the resilience of social systems, and undermine governance. Preserving cultural diversity and cultural capital, strengthening social cohesion and networks of relationships, and reducing destructive conflicts, are integral elements of this approach. In summary, for both ecological and socioeconomic systems, the emphasis is on improving system health and its dynamic ability to adapt to change across a range of spatial and temporal scales, rather than the conservation of some 'ideal' static state.

2.3 Poverty and equity

Poverty eradication is a primary goal of the development community. From the sustainable development viewpoint, both poverty and equity have not only economic, but also social and environmental dimensions, and therefore need to be assessed using a comprehensive set of indicators that go beyond income distribution alone. For example, economic policies seek to emphasise means of expanding employment and gainful opportunities for poor people through growth, improving access to markets, and increasing both assets and education. Social policies would focus on empowerment and inclusion, by making institutions more responsive to the poor, and removing barriers that exclude disadvantaged groups. Environmentally related measures to help poor people might seek to reduce their vulnerability to resource depletion and natural disasters, crop failures, loss of employment, sickness, economic shocks, etc.

Thus, an important objective of poverty alleviation is to provide poor people with enhanced physical, human and financial resources that will reduce their vulnerability. Such assets increase the capacity for both coping (*i.e.*, making short-run changes) and adapting (*i.e.*, making permanent adjustments) to external shocks [Moser 1998]. The foregoing ideas merge quite naturally with the "sustainable livelihoods" approach, which focuses on access to portfolios of assets (social, natural and manufactured), the capacity to withstand shocks, gainful employment, and social processes, within a community or individual oriented context.

2.4 Integration of economic, social and environmental considerations

From a longer term perspective, the evolution of social, economic and ecological systems within a larger, more complex adaptive system, provides useful insights regarding the integration of the various elements of sustainable development – see Figure 1(a) [Munasinghe 1994; Costanza 1997]. Two broad approaches are relevant for integrating the economic, social and environmental dimensions of sustainable development. They are distinguished by the degree to which the concepts of *optimality* and *durability* are emphasised (Box 1). While there are overlaps between the two approaches, the main thrust is somewhat different in each case. The degree of uncertainty involved often plays a key role in determining which approach would be preferred. For example, a policy modeller who is analysing relatively steady and well-ordered conditions may favour an optimising approach that attempts to control and even fine-tune outcomes, whereas a subsistence farmer facing chaotic and unpredictable circumstances might opt for a more durable response, which simply enhances survival prospects.

2.5 Convergence between optimality and durability approaches

The practical convergence of the optimality and durability approaches (see Box 1) in the area of climate change may be realised in several ways. For example, at the international level, the Framework Convention on Climate Change seeks to avoid levels of GHG concentrations that would constitute ‘dangerous anthropogenic interference with the climate system’. Thus, there is an interplay between the durability and optimality approaches, and the respective roles of adaptation and mitigation options and their costs, in determining what level of risk and cost is acceptable (for details see IPCC 1996a; Munasinghe 1998, and Example 1 below). At the national level, economy-wide policies involving both fiscal and monetary measures (*e.g.*, carbon taxes, subsidies, interest rates) might be optimised on the basis of quantitative macroeconomic models. Nevertheless, decision-makers inevitably modify these economically ‘optimal’ policies before implementing them, to take into account other socio-political considerations based more on durability. These considerations include protection of the poor and regional development factors, among others, which in turn facilitate governance and stability (see Example 2 below).

2.6 Relevant principles for policy formulation

When considering climate change response options, several principles and ideas, which are widely used in environmental analysis, may be useful. These include the polluter pays principle, economic valuation, internalisation of externalities, property rights, and equity considerations. We note that the applicability of some of these concepts to climate change issues has not been universally accepted.

The polluter pays principle calls for national authorities “to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment” (Principle 16, UN General Assembly 1992). The economic rationale is that this provides an incentive for polluters to reduce their emissions to optimal (*i.e.*, economically efficient) levels.

Quantification and economic valuation of potential damage from polluting emissions is an important prerequisite, when seeking to apply the polluter pays principle (see Box 2 and Annex 1). In the case of a common property resource like the atmosphere, GHG emitters can freely pollute without penalties. Such ‘externalities’ need to be internalised by imposing costs on polluters that reflect the damage caused. An externality occurs when the welfare of one party is affected by the activity of another party who does not take these repercussions into account in his/her decision making (*e.g.*, no compensating payments are made). The theoretical basis for this is well known since Pigou *[1920]* originally defined and treated externalities in rigorous fashion. In this context, the notion of property rights is also relevant to establish that the atmosphere is a valuable and scarce resource that cannot be used freely and indiscriminately.

IPCC work also indicates that although climate change policy cannot be expected to address all prevailing equity issues, it is important to seek adaptation and mitigation polices that avoid worsening existing inequities (IPCC 1996a – Ch.3). While economic theory is best suited to designing efficient economic policies, ethical and social considerations are helpful in addressing equity issues (Pinguelli-Rosa and Munasinghe 2002). Non-climate policies have been traditionally used to address both efficiency and equity issues. At the same time, some additional aspects may be considered in designing climate change policy, including the establishment of an equitable and participatory global framework for making and implementing collective decisions about climate change (e.g., like the one emerging through the UNFCCC).

Other key ideas that are relevant for developing climate change response options, include the concepts of durability, optimality, safe limits, carrying capacity, irreversibility, non-linear responses, and precaution. Broadly speaking, durability and optimality are complementary and potentially convergent approaches (see earlier discussion). Some systems may respond to climate change in a non-linear fashion, with the potential for catastrophic collapse. The need for precaution argues that lack of scientific certainty about climate change risks and vulnerabilities should not become a basis for inaction, especially where relatively low cost steps could be undertaken as a form of insurance – to facilitate both adaptation and mitigation efforts [*UNFCCC 1993*].

Box 1. Reconciling optimality and durability approaches

The optimality-based approach is used in economic analysis to generally maximise the discounted sum of welfare (or utility) over a period of time, subject to the requirement that the stock of productive assets (or welfare itself) does not decrease in the long term. Some ecological models also optimize variables like energy use, nutrient flow, or biomass production – giving more weight to system vigour as a measure of sustainability. However, given the difficulties of quantifying and valuing many such 'non-economic' assets, the costs and benefits associated with market-based activities tend to dominate in most economic optimization models. Basically, the optimal growth path maximizes economic output, while the sustainability requirement is met within this framework by ensuring that stocks of assets (or capital) do not decrease over time. Some analysts support a 'strong sustainability' constraint, 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. One version of this rule might correspond roughly to maximizing economic output, subject to side constraints on environmental and social variables that are deemed critical for sustainability (e.g., biodiversity loss or meeting the basic needs of the poor). Other researchers have argued in favour of 'weak sustainability,' which seeks to maintain the aggregate monetary value of the total stock of assets, assuming that the various asset types may be valued and that there is some degree of substitutability among them (see for example, Nordhaus and Tobin 1972).

Side constraints are often necessary, because the underlying basis of economic valuation, optimization and efficient use of resources may not be easily applied to ecological objectives like protecting biodiversity and improving resilience, or to social goals such as promoting equity, public participation and empowerment. Constraints on critical environmental and social indicators may be considered proxies representing "safe thresholds", which help to maintain the viability of those systems. In this context, techniques like multi-criteria analysis may be required, to facilitate trade-offs among a variety of non-commensurable variables and objectives (see for example, Meier and Munasinghe 1994). Risk and uncertainty will also necessitate the use of decision analysis tools (see Toth 1999). Recent work also underlines that risk perceptions are subjective and depend on the risk measures used, as well as other factors such as ethno-cultural background, socio-economic status, and gender [Bennet 2000].

…. Box 1 continued over page

Box 1 (*Cont.*) Reconciling optimality and durability approaches

The second broad integrative approach would focus primarily on sustaining the quality of life – e.g., by satisfying environmental, social and economic sustainability requirements. Such a framework favours 'durable' development paths that permit growth, but are not necessarily economically optimal. The economic constraint might be framed in terms of maintaining consumption levels (defined broadly to include environmental services, leisure and other 'non-economic' benefits) – i.e., per capita consumption that never falls below some minimum level, or is non-declining. The environmental and social sustainability requirements may be expressed in terms of indicators of 'state' that seek to measure the durability or health (resilience, vigour and organisation) of complex ecological and socio-economic systems. As an illustrative example, consider a simple durability index (D) for an ecosystem measured in terms of its expected lifespan (in a healthy state), as a fraction of the normal lifespan. We might specify: D = D(R,V,O,S) ; to indicate the dependence of durability on resilience (R), vigour (V), organisation (O), and the state of the external environment (S) – especially in relation to potentially damaging shocks.

Durability encourages a holistic systemic viewpoint. The self-organizing and internal structure of ecological and socio-economic systems makes 'the whole more durable (and valuable) than the sum of the parts'. A narrow definition of efficiency based on marginal analysis of individual components may be misleading [Schutz 1999]. For example, it is more difficult to value the integrated functional diversity in a forest ecosystem than the individual species of trees and animals. Therefore, the former is more likely to fall victim to market failure (as an externality). Furthermore, even where correct environmental shadow prices prevail, some analysts point out that cost minimization could lead to homogenization and consequent reductions in system diversity [Daly and Cobb 1989; Perrings et al. 1995]. Systems analysis also helps to identify the benefits of co-operative structures and behaviour, which a more partial analysis may neglect.

The possibility of many durable paths favours simulation-based methods, including consideration of alternative world-views and futures (rather than one optimal result). This approach is consonant with recent research on integrating human actors into ecological models (Ecological Economics 2000 – Special Issue). Key elements include, multiple-agent modeling to account for heterogeneous behaviour, recognition of bounded rationality leading to different perceptions and biases, and more emphasis on social interactions which give rise to responses like imitation, reciprocity and comparison.

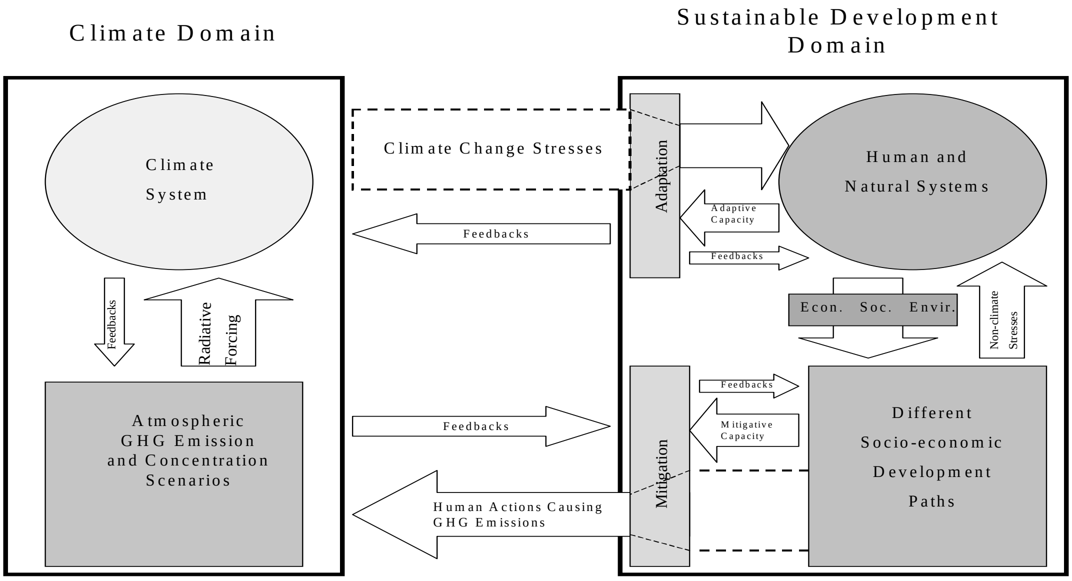
Source: Excerpt from Munasinghe 2001.

3. NEXUS OF SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE

3.1 Circular relationship between climate change and sustainable development

The full cycle of cause and effect between climate change and sustainable development is summarised in Figure 2, which outlines an integrated assessment modelling (IAM) framework (IPCC 2001a). Each socio-economic development path (driven by the forces of population, economy, technology, and governance) gives rise to different levels of greenhouse gas emissions. These emissions accumulate in the atmosphere, increasing the greenhouse gas concentrations and disturbing the natural balance between incident solar radiation and energy re-radiated from the earth. Such changes give rise to the enhanced greenhouse effect that increases radiative forcing of the climate system. The resultant changes in climate will persist well into the future, and impose stresses on the human and natural systems. Such impacts will ultimately have effects on socio-economic development paths, thus completing the cycle. The development paths also have direct effects on the natural systems, in the form of non-climate stresses such as changes in land use leading to deforestation and land degradation.

Figure 2. Integrated Assessment Modelling Framework for Analysing Climate Change and Sustainable Development linkages



Source: Adapted from IPCC 2001a.

To summarise, the climate and sustainable development domains interact in a dynamic cycle, characterised by significant time delays. Both impacts and emissions, for example, are linked in complex ways to underlying socio-economic and technological development paths. Adaptation reduces the impact of climate stresses on human and natural systems, while mitigation lowers potential greenhouse gas emissions. Development paths strongly affect the capacity to both adapt to and mitigate climate change in any region. In this way adaptation and mitigation strategies are dynamically connected with changes in the climate system and the prospects for ecosystem adaptation, food production, and long- term economic development.

Thus climate change impacts are part of the larger question of how complex social, economic, and environmental sub-systems interact and shape prospects for sustainable development. There are multiple links. Economic development affects ecosystem balance and, in turn, is affected by the state of the ecosystem. Poverty can be both a result and a cause of environmental degradation. Material- and energy-intensive life styles and continued high levels of consumption supported by non-renewable resources, as well as rapid population growth are not likely to be consistent with sustainable development paths. Similarly, extreme socio-economic inequality within communities and between nations may undermine the social cohesion that would promote sustainability and make policy responses more effective. At the same time, socio-economic and technology policy decisions made for non-climate-related reasons have significant implications for climate policy and climate change impacts, as well as for other environmental issues. In addition, critical impact thresholds, and vulnerability to climate change impacts, are directly connected to environmental, social and economic conditions, and institutional capacity.

3.2 Economic, social and environmental risks arising from climate change

For a variety of reasons, decision-makers are beginning to show more interest in the assessment of how serious a threat climate change poses to the future basis for improving human welfare [Munasinghe 2000; Munasinghe and Swart 2000].

First, from the *economic viewpoint*, projected climate change will have diverse effects, but the larger the changes and rate of change in climate, the more the adverse effects predominate (IPCC 2001b, p.67). In its simplest form, the economic efficiency viewpoint will seek to maximise the net benefits (or outputs of goods and services) from the use of the global resource represented by the atmosphere. Broadly speaking, this implies that the stock of atmospheric assets, which provide a sink function for GHGs, needs to be maintained at an optimum level. A target level defined mainly on the basis of economic principles would be set at the point where the marginal avoided damages arising from impacts and adaptation are equal to the marginal GHG mitigation costs. The underlying principles are based on optimality and the economically efficient use of a scarce resource, *i.e.*, the global atmosphere.

Second, from the *social perspective*, existing evidence demonstrates that poorer nations and disadvantaged groups within nations may be especially vulnerable to climate change [Clarke and Munasinghe 1994; Banuri 1998; IPCC 2001a]. The historical effects of large scale regional phenomena like El Nino could provide some indication of the likely future impacts of climate change on a planetary scale (Munasinghe 2001). Climate change is likely to exacerbate inequities due to the uneven distribution of the costs of damage, as well as of necessary adaptation and mitigation efforts – such differential effects could occur both among and within countries. However, adaptation and mitigation response measures can take into account, and seek to help address, equity issues (IPCC 2001a).

Third. the *environmental viewpoint* also draws attention to the fact that increasing anthropogenic emissions and accumulations of GHGs might significantly perturb a critical global sub-system – the atmosphere [UNFCCC 1993]. Environmental sustainability will depend on several factors, including climate change intensity (*e.g.*, magnitude and frequency of shocks), system vulnerability (*e.g.*, extent of impact damage); and system resilience (*i.e.*, ability to recover from impacts). Changes in the global climate (*e.g.*, mean temperature, precipitation, etc.) could also threaten the stability of a range of critical, vulnerable, and inter-linked physical, ecological and social systems and subsystems [IPCC 1996b and 2001].

3.3 Vulnerability, resilience, adaptation and adaptive capacity

As discussed above, durability criteria or constraints focus on maintaining the quality and quantity dimensions of asset stocks. In the area of climate change, the various forms of capital are viewed as a bulwark that decreases vulnerability to external shocks and reduces irreversible harm, rather than mere accumulations of assets that produce economic outputs. System resilience, vigour, organisation and ability to adapt will depend dynamically on the capital endowment, as well as on the magnitude and rate of change of a shock.

It is useful at this stage to define certain terms more precisely, in the context of climate change (*IPCC 2001a*). ***Vulnerability*** is the extent to which human and natural systems are susceptible to, or unable to cope with the adverse effects of climate change. It is a function of the character, magnitude and rate of climate variation, as well as the sensitivity and adaptive capacity of the system concerned. ***Resilience*** is the degree of change a system can undergo, without changing state. ***Adaptation*** refers to the adjustments in human and natural systems, in response to climate change stresses and their effects, which moderate damage and exploit opportunities for benefit (*e.g.*, building higher sea walls, or developing drought- and salt-resistant crops). Different types of adaptation include anticipatory versus reactive adaptation, private versus public adaptation, and autonomous versus planned adaptation. ***Adaptive capacity*** is the ability of a system to adjust to climate change.

Strengthening adaptive capacity is a key policy option, especially in the case of the most vulnerable and disadvantaged groups. Adaptive capacity itself will depend on the availability and distribution of economic, natural, social, and human resources; institutional structure and access to decision making processes; information, public awareness and perceptions; menu of technology and policy options; ability to spread risk; etc. (Smit et al. 2001; Yohe and Tol 2001). In turn, performance across these variables is likely to be linked to patterns of economic and social development in a given country or specific location.

3.4 Mitigation and mitigative capacity [to replace previous text with this heading

The IPCC recently elaborated six different reference scenarios that show a wide variety of alternative development pathways over the next century, each yielding a very different pattern of GHG emissions (IPCC 2000). Lower emission scenarios require less carbon-intensive energy resource development than in the past. In the past decade, progress on GHG emission reduction technologies has been faster than anticipated. Improved methods of land use (especially forests) offer significant potential for carbon sequestration. Although not necessarily permanent, such methods might allow time for more effective mitigation techniques to be developed. Ultimately, mitigation options will be determined by differences in the distribution of natural, technological, and financial resources, as well as mitigation costs across nations and generations (IPCC 2001a).

Although the path to a low emission future will vary by country, the IPCC results indicate that appropriate socio-economic changes combined with known mitigation technology and policy options could help to achieve a range of atmospheric CO2 stabilisation levels around 550 ppmv or less, in the next 100 years. Social learning and innovation, and changes in institutional structure could play an especially important role. Policy options that yield no-regrets outcomes will help to reduce GHG emissions at no or negative social cost. However, the incremental costs of stabilising almospheric CO2concentrations over the next century rise sharply as the target concentration level falls from 750 ppmv to 450 ppmv.

Integrating climate policies with non-climate national sustainable development strategy will increase the effectiveness of mitigation efforts. However, there are many technical, social, behavioural, cultural, political, economic, and institutional barriers to implementing mitigation options within countries. Coordinating actions across countries and sectors could reduce mitigations costs, and limit concerns about competitiveness, conflicts over international trade regulations, and carbon leakage. To summarize, early actions including mitigation measures, technology development, and better scientific knowledge about climate change, will increase the possibilities for stabilising atmospheric GHG concentrations.

The effectiveness of future mitigation could be improved by strengthening ***mitigative capacity*** (i.e., the social, political and economic structures and conditions required for mitigation). The mitigative capacity among nations is inevitably varied and suggests that more research and analytic capacity is needed in developing countries. Increases in mitigative capacity could allow climate change considerations to be more effectively integrated with action to address other (non-climate) sustainable development challenges in a manner that effectively limits GHG emissions over time, while maximising the developmental co-benefits of mitigative actions. Such a 'win-win' approach is elaborated in Example 2 (Figure 5) below.

4. TOOLS FOR ANALYSIS AND ASSESSMENT

Some important tools that may be used for analysis and assessment are summarised below. More details are provided in Annex 1.

4.1 Action impact matrix (AIM)

The Action Impact Matrix (AIM) is a tool to facilitate the sustainability of development by analysing economic, environmental and social interactions of various development policies. Global environmental problems, such as climate change, should be a key aspect of the assessment. For example, macroeconomic policies adopted routinely by national policy makers often have significant environmental and social impacts (Munasinghe 2002). In particular, such policies shape the development paths of nations, which in turn affect not only the severity of future climate change impacts, but also vulnerability to climate change, as well as adaptive and mitigative capacities.

The AIM approach will help to find ‘win-win’ policies and projects, which not only achieve conventional macroeconomic objectives (like growth), but also make local and national development efforts more sustainable. With respect to climate change, the approach can identify key linkages between development efforts and climate change issues like vulnerability, impacts (including changes in GHG emission levels), mitigation and adaptation. It would help to identify development paths that embed national climate change policies in the overall sustainable development strategy.

The process of preparing the matrix encourages stakeholder participation in identifying priority issues and relevant data, posing the appropriate questions, interpreting the results, and formulating and implementing policy outcomes. In particular, it facilitates consensus building among the development, climate change, and environmental communities.

The AIM itself promotes an integrated view, meshing development decisions with priority economic, environmental and social impacts. Usually, the rows of the table list the main development interventions (both policies and projects), while the columns indicate key sustainable development issues and impacts (including climate change vulnerability). Thus the elements or cells in the matrix help to:

- identify explicitly the key issues and linkages;
- focus the analysis on the most important vulnerabilities and issues; and
- suggest action priorities and remedies.

At the same time, the organisation of the overall matrix facilitates the tracing of impacts via complex pathways, as well as the coherent articulation of the links among a range of development actions - both policies and projects. More details are provided in Example 2.

4.2 Indicators

It will be important to monitor if and how climate change or climate change policies may affect stocks of natural, social and economic capital in different regions of the world. The risks to natural and economic capital are well documented in the recent IPCC Third Assessment Report (IPCC 2001a - Ch.19 of WGII; IPCC 2001b - Section 3), whereas the social dimension is more difficult to measure and has only received attention in the past few years. For example, recent OECD work advances definitions of human capital to encompass human well-being - measured through education and health indicators and social capital as networks of shared norms, values and understanding that facilitates co-operation within and between groups (OECD 2001). However these concepts of social capital have not yet been systematically applied in the assessment of climate change impacts or of climate policies. Nevertheless, these different types of stocks of assets are central to the optimality and durability approaches, as well as to the capacity to adapt to and mitigate climate change, and multi-dimensional indicators could be useful in assessing policy options. Annex 1 (Section A1.1) summarises the literature which describe a wide variety of indicators that are already in use. It may be possible to adapt some of these for use in the assessment of connections between development and climate policies.

4.3 Cost-Benefit Analysis (CBA)

Cost-benefit analysis (CBA) is one well-known example of a single value approach, which seeks to assign economic values to the various consequences of an economic activity. The resulting costs and benefits are combined into a single decision making criterion like the net present value (NPV), internal rate of return (IRR), or benefit-cost ratio (BCR). Useful variants include cost effectiveness, and least cost based methods. Both benefits and costs are defined as the difference between what would occur *with and without* the project being implemented. The economic efficiency viewpoint usually requires that shadow prices (or opportunity costs) be used to measure costs and benefits. All significant impacts and externalities need to be valued as economic benefits and costs (Box 2). However, since many environmental and social effects may not be easy to value in monetary terms, CBA is used in practice mainly as a tool to assess economic and financial outcomes. Annex 1 (Section A1.2) provides further details.

Box 2. Techniques for economically valuing environmental impacts

	TYPE OF MARKET		
BEHAVIOUR TYPE	**Conventional market**	**Implicit market**	**Constructed market**
Actual Behaviour	Effect on Production Effect on Health Defensive or Preventive Costs	Travel Cost Wage Differences Property Values Proxy Marketed Goods	Artificial market
Intended Behaviour	Replacement Cost Shadow Project		Contingent Valuation

Box 2 (*Cont.*) Techniques for economically valuing environmental impacts

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.

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 willing-to-pay (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 willingness 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 decision making, especially when other valuation methods were unavailable.

Source : Munasinghe [*1993*].

4.4 Multi-Criteria Analysis (MCA)

Multi-criteria analysis (MCA) or multi-objective decision-making is particularly useful in situations when a single criterion approach like CBA falls short – especially where significant environmental and social impacts cannot be assigned monetary values (see Annex 1, Section A1.3). In MCA, desirable objectives are specified and corresponding attributes or indicators are identified. Unlike in CBA, the actual measurement of indicators does not have to be in monetary terms – *i.e.*, different environmental and social indicators may be developed, side by side with economic costs and benefits. Thus, more explicit recognition is given to the fact that a variety of both monetary and non-monetary objectives and indicators may influence policy decisions. MCA provides techniques for comparing and ranking different outcomes, even though a variety of indicators are used.

4.5 Sustainable Development Assessment (SDA)

Sustainable development assessment (SDA) is an important tool to ensure balanced analysis of both development and sustainability concerns. The ‘economic’ component of SDA is based on conventional economic and financial analysis (including cost benefit analysis, as described earlier). The other two key components are environmental and social assessment (EA and SA) – *e.g.*, see World Bank 1998. Poverty assessment is often interwoven with SDA. Economic, environmental and social analyses need to be integrated and harmonised within SDA. Since traditional decision making relies heavily on economics, a first step towards such an integration would be the systematic incorporation of environmental and social concerns into the economic policy framework of human society (see Annex 1, Section A1.4).

5. ASSESSING THE SUSTAINABILITY OF CLIMATE CHANGE AND NATURAL RESOURCE MANAGEMENT DECISIONS

The concepts outlined above are highlighted in practical examples outlined below. These case studies provide additional insights into the potential convergence between optimality and durability approaches, and the practical use of the various analytical tools, in the context of climate change and natural resource management problem-solving.

5.1 Transnational scale: climate change policy objectives

Human-induced climate change is a global environmental problem that will have impacts at the local, regional and (potentially) global levels. Successfully limiting the pace and extent of the harmful effects of climate change will require international co-operation. The first example examines the interplay of impacts, adaptation, and mitigation, with optimality and durability based approaches in determining global GHG emission levels [Munasinghe 2001]. GHG concentrations should "be stabilised at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (Article 2, UNFCCC 1993).

***Example 1**: Setting global objectives for climate change co-operation*

Under an economic optimising framework, the ideal solution would be to estimate two curves associated with different GHG emission profiles:

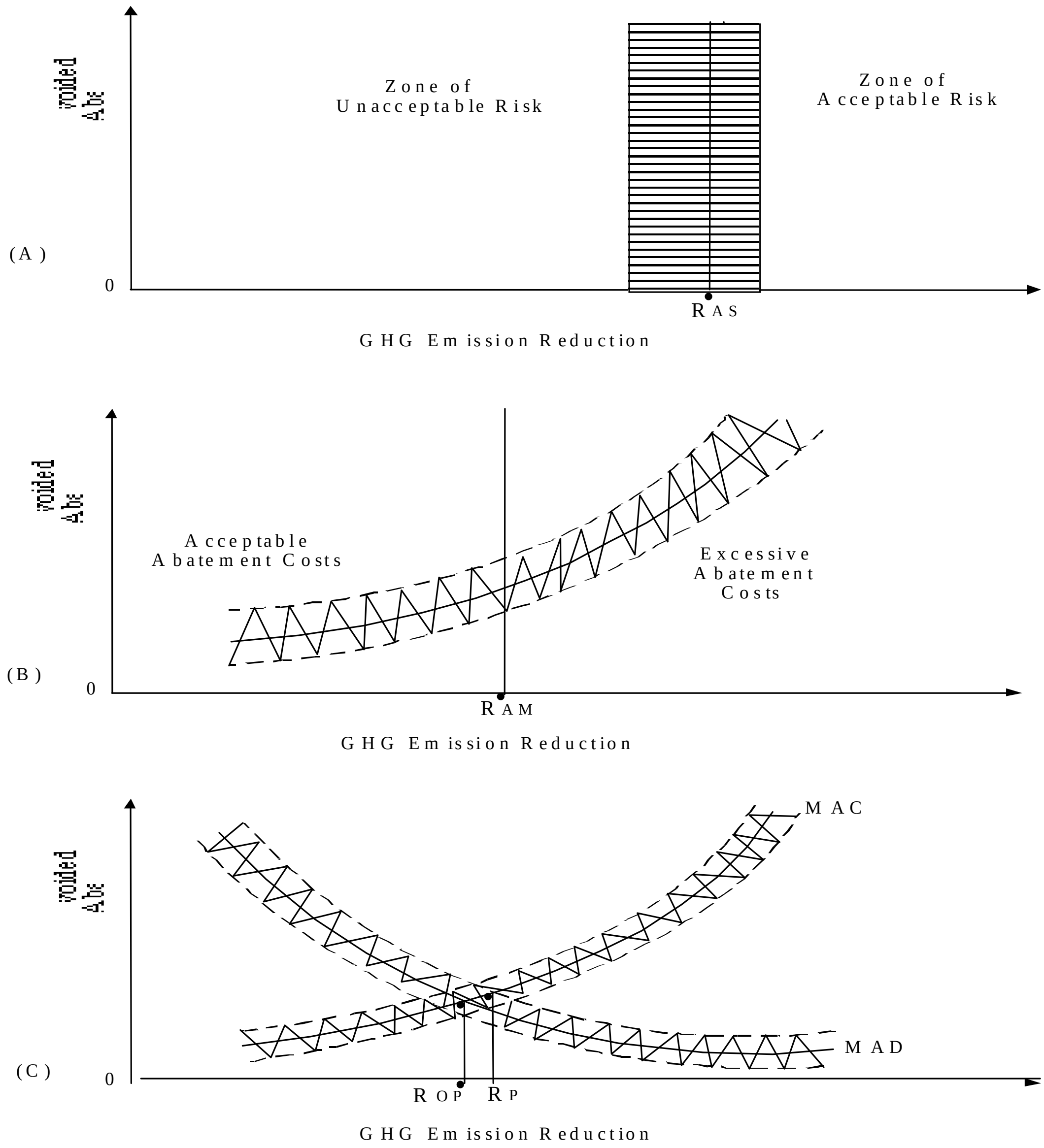
a) the marginal avoided damages (MAD) which depends on climate change impacts and adaptation costs; and
b) the long-run marginal abatement costs (MAC) based on mitigation efforts.

The MAD and MAC curves are shown in Figure 3(c), where the error bands on the curves indicate measurement uncertainties (IPCC 1996c).

The optimisation approach indicates that the desirable emission level would be determined at the point where future benefits (in terms of climate change damage avoided by reducing one unit of GHG emissions) are just equal to the corresponding costs (of mitigation measures required to reduce that unit of GHG emissions), *i.e.*, MAD = MAC at point ROP.

"Durable" strategies become more relevant when we recognise that MAC and/or MAD might be poorly quantified and uncertain. Figure 3(b) assumes that MAC is better defined than MAD. Here, MAC is determined using techno-economic least cost analysis – an optimising approach. Next, the target emissions are set on the basis of the affordable safe minimum standard (at R_{AM}), which is the upper limit on costs that will still avoid unacceptable socio-economic disruption. This line of reasoning takes into consideration the capability of social and economic systems to absorb the shock of the financial burden of mitigation, and is closer to the durability approach.

Figure 3. Determining Global Abatement Targets based on different approaches: A) absolute standard; B) affordable standard; C) cost-benefit optimum



Source: Adapted from IPCC 1996c, Figure 5.10.

Finally, Figure 3(a) indicates an even more uncertain world, where neither MAC nor MAD is defined. Here, the emission target is established on the basis of an absolute standard (R_{AS}) or safe limit, which would avoid an unacceptably high risk of impact damage to ecological (and/or social) systems. This last approach places greater emphasis on vulnerability, impacts and adaptation, and would be more in line with the durability concept.

5.2 National-economy-wide scale: macroeconomic management

Conventional economic valuation of environmental impacts is a key step in incorporating the results of project level environmental assessment into economic decision making – *e.g.*, cost-benefit analysis (see also Annex 1, Section A1.4). At the macroeconomic level, recent work has focused on incorporating environmental considerations such as depletion of natural resources and pollution damage into the system of national accounts [UN Statistical Office 1993; Atkinson et al. 1997]. These efforts have yielded useful new indicators and measures, such as the system of environmental and economic accounts (SEEA), green gross national product, and genuine savings, which adjust conventional macroeconomic measures to allow for environmental effects.

Meanwhile, national policy-makers routinely make many key macro-level decisions that could have (often inadvertent) environmental and social impacts, which are far more significant than the effects of local economic activities. These pervasive and powerful measures are aimed at achieving economic development goals like accelerated growth – which invariably have a high priority in national agendas. Typically, many macroeconomic policies seek to induce rapid growth, which in turn could potentially result in greater environmental harm or impoverishment of already disadvantaged groups. In particular, such policies shape the development paths of nations, which in turn affect the vulnerability to climate change, as well as adaptive and mitigative capacities. Therefore, more attention needs to be paid to such economy-wide policies, whose environmental and social linkages have not been adequately explored in the past [Munasinghe and Cruz 1994].

Clearly, sustainable development strategies (including options that reduce vulnerability and strengthen adaptive and mitigative capacities), need to be made more consistent with other national development policies. Such strategies are more likely to be effective than isolated technological or policy options. In particular, the highest priority needs to be given to finding any ‘win-win policies’, which not only achieve conventional macroeconomic objectives, but also make local and national development efforts more sustainable, and address climate change issues. Such policies could help to build support for sustainable climate change strategies among the traditional decision making community, and conversely make climate specialists more sensitive to shorter term macroeconomic and development goals. They would reduce the potential for conflict between two powerful current trends – the growth oriented, market based economic reform process, and protection of the global environment.

5.2.1 Scope of policies and range of impacts

The most important economic management tools currently in common use are economy-wide reforms, which include structural adjustment packages. Economy-wide (or country-wide) policies consist of both sectoral and macroeconomic policies that have widespread effects throughout the economy. Sectoral measures mainly involve a variety of economic instruments, including pricing in key sectors (for example, energy or agriculture) and broad sector-wide taxation or subsidy programs (for example, agricultural production subsidies, and industrial investment incentives). Macroeconomic measures are even more sweeping, ranging from exchange rate, interest rate, and wage policies, to trade liberalisation, privatisation, and similar programs. Since space limitations preclude a comprehensive review of interactions between economy-wide policies and sustainable development, we briefly examine several examples that provide a flavour of the possibilities involved (for details, see Munasinghe 1996; Jepma and Munasinghe 1998).

On the positive side, liberalising policies such as the removal of price distortions and promotion of market incentives have the potential to improve economic growth rates, while increasing the value of output per unit of pollution emitted (*i.e.*, so called ‘win-win’ outcomes). For example, improving property rights and strengthening incentives for better land management not only yield economic gains and reduce deforestation of open access lands (*e.g.*, due to 'slash and burn' agriculture), but also help to reduce vulnerability, improve the adaptive capacity of ecosystems, and mitigate greenhouse gas emissions.

At the same time, growth-inducing economy-wide policies could lead to increased environmental damages and greater vulnerability to climate change, unless the macro-reforms are complemented by additional environmental and social measures. Such negative impacts are invariably unintended and occur when some broad policy changes are undertaken while other hidden or neglected economic and institutional imperfections persist [Munasinghe and Cruz 1994]. In general, the remedy does not require reversal of the original reforms, but rather the implementation of additional complementary measures (both economic and non-economic) that reduce climate change vulnerability and increase adaptive and mitigative capacities. For example, export promotion measures and currency devaluation might increase the profitability of timber exports (see the example below). This in turn, could further accelerate deforestation that was already under way due to low stumpage fees and open access to forest lands. Establishing property rights and increasing timber charges would reduce deforestation, thereby diminishing vulnerability to climate change and improving both adaptation and mitigation prospects, without interrupting the macroeconomic benefits of trade liberalisation.

Similarly, market-oriented liberalisation in a country could lead to economic expansion and the growth of wasteful resource-intensive activities in certain sectors – if such growth was associated with subsidised resource prices. Such a situation is reported in a case study of Morocco, where irrigation water is the scarce resource affected by economic expansion (Munasinghe 1996). Eliminating the relevant resource price subsidy could help to reduce local water scarcities and reduce vulnerability to future climate change, while enhancing macroeconomic gains. Other countrywide policies could influence adaptation to climate change, negatively or positively. For example, national policies that encouraged population movement into low-lying coastal areas might increase their vulnerability to future impacts of sea level rise. On the other hand, government actions to protect citizens from natural disasters – such as investing in safer physical infrastructure or strengthening the social resilience of poorer communities – could help to reduce vulnerability to extreme weather events associated with future climate change [Clarke and Munasinghe 1995].

In this context, systematic assessment of economic-environmental-social interactions helps to formulate effective sustainable development policies, by linking and articulating these activities explicitly. In particular, it is important to identify those systems, sectors and communities that are likely to be the most vulnerable to climate change, especially if they are already under threat due to existing national policies. Implementation of such an approach would be facilitated by constructing a simple Action Impact Matrix or AIM, as described below in Example 2 [Munasinghe and Cruz 1994].

***Example 2*: Action impact matrix (AIM) for policy analysis**

A simple example of the Action Impact Matrix (AIM) – is shown in Table 1, although an actual AIM would be very much larger and more detailed [Munasinghe 1992, 1996]. The far left column of the Table lists examples of the main development interventions (both policies and projects), while the top row indicates some typical sustainable development issues - including climate change vulnerability and adaptive and mitigative capacity. As indicated earlier, the elements or cells in the matrix help to explicitly identify the key issues and linkages, focus the analysis on the most important vulnerabilities and adaptation issues, and suggest action priorities and remedies. At the same time, the organisation of the overall matrix facilitates the tracing of impacts, as well as the coherent articulation of the links among development policies and projects.

Table 1. A simplified preliminary Action Impact Matrix (AIM)[1]

Activity/Policy	*Main (Economic) Objective* **(A)**	***Impacts On Key Sustainable Development Issues*** *Land Degradation & Biodiversity Loss* **(B)**	*Water Scarcity & Pollution* **(C)**	*Resettle-ment & Social Effects* **(D)**	*Climate Change Effects (eg., vulnerability, impacts and adaptation; and mitigation)* **(E)**
Macro-economic & Sectoral Policies	Macroeconomic and sectoral improvements	Positive impacts due to removal of distortions Negative impacts mainly due to remaining constraints			
Exchange Rate **(1)**	Improve trade balance and economic growth	(-H) (deforest open-access areas)			(-M) (more vulnerable, less adaptive & mitigative capacity)
Water Pricing **(2)**	More efficient water use and economic efficiency		(+M) (water use efficiency)		(+M) (less vulnerable, better adaptive capacity)
Others **(3)**					
Complementary Measures and Remedies[2]	Specific socio-economic and environmental gains	Enhance positive impacts and mitigate negative impacts (above) of broader macroeconomic and sectoral policies			
Market Based **(4)**			(+M) (pollution tax)		(+L) (less vulnerable)
Non-Market Based **(5)**		(+H) (property rights)	(+M) (public sector accountability)		
Investment Projects	Improve effectiveness of investments	Investment decisions made more consistent with broader policy and institutional framework			
Project 1 (*Hydro Dam)* **(6)**		(-H) (inundate forests)		(-M) (displace people)	(+M, -L) (less fossil fuel use, more vulnerable)
Project 2 *(Re-afforest and relocate)* **(7)**		(+H) (replant forests)		(+M) (relocate people)	(+M) (absorb carbon, less vulnerable)
Other Projects					

Source: adapted from Munasinghe and Cruz [1994].

[1] **Notes**:

1. A few examples of typical policies and projects as well as illustrative impact assessments are indicated. + and - signify beneficial and harmful impacts, while H and M indicate high and moderate intensity. The AIM process helps to focus on the highest priority economic social and environmental issues.

2. Commonly used market-based measures include effluent charges, tradable emission permits, emission taxes or subsidies, bubbles and offsets (emission banking), stumpage fees, royalties, user fees, deposit-refund schemes, performance bonds, and taxes on products (such as fuel taxes). Non-market based measures comprise regulations and laws specifying environmental standard (such as ambient standards, emission standards, and technology standards) which permit or limit certain actions (‘dos’ and ‘don’ts’).

A stepwise procedure, based on readily available data, has been used effectively to develop the AIM in several country studies [Munasinghe and Cruz 1994]. This process has facilitated the participation of key stakeholders in identifying issues, analysing data, and formulating and implementing policy options. It has helped build the consensus and harmonise views, especially between the development and climate communities. A good starting point would be basic development documents such as the poverty reduction strategy paper (PSRP), national strategy for sustainable development (NSSD), national agenda 21 plan, and millennium development goals (MDG); as well as environmental reports like the National Environmental Action Plan (NEAP), the National Communications to the UNFCCC, and the National Adaptation Programme of Action (NAPA).[1]

A typical AIM exercise might begin with a group of persons concerned with climate change coming together to determine the most important areas of vulnerability and impacts. These topics would be organised into a large ***'vulnerabilities table'*** (Table 2). For example, suppose that the first column indicated 'deforestation and biodiversity loss' as a high-risk issue. The second column would set out the status as measured by relevant bio-physical indicators such as the land area under forest cover or information on threatened species. The third column could provide socio-economic information, including the numbers of persons whose livelihoods were at risk, their income levels, the economic value of forest loss, and so on. Finally, the fourth column might summarise the key underlying causes or drivers that might increase climate change vulnerability - including pricing policies (like inadequate stumpage fees), institutional factors (like open access forests), and other pressures (like the landless population). A national vulnerabilities table would summarise information about many other risk areas, like water resource scarcity, land degradation, and damage to coastal zones.

Table 2. Typical Elements from a Vulnerabilities Table

ISSUE	BIO-PHYSICAL IMPACTS	SOCIO-ECONOMIC IMPACTS	CAUSES AND DRIVERS
Deforestation and Biodiversity Loss	Area under forest cover, threatened species, etc.	Stakeholder income levels, livelihoods at risk, value of forest loss, etc.	Landless population, open access to forests, lack of stumpage fees, etc.

The next task would be the preparation of a ***'development activities table'*** (Table 3). The first column of this table would contain major development goals and policies, such as an exchange rate devaluation (to improve the balance of payments). The second column might indicate the current status from a development perspective – in the forest sector, typical effects might include balance of payments improvement due to greater timber exports, increased timber demand for exports and local construction, higher deforestation rate, illegal felling, and 'slash and burn' agriculture. The third column could contain environmental and climate related implications, such as threats to the adaptive capacity of forest areas, soil erosion, and loss of watersheds. The fourth column would set out ongoing or proposed remedies, including restricted access to forests, better enforcement, higher stumpage fees, and re-afforestation. A normal development activities table would summarise information on many such major policy areas, dealing with acceleration of economic growth, import substitution, fiscal and monetary balance, industrialisation, agricultural self-sufficiency, energy development, etc.

[1] Except for MDG, these documents are country-specific reports developed in consultation with the development assistance community, which provide a broad review of development status, strategies and plans, as well as the articulation between macro, sectoral and sub-sectoral issues and policies. For example, the PRSPs focus on low-income countries, and stem from the World Bank-IMF initiative on heavily indebted poor countries. The MDG are internationally agreed objectives, including eradicating extreme poverty; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality; improving maternal health; combating, HIV/AIDS, tuberculosis, malaria, and other diseases; ensuring environmental sustainability; and developing a global partnership for development.

Table 3. Typical Elements from a Development Activities Table

DEVELOPMENT GOALS AND POLICIES	DEVELOPMENT IMPACTS	ENVIRONMENT AND CLIMATE IMPACTS	REMEDIES
Exchange rate devaluation to improve balance of payments	**Forest Sector** Higher timber demand for exports and local construction, increased deforestation, illegal timber felling, 'slash and burn' agriculture, etc.	Adaptive capacity of forests, watershed loss, soil erosion, etc.	Restrict forest access, better enforcement, higher stumpage fees, more re-afforestation, etc.

The AIM would be put together by bringing all stakeholders together, to integrate the information in the two tables prepared earlier. Table 3 shows how a simple AIM might be organised, by combining information on development activities and vulnerabilities.

5.2.2 Screening and problem identification

One of the early objectives of the AIM-based process is to help in *screening and problem identification* – by preparing a preliminary matrix that identifies broad relationships, and provides a qualitative idea of the magnitudes of the impacts. Thus, the preliminary AIM would be used to prioritise the most important links between policies and their sustainability impacts (especially climate effects). As mentioned earlier, row (1) of Table 3 shows how a currency devaluation aimed at improving the trade balance, may make timber exports more profitable and lead to deforestation of open access forests. Column (A) indicates a negative local environmental side effect involving severe land degradation and biodiversity loss. In the same row, column (D) shows negative climate change effects, including greater vulnerability etc. Some air pollution and GHG emissions due to burning of wood might also occur, although this is not indicated here. Potential remedial policies are shown lower down in column (A) – *e.g.*, complementary measures to strengthen property rights and restrict access to forest areas, which would prevent the deforestation. As shown in column (D), such steps would reverse the negative climate change effects.

A second example shown in row (2) involves raising (subsidised) water prices to reflect marginal supply costs - to improve the efficiency of water use, and thereby have the additional positive effect of decreasing water scarcity [column (B)] and reducing vulnerability to future climate change [column (D)]. A complementary measure indicated in row (4), column (B) consists of adding water pollution taxes to water supply costs, which will help to reduce both water pollution and damage to human and ecological health, while reducing vulnerability to climate change. As shown in row (5), column (B), improving competition and public sector accountability will reinforce favourable responses to these price incentives, by reducing the ability of inefficient firms to pass on the increased costs of water to consumers or to transfer their losses to the government.

The third example involves a major hydroelectric project, shown in row (6), which has two adverse impacts (inundation of forested areas and village dwellings), as well as one net positive impact (the replacement of thermal power generation, which would reduce air pollution and GHG emissions – despite potential methane emissions from inundated vegetation). A re-afforestation project coupled with resettlement schemes, as indicated in row (7), would help to address the negative impacts.

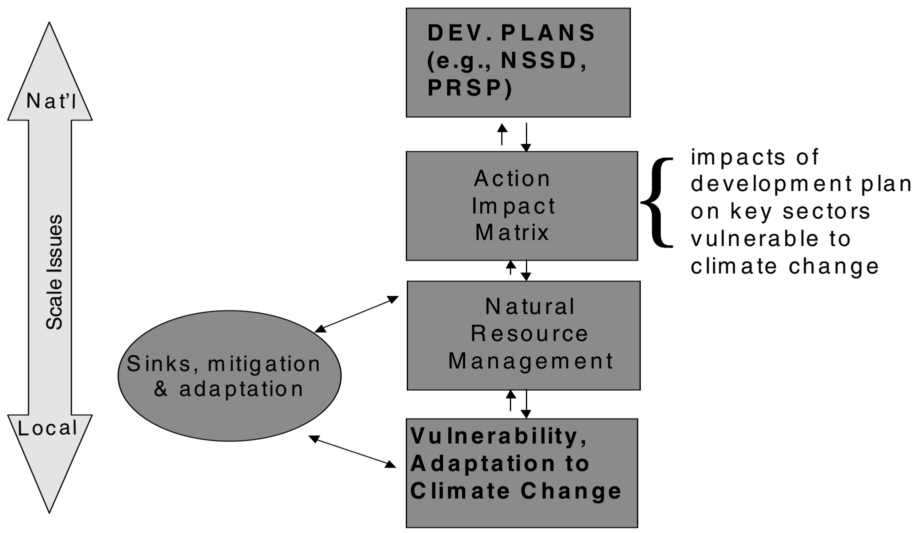
This matrix-based approach therefore encourages the systematic articulation and co-ordination of policies and projects to make development more sustainable. Based on readily available data, it would be possible to develop such an initial matrix as the organising framework for case studies in the OECD project.

5.2.3 Analysis and remediation

This process may be developed further to assist in *analysis* and *remediation*. For example, more detailed analyses and modelling may be carried out for those matrix elements in the preliminary AIM that had been already identified as representing high priority linkages between development activities and climate change vulnerabilities, impacts and adaptation. This, in turn, would lead to a more refined and updated AIM, which would help to quantify impacts and formulate additional policy measures to enhance positive linkages and mitigate negative ones.

The types of more detailed analyses, which could help to determine the final matrix would be case specific, and depend on planning goals and available data and resources. They may range from fairly simple methods to rather sophisticated economic, ecological and social models. The flow of the analytical process, from broad national-level development objectives to detailed local level vulnerabilities, impacts and adaptation, are summarised in Figure 4.

Figure 4. Assessing the link between development plans and climate policy objectives through the natural resources management window



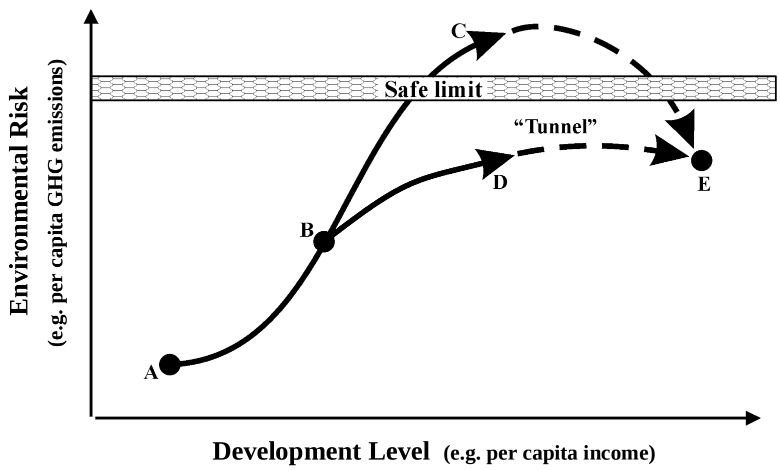
Source: OECD (2002).

5.2.4 Using the AIM to reconcile development and climate change objectives

Given that the majority of the world population lives under conditions of absolute poverty, a climate change strategy that unduly constrained growth prospects in those areas would be more unattractive. The AIM based approach can help to ensure the sustainability of long term growth by reconciling climate change and development objectives [Munasinghe et al. 2001].

Such a 'win-win' outcome is illustrated in Figure 5, which shows how a country's GHG emissions might vary with its level of development. One would expect carbon emissions to rise more rapidly during the early stages of development (along AB), and begin to level off only when *per capita* incomes are higher (along BC). A typical developing country would be at a point such as B on the curve, and an industrialized nation might be at C. The key point is that if the developing countries were to follow the growth path of the industrialized world, then atmospheric concentrations of GHGs would soon rise to dangerous levels. The risks arising from exceeding the safe limit (shaded area) could be avoided by adopting sustainable development strategies that would (a) reduce GHG emissions in industrialized countries along a path like CE; and (b) permit developing countries to progress along a path such as BD (and eventually DE). The Kyoto Protocol favours this approach, by placing the primary obligation for emissions reduction on Annex I (industrialized) countries, while providing incentives for non-Annex I (developing) nations to also participate in mitigation through the clean development mechanism (CDM).

Figure 5. Environmental Risk versus Development Level



Source: Adapted from Munasinghe (1998).

It would be fruitful to encourage a more proactive approach whereby the developing countries could learn from the past experiences of the industrialized world – by adopting 'win-win' sustainable development strategies that incorporate climate change measures, thus enabling them to follow development paths such as BDE shown in the Figure [*Munasinghe 1998*]. The emphasis is on identifying policies that will help de-link carbon emissions and growth in both developed and developing countries, with the curve in Figure 5 serving mainly as a useful metaphor or organizing framework for policy analysis.

This approach also illustrates the complementarity of the optimal and durable approaches discussed earlier. It has been shown that the higher path ABC in the Figure could be caused by economic imperfections which make private decisions deviate from socially optimal ones [*Munasinghe 1998*]. Thus the adoption of corrective policies that reduce such divergences from optimality and thereby reduce GHG emissions per unit of economic output, would facilitate movement along the lower path ABD. Concurrently, the durability viewpoint suggests that flattening the peak of environmental damage (at C) would be especially desirable to avoid exceeding the safe limit or threshold representing dangerous accumulations of GHGs (shaded area in the figure). Thus, the path BDE (both more socially optimal and durable) could be viewed as a sustainable development 'tunnel' [*Munasinghe 1998*].

Several authors have econometrically estimated the relationship between GHG emissions and *per capita* income using cross-country data and found curves with varying shapes and turning points [*Holtz-Eakin and Selden 1995; Sengupta 1996; Cole et al. 1997; Unruh and Moomaw 1998*]. One reported outcome is an inverted U-shape (called the environmental Kuznet's curve or EKC) – like the curve ABCE in the Figure.

5.3 Sub-national scale: energy sector planning and forest ecosystem management

At the sub-national scale, sustainable development issues arise in various forms. In this section, we consider an example dealing with issues in the important energy sector of the Sri Lankan economy.

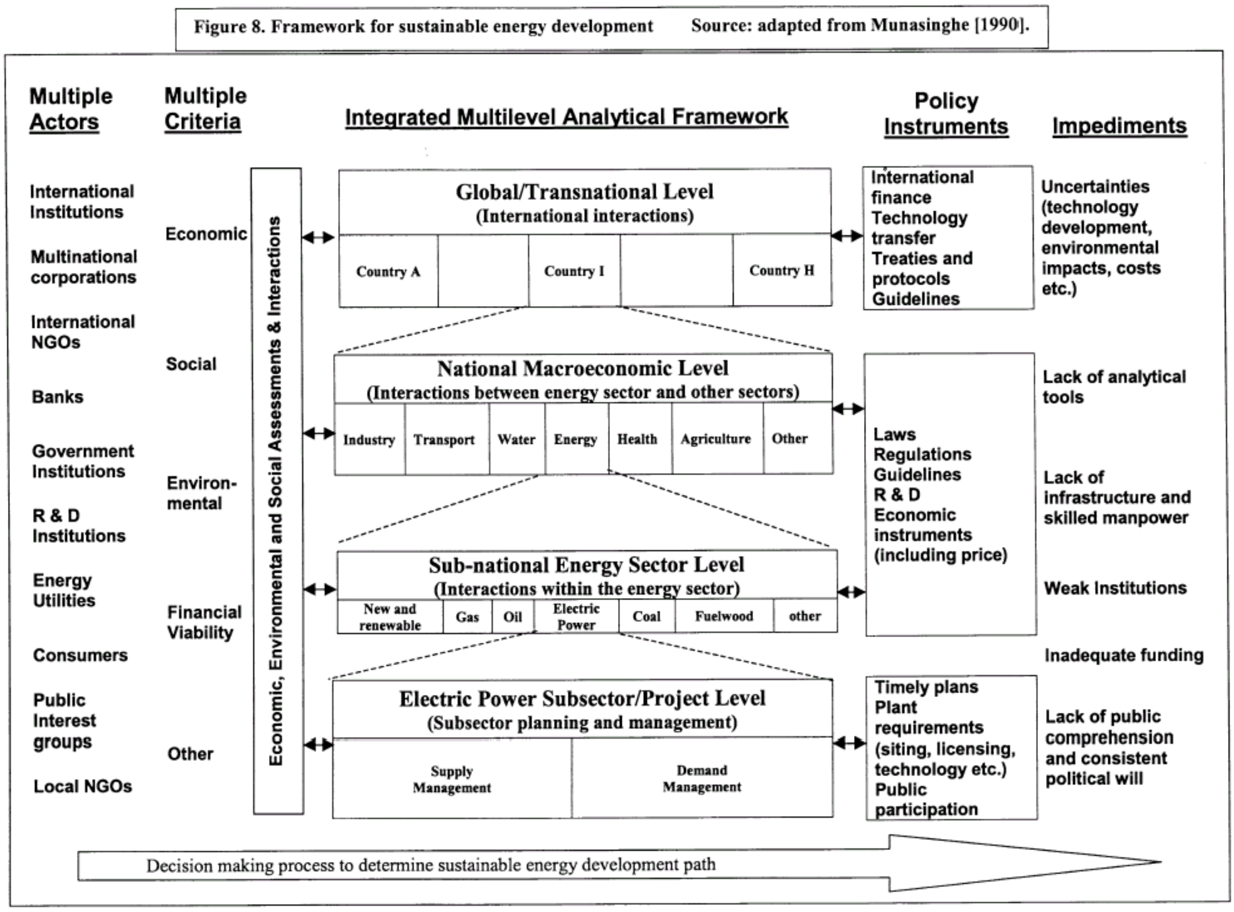
<u>Example 3</u>: Improving energy sector decision-making in Sri Lanka

Actions that affect an entire economic sector or region of a country can have significant and pervasive environmental and social impacts. Thus typically, policies in a given sector like energy have widespread impacts on other sectors of the economy. This requires an integrated, multi-sectoral analytic framework [Munasinghe 1990].

5.3.1 Sustainable energy development framework

A framework for sustainable energy decision making is depicted in Figure 6. The middle column of the Figure shows the core of the framework comprising an integrated multilevel analysis that can accommodate issues ranging from the global scale down to the local or project level. At the top level, individual countries constitute elements of an international matrix. Economic and environmental conditions imposed at this global level constitute exogenous inputs or constraints on national level decision-makers. Typical examples of such external constraints include emerging agreements under the UNFCCC, which have implications for both adaptation and mitigation.

Figure 6. Framework for sustainable energy development



Source: adapted from Munasinghe [1990].

The next level in the hierarchy focuses on the multi-sectoral national economy, of which the energy sector is one element. This level of the framework recognises that planning within the energy sector requires analysis of the links between that sector and the rest of the economy. At the third or sub-national level, we focus on the energy sector as a separate entity composed of sub-sectors such as electricity, petroleum products and so on. This permits detailed analysis, with special emphasis on interactions among different energy sub-sectors. Finally, the most disaggregate and lowest hierarchical level pertains to energy analysis within each of the energy sub-sectors. At this level, most of the detailed energy planning and implementation of projects is carried out by line institutions (both public and private).

In practice, the various levels of analysis merge and overlap considerably, requiring that inter-sectoral linkages should be carefully examined. Energy-economic-environmental-social interactions (represented by the vertical bar) tend to cut across all levels and need to be incorporated into the analysis as far as possible. Such interactions also provide important paths for incorporating environmental and social considerations into sustainable energy development policies.

5.3.2 Methodology

The incorporation of environmental and social externalities into decision making is particularly important in the electric power sector (see also Annex 1, Section A1.4). It is also clear that in order for environmental and social concerns to play a real role in power sector decision making, one must address these issues early - at the sectoral and regional planning stages, rather than later at the stage of environmental and social assessment of individual projects. Many of the valuation techniques discussed earlier are most appropriate at the micro-level, and may therefore be very difficult to apply in situations involving choices among a potentially large number of technology, site, and mitigation options. Therefore, multi-criteria analysis (MCA) may be applied, since it allows for the appraisal of alternatives with differing objectives and varied costs and benefits, which are often assessed in differing units of measurement.

Such an approach was used by Meier and Munasinghe [1994] in a study of Sri Lanka, to demonstrate how externalities could be incorporated into power system planning in a systematic manner. Sri Lanka presently depends largely on hydro power for electricity generation, but over the next decade the main choices seem to be large coal- or oil-fired stations, or hydro plants whose economic returns and environmental impacts are increasingly unfavourable. In addition, there is a wide range of other options (such as wind power, increasing use of demand side management, and system efficiency improvements), that make decision making quite difficult - even in the absence of the environmental concerns. The study is relatively unique in its focus on system wide planning issues, as opposed to the more usual policy of assessing environmental concerns only at the project level after the strategic sectoral development decisions have already been made.

The methodology involves the following steps: (a) definition of the generation options and their analysis using sophisticated least-cost system planning models; (b) selection and definition of the attributes, selected to reflect planning objectives; (c) explicit economic valuation of those impacts for which valuation techniques can be applied with confidence - the resultant values are then added to the system costs to define the overall attribute relating to economic cost; (d) quantification of those attributes for which explicit economic valuation is inappropriate, but for which suitable quantitative impact scales can be defined; (e) translation of attribute value levels into value functions (known as "scaling"); (f) display of the trade-off space, to facilitate understanding of the trade-offs to be made in decision making; and (g) definition of a candidate list of options for further study; this also involves the important step of eliminating inferior options from further consideration.

5.3.3 Main results of Example 3

The main set of sectoral policy options examined included: (a) variations in the currently available mix of hydro, and thermal (coal and oil) plants, included; (b) demand side management (using the illustrative example of compact fluorescent lighting); (c) renewable energy options (using the illustrative technology of wind generation); (d) improvements in system efficiency (using more ambitious targets for transmission and distribution losses than the base case assumption of 12% by 1997); (e) clean coal technology (using pressurised fluidised bed combustion (PFBC) in a combined cycle mode as the illustrative technology); and (f) pollution control technology options (illustrated by a variety of fuel switching and pollution control options such as using imported low sulphur oil for diesels, and fitting coal burning power plants with flue gas desulphurisation (FGD) systems).

Great care needs to be exercised in selecting a limited number of key criteria or attributes, which normally reflect issues of national as well as local project level significance, and have implications for both adaptation and mitigation policies. To capture the potential impact on global warming, CO_2 emissions were defined as the appropriate proxy. Three key indicators based on impacts on human beings, social systems, and ecological systems, were identified. Human health impacts were measured through population-weighted increments in both fine particulates and NO_x attributable to each source. As an illustrative social impact, employment creation was used. To capture the potential biodiversity impacts, a composite biodiversity loss index was derived (Table 4).

Table 4. Deriving a preliminary biodiversity index

Rank	Ecosystem	Relative biodiversity value (w)
1	Lowland wet evergreen forest	0.98
2	Lowland moist evergreen forest	0.98
3	Lower montane forest	0.90
4	Upper montane forest	0.90
5	Riverrine forest	0.75
6	Dry mixed evergreen forest	0.5
7	Villus	0.4
8	Mangroves	0.4
9	Thorn forest	0.3
10	Grasslands	0.3
11	Rubber lands	0.2
12	Home gardens	0.2
13	Salt marshes	0.1
14	Sand dunes	0.1
15	Coconut lands	0.01

Source: adapted from Meier and Munasinghe [*1994*].

We define Gi as the average biodiversity loss index value per unit of energy produced per year at hydro site i.

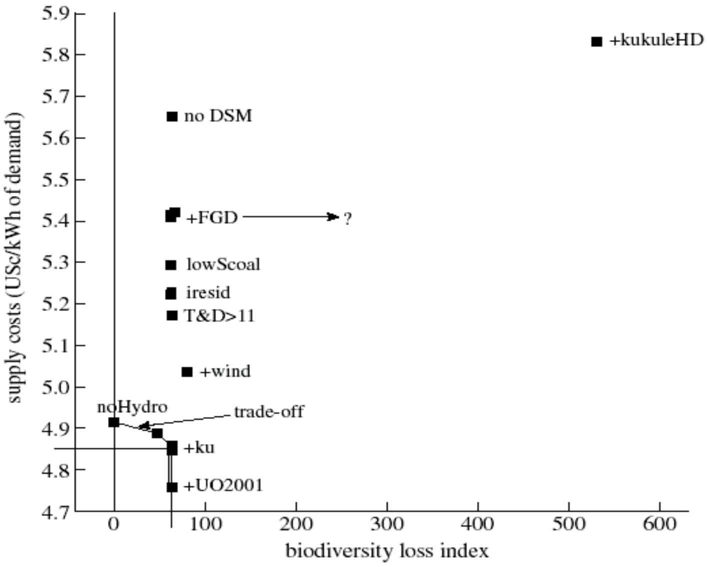
$G_i = \sum_j (w_j).(A_{ij})/$ [Hydroelectric energy generated per year at site i]

where A_{ij} is the area of ecosystem type j at hydro site i, and w_j is relative biodiversity value of ecosystem type j (as defined in Table 4).

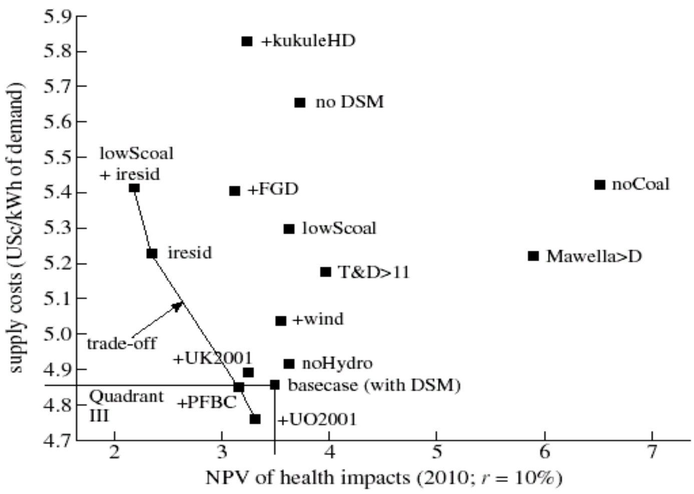
Figure 7(a) illustrates a typical trade-off curve for biodiversity loss (see also, the earlier discussion on MCA in Annex 2, Section 1.3). The "best" solutions lie closest to the origin. The so-called trade-off curve is defined by the set of "non-inferior" solutions, representing the set of options that are better, regardless of the weights assigned to the different objectives. For example, on this curve, the option called “no hydro” is better than the option “wind”, in terms of both economic cost and biodiversity loss.

Figure 7. Trade-off curves for economic costs versus (a) biodiversity loss; and (b) health impacts

(a)



(b)



Source: Meier and Munasinghe 1994.

While most of the options have an index value that falls in the range of 50-100, the no hydro option has an essentially zero value, because the thermal projects that replace hydro plants in this option tend to lie at sites of poor bio-diversity value (either close to load centres or on the coast). Meanwhile, wind plants would require rather large land area, and their biodiversity loss index is higher. However, the vegetation in the area on the south coast (where the wind power plants would be located) has relatively low bio-diversity value, and therefore the overall bio-diversity impact of this option is small. In summary, the best options (on the trade-off curve) include the no hydro, and run-of-river hydro options that require essentially zero inundation. Note the extreme outlier at the top right hand corner, which is the Kukule hydro dam - it has a bio-diversity loss index (B = 530) that is an order of magnitude larger than for other options (B = 50 to 70).

A quite different trade-off curve was derived between health impacts and average incremental cost, as illustrated in Figure 7 (b). Note that the point "iresid" on the trade-off curve (which calls for the use of low sulphur imported fuel oil at diesel plants), is better than the use of flue gas desulphurisation systems (point "FGD") - in terms of both economic cost and environment.

5.3.4 Conclusions of Example 3

This example draws several useful conclusions. First, the results indicate that those impacts for which valuation techniques are relatively straightforward and well-established - such as valuing the opportunity costs of lost production from inundated land, or estimating the benefits of establishing fisheries in a reservoir - tend to be quite small in comparison to overall system costs, and their inclusion into the benefit-cost analysis does not materially change results. Second, even in the case where explicit valuation may be difficult, such as in the case of mortality and morbidity effects of air pollution, implicit valuation based on analysis of the trade-off curve can provide important guidance to decision-makers. Third, the example indicated that certain options were in fact clearly inferior, or clearly superior, to all other options when one examines all impacts simultaneously. For example, the high dam version of the Kukule hydro project can be safely excluded from all further consideration here, as a result of poor performance on all attribute scales (including the economic one). Fourth, the results indicate that it is possible to derive attribute scales that can be useful proxies for impacts that may be difficult to value. For example, use of the biodiversity loss index, and the population-weighted incremental ambient air pollution scale as a proxy for health impacts permitted a number of important conclusions that are independent of the specific economic value assigned to biodiversity loss and health effects, respectively.

Finally, with respect to the practical implications for planning, the study identified several specific recommendations on priority options, including (i) the need to systematically examine demand side management options, especially fluorescent lighting; (ii) the need to examine whether the present transmission and distribution loss reduction target of 12% ought to be further reduced; (iii) the need to examine the possibilities of pressurised fluidised bed combustion (PFBC) technology for coal power; (iv) replacement of some coal-fired power plants (on the South coast) by diesel units; and (v) the need to re-examine cooling system options for coal plants.

5.3.5 Local-project scale: Hydroelectric power

The procedures for conventional environmental and social assessment at the project/local level (which are now well accepted world wide), may be readily adapted to assess the environmental and social effects of micro-level activities [World Bank 1998]. The OECD [1994] has pioneered the ‘Pressure-State-Response’ framework to trace socio-economic-environment linkages. This P-S-R approach begins with the pressure (*e.g.*, population growth), then seeks to determine the state of the environment (*e.g.*, ambient pollutant concentration), and ends by identifying the policy response (*e.g.*, pollution taxes). The focus here is on local pressures, but bearing in mind that climate change impacts would eventually exacerbate the local impacts – the examples are useful because the same analytical techniques may be applied to deal with the impacts of both local and global environmental drivers on key sustainable development indicators.

Specific methods for economic valuation of environmental and social impacts were described earlier (Box 2). The practical application of such techniques were illustrated in the previous example. When valuation is not feasible for certain impacts, MCA may be used.

***Example 4:* Comparison of hydroelectric power projects**

In this example, multi-criteria analysis (MCA) is used to compare hydroelectric power schemes (for details, see Morimoto et al.2000). The three main sustainable development issues that are considered comprise the economic costs of power generation, ecological costs of biodiversity loss, and social costs of resettlement.

The principal objective is to generate additional kilowatt-hours (kWh) of electricity to meet the growing demand for power in Sri Lanka. As explained earlier in the section on cost-benefit analysis (CBA), we assume that the benefits from each additional kWh are the same. Therefore, the analysis seeks to minimise the economic, social and environmental costs of generating one unit of electricity from different hydropower sites. Following the MCA approach, environmental and social impacts are measured in different (non-monetary) units, instead of attempting to economically value and incorporate them within the single-valued CBA framework.

5.3.6 Environmental, social and economic indicators

Sri Lanka has many varieties of fauna and flora, many of which are endemic or endangered. Often large hydro projects destroy wildlife at the dam sites and the downstream areas. Hence, biodiversity loss was used as the main ecological objective. A biodiversity loss index, as outlined above, was estimated for each hydroelectric site.

Although dam sites are usually in less densely populated rural areas, resettlement is still a serious problem in most cases. In general, people are relocated from the wet to the dry zone where soils are less rich, and therefore the same level of agricultural productivity cannot be maintained. In the wet zone, multiple crops including paddy rice, tobacco, coconuts, mangoes, onions, and chilies can be grown. However, these crops cannot be cultivated as successfully in the dry zone, due to limited access to water and poor soil quality. Living standards often become worse and several problems (like malnutrition) could occur. Moreover, other social issues such as erosion of community cohesion and psychological distress due to change in the living environment might arise. Hence, limiting the number of people resettled due to dam construction is one important social objective.

The project costs are available for each site, from which the critical economic indicator – average cost per kWh per year – may be estimated (for details, see Ceylon Electricity Board (CEB) 1987, 1988, 1989). The annual energy generation potential at the various sites ranges from about 11 to 210 GWh (see Table 5). All three variables, the biodiversity loss index, number of people resettled, and generation costs, are divided by the amount of electrical energy generated. This scaling removes the influence of project size and makes them more comparable.

Table 5. Multi-criteria indexing of hydropower project options[1]

Hydro Site	Annual Generation	Generation cost		Persons Resettled		Biodiversity loss	
	Gwh	AVC/KWh/yr	Rank	RE/KWh/yr	Rank	BDI/KWh/yr	Rank
1. AGRA003	28	12.1	16	11.07	22	0.86	12
2. DIYA008	11	15.8	18	2.39	15	1.74	15
3. GING052	159	12	15	0.6	9	3.71	20
4. GING053	210	16.4	19	5.77	20	4.71	21
5. GING074	209	4.3	1	0.74	10	0.2	7
6. HEEN009	20	17.7	21	1.31	12	7.09	22
7. KALU075	149	9.7	11	3.36	17	0	1
8. KRLA071	114	6.8	3	4.56	18	3.51	19
9. KOTM033	390	7.3	5	0.44	8	0.01	3
10. KUKU022	512	7.5	7	1.78	13	2.3	17
11. LOGG011	22	12.6	17	5	19	2.14	16
12. MAGA029	78	8.5	9	0	1	0.14	6
13. MAGU043	161	9.9	12	0.25	7	2.37	18
14. MAHA096	34	18.4	22	8.06	21	1.64	14
15. MAHO007	50	16.5	20	0	1	0.02	4
16. MAHW235	83	7.3	5	0	1	0.78	11
17. MAHW287	42	11.1	14	0	1	0.09	5
18. NALA004	18	7.1	4	0	1	0	1
19. SITA014	123	8.8	10	2.93	16	0.57	9
20. SUDU009	79	9.9	12	1.27	11	0.72	10
21. SUDU017	113	7.9	8	2.3	14	0.88	13
22. UMAO008	143	5.1	2	0	1	0.54	8

Source: CEB (1987); CEB (1988); Meier and Munasinghe (1994)

[1]**Notes:** Average generation costs (AVC), biodiversity loss index (BDI), and number of resettled people (RE) by hydroelectricity project. All indices are per kWh per year. Numbers of people resettled and biodiversity loss index are scaled for convenience (by multipliers 10^{-5} and 10^{-9} respectively).

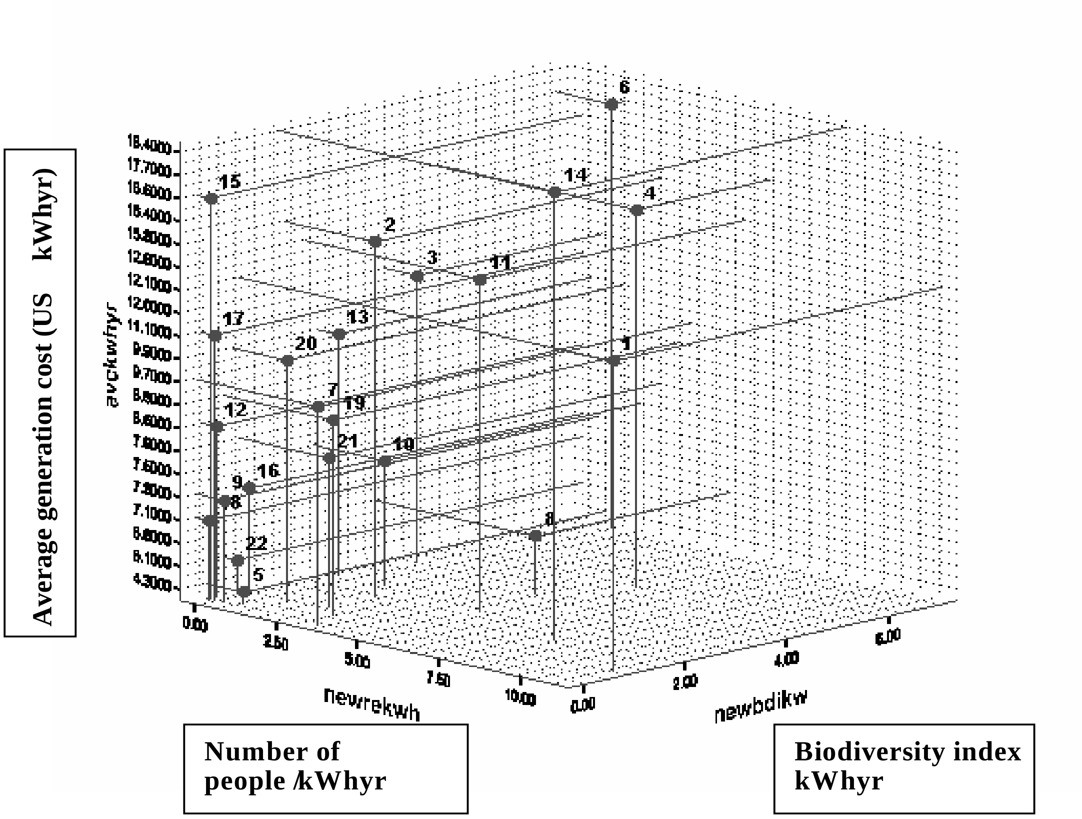
Conclusions of Example 4

A simple statistical analysis shows that pair-wise, there is a little correlation between the quantity of electricity generated, average generation cost, number of people resettled, and biodiversity loss index.

From Table 5, it is clear that on a per kWh per year basis, the projects named AGRA003 and KALU075 have the highest and lowest biodiversity loss index, HEEN009 and MAGA029 have the highest and lowest numbers of resettled people, and MAHA096 and GING074 have the highest and lowest average generation costs, respectively. Some important comparisons may be made. For example, KALU075 is a relatively large project where the costs are low, whereas MAHA096 is a smaller scheme with much higher costs with respect to all three indices. Another simple observation is that a project like KELA071 fully dominates GING053, since the former is superior in terms of all three indicators. Similar comparisons may be made between other projects.

This type of analysis gives policymakers some idea about which project is more favourable from a sustainable energy development perspective. Suppose we arbitrarily give all the three objectives an equal weight. Then, each project may be ranked according to its absolute distance from the origin of the three axes, as shown in Figure 8. For example, rank 1 is given to the one that is closest to the origin, rank 2 to the second closest and so on. On this overall basis, from a sustainable energy development perspective, project no.5 (GING074) is the most favourable one, whereas the least favourable one is project no. 14 (MAHA096).

Figure 8. Three dimensional MCA of sustainable development indicators for various hydropower options



Source: Morimoto, Munasinghe and Meier (2000).

The strength of this type of analysis lies in its ability to help policy-makers in comparing project alternatives more easily and effectively. The simple graphical presentations are more readily comprehensible, and identify the sustainable development characteristics of each scheme quite clearly. The multi-dimensional analysis supplements the more conventional CBA, based on economic analysis alone. Since each project has different features, assessing them by looking at only one aspect (*e.g.*, generation costs, effects on biodiversity, or impacts on resettlement) could be misleading.

There are some weaknesses in the MCA approach used here. First, for simplicity each major objective is represented by only one variable, assuming that all the other impacts are minor. In reality, there may be more than one variable that can describe the economic, social and environmental aspects of sustainable development. Further analysis that includes other variables may provide important new insights. Second, this study could be extended, for example, to include other renewable sources of energy in the analysis. Finally, improved 3D-graphic techniques could yield a better and clearer representation of these multi-criteria outcomes [Tufte 1992].

6. CONCLUDING REMARKS

Development assistance strategies must consider how projects would be affected by and also affect climate change. The proposed case studies for the OECD project may therefore wish to focus on developing an interactive process to explore the dynamics of climate change, vulnerability and adaptation – especially when one goes beyond simple "win-win" outcomes, and confronts difficult trade-off situations among conflicting objectives.

The proposed framework is still incomplete due to the wide scope of issues to be analysed. However, it is designed to be dynamically evolving, in order to address rapidly changing problems. The existing gaps of the framework should be filled, as the empirical country case studies progress. The main ideas most relevant and practical for this project are summarised below.

- Emphasising that development comes first – *i.e.*, starting from a development perspective, while recognising that climate change will affect future development paths and vice versa, with many complex and dynamic feedback mechanisms. Ideally, climate change policies should become a part of the overall core sustainable development strategy.

- Focusing on ‘making development more sustainable’ – because improving the sustainability of existing development activities is a more easily achievable, relevant and practical goal, rather than striving to define the elusive topic of sustainable development.

- Integrating and balancing the social, economic and environmental dimensions of sustainable development using interdisciplinary approaches, while acknowledging that these perspectives may differ among countries and communities.

- Recognising durability and optimality as complementary, integrative approaches, and identifying where they might be appropriately applied.

- Focusing on poverty, growth and equity on the development side, and on vulnerability adaptation, and mitigation on the climate side (especially aspects of mitigation, which are closely linked with adaptation).

- Developing an analytical process that flows from the transnational to the national and local levels - which starts with development documents (such as NSSDs, PRSPs, which are rooted in the MDGs) and environmental documents (like NEAPs and climate change reports); passes through the action impact matrix (AIM); then utilises natural resource management methods; and finally focuses on consistency with climate vulnerability, adaptation and mitigation policy objectives.

- Applying the action impact matrix (AIM) method to inter-link and articulate development activities with climate change vulnerabilities, adaptation and impacts (on economic, social and environmental goal including GHG emission levels). The AIM process engages all key stakeholders and promotes consensus building, especially between the often distinct development and climate communities. The cells in the matrix help to explicitly identify key vulnerabilities, changes in GHG emission levels and climate impacts in relation to development activities – especially, powerful macro-policies which have far more important consequences than localised projects. This approach focuses attention on the most important issues, as well as detailed methods of analysing them. The results of the analysis, in turn, suggest action priorities and remedies to problems (including both synergies and trade-offs).

- Applying a range of sustainable development assessment (SDA) techniques to the priority issues that were identified during the AIM process. Specific methods include economic analysis (including cost-benefit analysis and multi-criteria analysis), environmental assessment, and social assessment. Other case specific analytical methods and appropriate indicators of sustainability would also be used, to facilitate in-depth assessment of synergies and trade-offs between climate and development.

- Using a range of sectoral, regional and macro-models, to indicate national sustainable development paths and policy options that incorporate concerns about climate change vulnerability, adaptation and impacts, as well as opportunities for cost-effective mitigation.

We conclude by identifying helpful criteria for the country case studies in the next stage of the OECD project. The ultimate objective would be to determine priorities for future development assistance, including the strengthening of adaptive and mitigative capacity, and practical guidance to help in mainstreaming climate change considerations into development and development assistance policies. The following general criteria would be useful in determining priority areas for more detailed analysis:

- extent of adverse impacts and vulnerability;
- synergies and trade-offs with other development goals and policies;
- potential for implementing remedies (including adaptive and mitigative capacity);
- cost-effectiveness.

ANNEX 1: TOOLS FOR ANALYSIS AND ASSESSMENT

A1.1 Indicators

A wide variety of indicators relating to the social, economic and environmental dimensions of sustainable development have been discussed in the literature [e.g., Munasinghe and Shearer 1995; UNDP 1998; World Bank 1998; Liverman et al. 1988; Kuik and Verbruggen 1991; Opschoor and Reijnders 1991; Holmberg and Karlsson 1992; Adriaanse 1993; Alfsen and Saebo 1993; Bergstrom 1993; Gilbert and Feenstra 1994; Moffat 1994; OECD 1994; Azar 1996; UN 1996; Commission on Sustainable Development (CSD) 1998; World Bank 1997]. In particular, we note that measuring the stocks of economic, environmental (natural), human and social capital raises various problems.

Manufactured capital may be estimated using conventional neo-classical economic analysis. As described later in the section on cost-benefit analysis, market prices are useful when economic distortions are relatively low, and shadow prices could be applied in cases where market prices are unreliable (e.g., Squire and van der Tak 1975).

Natural capital needs to be quantified first in terms of key physical attributes. Typically, damage to natural capital may be assessed by the level of air pollution (*e.g.*, concentrations of suspended particulate, sulphur dioxide or GHGs), water pollution (*e.g.*, BOD or COD), and land degradation (*e.g.*, soil erosion or deforestation). Then the physical damage could be valued using a variety of techniques based on environmental and resource economics (e.g., Munasinghe 1992; Freeman 1993; Teitenberg 1992).

Social capital is the one that is most difficult to assess [Grootaert 1998]. Putnam [1993] described it as ‘horizontal associations’ among people, or social networks and associated behavioural norms and values, which affect the productivity of communities. A somewhat broader view was offered by Coleman [1990], who viewed social capital in terms of social structures, which facilitate the activities of agents in society – this permitted both horizontal and vertical associations (like firms). An even wider definition is implied by the institutional approach espoused by North [1990] and Olson [1982], that includes not only the mainly informal relationships implied by the earlier two views, but also the more formal frameworks provided by governments, political systems, legal and constitutional provisions etc. Recent work has sought to distinguish between social and political capital (*i.e.*, the networks of power and influence that link individuals and communities to the higher levels of decisionmaking). Human resource stocks are often measured in terms of the value of educational levels, productivity and earning potential of individuals.

A1.2 Cost-Benefit Analysis (CBA)

Cost-benefit analysis is an important tool in the economic and financial analysis of projects and for determining their viability. The basic criterion for accepting a project is that the net present value (NPV) of benefits is positive. Typically, NPV = PVB – PVC, where $PVB = \sum_{t=0}^{T} B_t \,/\, (1 + r)^t$; and $PVC = \sum_{t=0}^{T} C_t \,/\, (1 + r)^t$.

B_t and C_t are the project benefits and costs in year t, r is the discount rate, and T is the time horizon. Both benefits and costs are defined as the difference between what would occur *with and without* the project being implemented.

When two projects are compared, the one with the higher NPV is deemed superior. Furthermore, if both projects yield the same benefits (PVB), then it is possible to derive the least cost criterion - where the project with the lower PVC is preferred. The IRR is defined as that value of the discount rate for which PVB = PVC, while BCR = PVB/PVC. The BCR may be interpreted as a measure of 'cost effectiveness', *e.g.*, even if the benefits are not measurable in monetary terms, BCR indicates the gain derived per unit of investment in a project. Further details of these criteria, as well as their relative merits in the context of sustainable development, are provided in [Munasinghe 1992].

If a purely financial analysis is required from the private entrepreneurs viewpoint, then B, C, and r are defined in terms of market or financial prices, and NPV yields the discounted monetary profit. This situation corresponds to the economist's ideal world of perfect competition, where numerous profit-maximising producers and utility-maximising consumers achieve a Pareto-optimal outcome. However, conditions in the real world are far from perfect, due to monopoly practices, externalities (such as environmental impacts which are not internalised in the private market), and interference in the market process (*e.g.*, taxes). Such distortions cause market (or financial) prices for goods and services to diverge from their economically efficient values. Therefore, the economic efficiency viewpoint usually requires that shadow prices (or opportunity costs) be used to measure B, C and r. In simple terms, the shadow price of a given scarce economic resource is given by the change in value of economic output caused by a unit change in the availability of that resource. In practice, there are many techniques for measuring shadow prices – *e.g.*, removing taxes, duties and subsidies from market prices (for details, see Munasinghe 1992; Squire and van der Tak 1975).

The incorporation of environmental considerations into the economist's single valued CBA criterion requires further adjustments. All significant environmental impacts and externalities need to be valued as economic benefits and costs. As explained earlier in the section on indicators, environmental assets may be quantified in physical or biological units. Recent techniques for economically valuing environmental impacts are summarised in Box 3. However, many of them (such as biodiversity) cannot be accurately valued in monetary terms, despite the progress that has been made in recent years [Munasinghe 1992; Freeman 1993]. Therefore, criteria like NPV often fail to adequately represent the environmental aspect of sustainable development.

Capturing the social dimension of sustainable development within CBA is even more problematic. Some attempts have been made to attach 'social weights' to costs and benefits so that the resultant NPV favours poorer groups (see also, Box 2). However, such adjustments (or preferential treatment for the poor) are rather arbitrary, and have weak foundations in economic theory. Other key social considerations like empowerment and participation are hardly represented within CBA. In summary, the conventional CBA methodology would tend to favour the market-based economic viewpoint, although environmental and social considerations might be introduced in the form of side constraints.

A1.3 Multi-Criteria Analysis (MCA)

This technique is particularly useful in situations where a single criterion approach like CBA falls short – especially when significant environmental and social impacts cannot be assigned monetary values. MCA is implemented usually within a hierarchical structure. The highest level represents the broad overall objectives (for example, improving the quality of life), which are often vaguely stated. However, they can be broken down - usually into more comprehensible, operationally relevant and easily measurable lower level objectives (*e.g.*, increased income). Sometimes only proxies are available – *e.g.*, if the objective is to preserve biological diversity in a rainforest, the practically available attribute may be the number of hectares of rainforest remaining. Although value judgements may be required in choosing the proper attribute (especially if proxies are used), actual measurement does not have to be in monetary terms – unlike CBA. More explicit recognition is given to the fact that a variety of objectives and indicators may influence planning decisions.

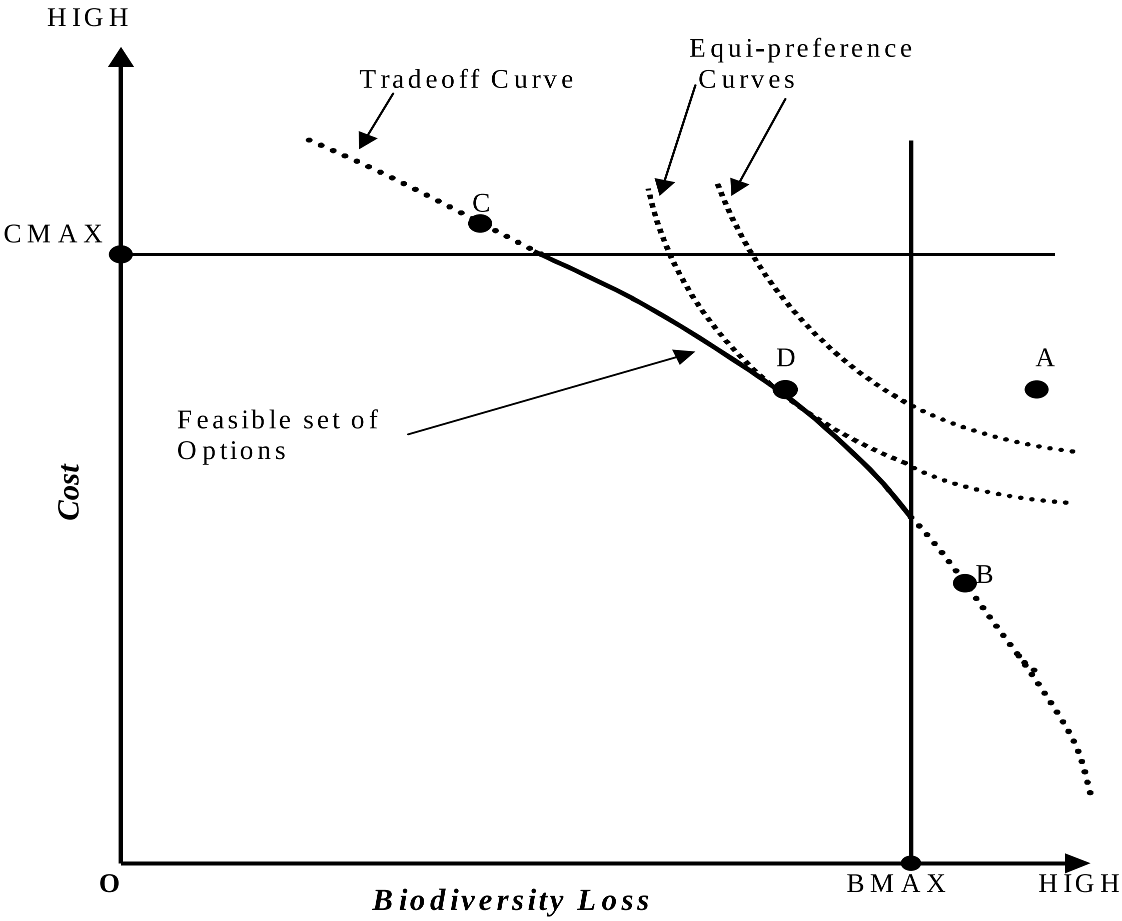
Figure A1.1 is a two dimensional representation of the basic concepts underlying MCA. Consider an electricity supplier, who is evaluating a hydroelectric project that could potentially cause biodiversity loss. Objective Z_1 is the additional project cost required to protect biodiversity, and Z_2 is an index indicating the loss of biodiversity. The points A, B, C and D in the figure represent alternative projects (*e.g.*, different designs for the dam). In this case, project B is superior to (or dominates) A in terms of both Z_1 and Z_2 – because B exhibits lower costs as well as less bio-diversity loss relative to A. Thus, alternative A may be discarded. However, when we compare B and C, the choice is more complicated since the former is better than the latter with respect to costs but worse with respect to biodiversity loss. Proceeding in this fashion, a trade-off curve (or *locus* of best options) may be defined by all the non-dominated feasible project alternatives such as B, C and D. Such a curve implicitly places both economic and environmental attributes on a more equal footing.

Further ranking of alternatives is not possible without the introduction of value judgements (for an unconstrained problem). Typically, additional information may be provided by a family of equi-preference curves that indicate the way in which the decision maker or society trades off one objective against the other (see the figure). Each such equi-preference curve indicates the *locus* of points along which society is indifferent to the trade-off between the two objectives. The preferred alternative is the one that yields the greatest utility – *i.e.*, at the point of tangency D of the trade-off curve with the best equi-preference curve (*i.e.*, the one closest to the origin).

Since equi-preference curves are usually not measurable, other practical techniques may be used to narrow down the set of feasible choices on the trade-off curve. One approach uses limits on objectives or 'exclusionary screening'. For example, the decision maker may face an upper bound on costs (*i.e.*, a budgetary constraint), depicted by CMAX in the figure. Similarly, ecological experts might set a maximum value of bio-diversity loss BMAX (*e.g.*, a level beyond which the ecosystem suffers catastrophic collapse). These two constraints may be interpreted in the context of durability considerations, mentioned earlier. Thus, exceeding CMAX is likely to threaten the viability of the electricity supplier, with ensuing social and economic consequences (*e.g.*, jobs, incomes, returns to investors etc.). Similarly, violating the biodiversity constraint will undermine the resilience and sustainability of the forest ecolosystem. In a more practical sense, CMAX and BMAX help to define a more restricted portion of the trade-off curve (darker line) – thereby narrowing and simplifying the choices available to the single alternative D, in the figure.

This type of analysis may be expanded to include other dimensions and attributes. For example, in our hydroelectric dam case, the number of people displaced (or resettled) could be represented by another social variable Z_3.

Figure A1.1 Simple Two Dimensional Example of Multi-criteria Analysis



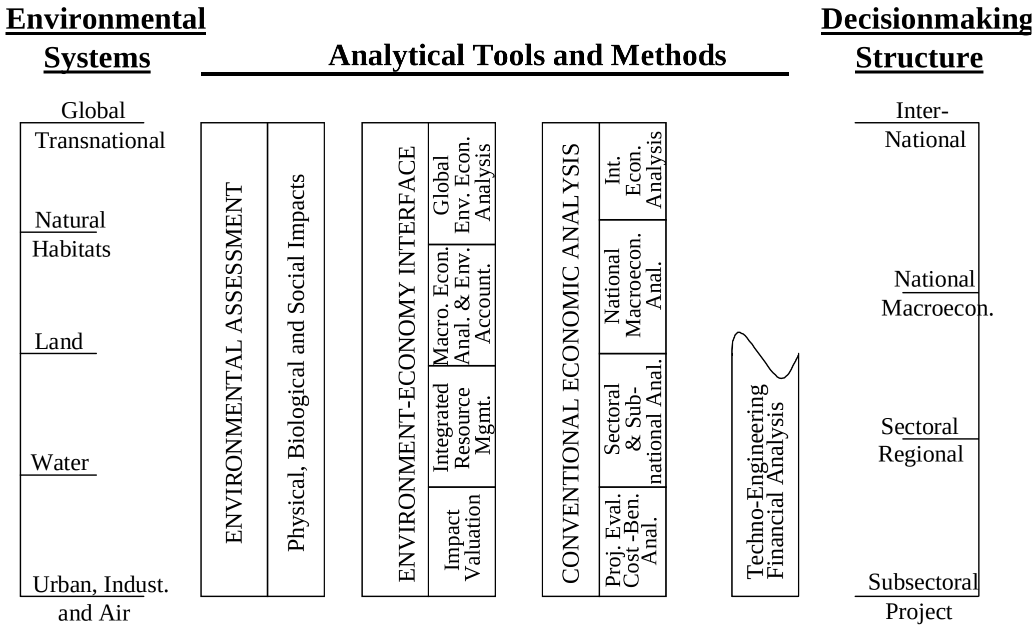
Source: adapted from [*Munasinghe 1992*].

A1.4 Linking sustainable development issues with conventional decision making

Figure A1.2 provides an example of how environmental assessment is combined with economic analysis. The right-hand side of the diagram indicates the hierarchical nature of conventional decision making in a modern society. The global and international level consists of sovereign nation states. In the next level are individual countries, each with a multi-sectored macro-economy. Various economic sectors (like industry and agriculture) exist in each country. Finally, each sector consists of different sub-sectors and projects. The conventional decision making process in a modern economy is shown on the right side of Figure A1.2. It relies on techno-engineering, financial and economic analyses of projects and policies. In particular, conventional economic analysis has been well developed in the past, and uses techniques such as project evaluation/cost-benefit analysis (CBA), sectoral/regional studies, multi-sectoral macroeconomic analysis, and international economic analysis (finance, trade, etc.) at the various hierarchic levels.

Figure A1.2 Incorporating Environmental Concerns into Decision making

Figure A1.2. Incorporating Environmental Concerns Into Decisionmaking



Source: adapted from Munasinghe [1992].

Unfortunately, environmental and social analysis cannot be carried out readily using the above process (*i.e.*, economic, financial and techno-engineering analyses). We examine how environmental issues might be incorporated into this framework (with the understanding that similar arguments may be made with regard to social issues). The left side of Figure A1.2 shows one convenient breakdown of environmental issues:

- global and transnational (*e.g.*, climate change, ozone layer depletion);
- natural habitat (*e.g.*, forests and other ecosystems);
- land (*e.g.*, agricultural zone);
- water resource (*e.g.*, river basin, aquifer, watershed); and
- urban-industrial (*e.g.*, metropolitan area, airshed).

In each case, a holistic environmental analysis would seek to study a physical or ecological system in its entirety. Complications arise when such natural systems cut across the structure of human society. For example, a large and complex forest ecosystem (like the Amazon) could span several countries, and also interact with many economic sectors (*e.g.*, agriculture, energy, etc.) within each country.

The causes of environmental degradation arise from human activity (ignoring natural disasters and other events of non-human origin), and therefore, we begin on the right side of the figure. The ecological effects of economic decisions must then be traced through to the left side. The techniques of environmental assessment (EA) have been developed to facilitate this analysis [World Bank 1998]. For example, destruction of a primary moist tropical forest may be caused by activities in many different sectors of the economy. Slash and burn agriculture often exacerbates forest depletion. Land clearing could be encouraged by land-tax incentives arising from fiscal policy. Hydroelectric dams will inundate large tracks of forest. The construction of rural roads may cause significant forest cutting. Mining in remote areas also could cause large-scale depletion of forests. Disentangling and prioritising these multiple causes (right side) and their impacts (left side) will involve a complex analysis.

Figure A1.2 also shows to bridge the ecology-economy interface, by mapping the EA results (measured in physical or ecological units) onto the framework of conventional economic analysis. A variety of environmental and economic techniques facilitate this process of incorporating environmental issues into traditional decision making. These include valuation of environmental impacts (at the local/project level), integrated resource management (at the sector/regional level), environmental macroeconomic analysis and environmental accounting (at the economy-wide level), and global/transnational environmental economic analysis (at the international level). Since there is considerable overlap among the analytical techniques described above, this conceptual categorisation should not be interpreted too rigidly. Furthermore, when economic valuation of environmental impacts is difficult, techniques such as multi-criteria analysis (MCA) would be useful (see Section A1.3).

Once the foregoing steps are completed, projects and policies must be redesigned to reduce their environmental impacts and shift the development process towards a more sustainable path. Clearly, the formulation and implementation of such policies is itself a difficult task. In the deforestation example described earlier, protecting this ecosystem is likely to raise problems of co-ordinating policies in a large number of disparate and (usually) uncoordinated ministries and line institutions (*i.e.*, energy, transport, agriculture, industry, finance, forestry, etc.).

Analogous reasoning may be readily applied to social assessment (SA) at the society-economy interface, in order to incorporate social considerations more effectively into the conventional economic decision making framework. In this case, the left side of Figure A1.2 would include key elements of SA, such as asset distribution, inclusion, cultural considerations, values and institutions. Impacts on human society (*i.e.*, beliefs, values, knowledge and activities), and on the bio-geophysical environment (*i.e.*, both living and non-living resources) are often inter-linked via second and higher order paths, requiring integrated application of SA and EA. For example, economic theory emphasises the importance of pricing policy to provide incentives that will influence rational consumer behaviour. However, cases of seemingly irrational or perverse behaviour abound, which might be better understood through findings in areas like behavioural and social psychology, and market research.

Such work has identified basic principles that help to influence society and modify human actions, including reciprocity (or repaying favours), behaving consistently, following the lead of others, responding to those we like, obeying legitimate authorities, and valuing scarce resources [Cialdini 2001]. These insights reflect current thinking on the co-evolution of socio-economic and ecological systems.

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