Saving Small Island Developing States

Environmental and Natural Resource Challenges

Edited by Shyam Nath, John L Roberts and Yeti Nisha Madhoo

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Commonwealth Secretariat

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Editors

Preface

The idea to develop this book for public policy-makers in small states and students of public policy emanated from the teaching of the module on environment and natural resource analysis as part of the public policy and administration masters at the University of Mauritius. In fact, Dr John L. Roberts gave the idea for this book and helped as an advisor in various capacities. This book, part of a wider project that introduced the public policy course at the University of Mauritius, benefitted from the lectures delivered by Dr Yeti Nisha Madhoo, Dr John L. Roberts and Professor Shyam Nath. The ministries of finance, economic development, environment and quality of life, international trade, foreign affairs and regional co-operation, education and health, public utilities and social services contributed by making their requirements for this course very specific. Moreover, academics from various universities around the world provided useful inputs. These included Professor James Robinson, Harvard University; Professor Alistair Munro, University of East Anglia; Professor Mukul Asher, National University of Singapore; Professor Larry Schroeder, Syracuse University; Professor Dan Atwood, Director of the School of International Social Affairs, University of Minnesota; Professor Roy W. Bahl, Georgia State University, Atlanta; and Professor Glenn Withers, Australian National University; University of Western Australia in Perth, Washington State University in Seattle, National Institute of Public Finance and Policy and Jawaharlal Nehru University in New Delhi.

The Commonwealth Secretariat collaborated on the publication of this book as part of its programme of assistance to its small member states; 32 of the 54 members of the Commonwealth are small states. The Commonwealth has been at the forefront of advocacy on behalf of small states, having devoted substantial resources to ensuring that international development priorities take into account the issues affecting these countries. This book is particularly useful for policy-makers in small states that are responsible for the implementation of the Mauritius Strategy for the further implementation of the Barbados Programme of Action for the sustainable development of small island developing states.

Shyam Nath
University of Mauritius

Introduction

The significance of environmental and natural resource analysis for capacity building in public policy design and programme planning and evaluation is tremendous. The contribution of the idea of the 'tragedy of the commons' by Hardin (1968) is a seminal one, which takes off from the property rights literature and proceeds to discuss the consequences of the lack of property rights and excessive use of common resources. The conventional wisdom predicts that environmental resources having the characteristics of common pool resources would be degraded if regulation or other policy instruments are not in force. The 2009 Nobel Prize winner E. Ostrom (1990) challenges this contention about the need for regulation or privatisation and discusses conditions under which the commons can be successfully managed by resource user groups such that the tragedy is avoided. Nevertheless, the role of the public sector institutions in enforcing rules, particularly access rules for common pool resources, is highlighted. The crux of the need is to develop a proactive public policy and a proactive environmental public policy. While recognising the policy instance in resource management, giving a shape to proactive policies is bristled with insurmountable challenges.

Extensive literature exists on why markets fail in providing public goods and public utilities for human survival and development, and why governmental intervention is needed. Primary education and health, basic shelter, natural environmental quality and drinking water are some examples of common concern. Direct public production or intervention is expected to correct the market distortions. As governments perform these functions, self-interested bureaucrats and political agents may jeopardise efficient government operations resulting in government failure. In recent times, when governments have failed in delivering public supplies private market solutions have been introduced in the public sector production and management spheres. But the interesting part is that both privatisation and government regulation now commonly co-exist in public utility regimes and in activities with social orientations. The changing position of the public sector therefore depends on a web of economic, social and political considerations, continually appraised in the light of experience. In cases where political philosophy dominates, the role of government becomes excessive and reforms are needed either within the public sector itself or again by reversion to the markets.

It is recognised that regulatory policies are crucial for both economic and environmental management. It is important to note that while the role of governmental regulation is challenged in a neoclassical mainstream economic analysis, the new growth theories have reinforced the role of policy and government intervention in education, health, environmental management and infrastructure development. Regulatory episodes, however, have resulted in varying degrees of economic performance and welfare regimes. New development economics goes further to analyse economic performance of nations in

terms of geography, policy and institutions (see Nath and Madhoo, 2008 for a summary of this literature).

Mauritius experimented with a policy of soft and selective regulation, as against hard controls in many other African countries, which immensely contributed to exemplary economic growth and income redistribution. Other small and island states, for example, Malta, Singapore, Seychelles and Fiji manifest varying levels of regulation and controls but their growth trajectories have also been divergent. Singapore is a high performer and Seychelles (an upper middle income country like Mauritius) has also done better with more government regulation. On the other hand, Fiji has had several military coups, leading to decay and stagnation. Even though Fiji is one of the more developed of the Pacific island economies, it remains a developing country with a large subsistence agriculture sector. Malta's position is in the middle. Its economic performance is low among members of the European Union and the state of regulation is highly diluted because of democratic governance.

This shows that both free market policies and selective institutional interventions are necessary for rapid and inclusive economic growth. Designing pragmatic public policies has assumed more significance in recent years when the role of government is more of a facilitator and collaborator. It also has the effect, especially in small and island states, of bringing the value of environment and natural resources and their regulation and conservation onto the agenda, both in the public and the private sector. On the development policy front, the major issue is to identify various implications of environmental regulation on output growth; it is a given fact that regulation, that is controlling and monitoring the use of environmental and natural resources, can have an adverse effect on GDP growth in developing countries in the short run. There are related macroeconomic policy issues also such as implications for unemployment and inflation during the process of managing and conserving these scarce resources. So there is a trade-off between growth and environmental quality. Environmental management also entails microeconomic policy issues governing poverty and income distribution.

With the current financial melt-down and economic recession, the role of regulation and public policy is witnessing a new upsurge globally in which small and island countries will have to readjust their positions in terms of economics, politics and environmental policies. During the period of present crises, the emphasis on recovery and employment generation has diverted budgetary allocations from environmental projects at least in the short run. While emphasis shifts from markets to public policy where both markets and governments are lacking, the real search is for an appropriate mix and a new ethics in management of environmental and natural resources. To get even the right mix, we need to revisit the fundamental principles inherent in policies and in the behaviour of the key players in the field to stimulate fresh and more sustainable styles in public-private or private-public environmental management.

To improve the quality of public sector management, the need for civil service training and improved quality of human resources has attracted the attention of both policy-makers and international donor agencies. It will be instructive here to discuss an interesting policy intervention in Mauritius where, some five years ago, the government contracted a World Bank Public Expenditure Reform Loan (PERL). Besides education, health and social

security, training of civil servants is one of the major segments of PERL. While loans are raised to meet the financing needs of capital investment by the government, the philosophy underlying this loan is different, which makes it interesting. This agreement between the donor and the recipient government lays greater emphasis on social needs, that is, improved allocations to capacity building in the government.

Thus, the financing of civil service training through loan arrangement is special. It is clear that the objectives of this loan policy can have far reaching long-run implications. External loan financed allocations to these social sectors are designed to raise the quality of human resources, at the same time releasing budgetary resources for meeting public sector investment obligations. Moreover, the underlying strategy is that improved human resources will have a positive impact on economic growth. It should, in turn, generate a higher amount of investible resources for financing development needs. This approach is quite useful because small and island states have very visible environmental stress points that can be targeted by improved resources and selective grants.

It is contended that small countries have large public sector budgets, measured by government consumption expenditure as a percent of GDP. The basic argument is that there is a lack of economies of scale in public administration (Alesina and Wacziarg 1998; Rodrik 1996). Government budget size is further enhanced because governments in these economies are required to play a counter-cyclical role of stabilisation as these economies are more open and are prone to external shocks. This explains as well as justifies the need for higher government expenditure in small countries. What is missing in the literature, however, is that environmental and natural resource challenges in small island states necessitate governmental regulation and contribute to larger public budgets. This shows that public economics literature has not accorded enough space for mitigation of environmental and natural resource challenges of small geographical landmass.

While national policies for economic growth and welfare and environmental governance are important, there are two interesting trends that can be observed in the policy arena, namely globalisation and decentralisation of public and environmental policies. The responsibility of environmental management and quality is not limited to a country's geographical boundary and political jurisdiction. International tourism, migration and cross-border business and investments complicate environmental governance. Gradual doses of globalisation and regional integration have therefore increased the role of the national government in formulating regional and global public policies. The jurisdiction of international political and trade diplomacy has been expanded to include typical public policy issues. Thus, country governments are busy expanding the economic space through agreements to promote international trade in goods and services and investment operations. Policy-making and appraisal needs have crossed national boundaries, inviting intergovernmental co-ordination between nations and international institutions for effective management of the economy and conservation of environmental and natural resources.

Decentralised management of public policies has witnessed large scale support both on efficiency and equity grounds. Positive political developments resulting in democratic outcomes have also increased the preference for sub-national and local governments. International donors, while designing conditionalities, have shifted from top-heavy cen-

tral governments to local governments in implementing funded projects involving provision of public goods and services (UNDP 1992; World Bank 1991). It is contended that local governments can have more information on local issues including those in environmental sectors. Efforts for capacity building in local governments have taken off in the light of these developments. It is important to note that the two processes, namely globalisation and decentralisation of public policies, are complementary; both have their distinct jurisdictions in meeting efficiency and equity objectives. It is recognised that some form of regulation at international, regional, national and local level in meeting these objectives is a necessity.

There is an interesting dimension of globalisation that makes the whole exercise of decentralised governance much more promising. With vanishing national boundaries, countries are known by cities, clusters and centres. The attractions of city states, for instance, are the quality of public services and environmental management. Hotels, buildings and multi-national establishments constitute the built environment, entailing both economic and environmental agglomeration economies and diseconomies. Agglomeration effects connect built environments across the world giving a boost to decentralised governance in a globalising world.

Environmental governance and public policy concerns in small islands

Environmental and natural resource analysis has evolved as a major component of public policy analysis because of growing concerns for sustainable development. This concern is more pertinent to island states because of the environmental intensity of their economic sectors. These economies depend more on international tourism, both sea and non-sea, and on exports of primary products which use environmental and natural resources as inputs. This makes a special case for effective environmental governance regimes in small islands against environmental changes and natural calamities.

While growth of GDP (gross domestic product) necessitates the use of environmental and natural resources along with other inputs, the main concern here is what happens to environmental quality when growth takes place. During the process of production for economic growth the planet uses photosynthesis (the process for converting carbon dioxide into oxygen using sunlight) to produce an invisible output. It is called the photosynthetic product of the planet (PPP) and serves as one of the inputs in GDP, and therefore its quality is vitally important. If GDP growth degrades environment and there are no remedial measures, this will adversely affect PPP and also the GDP growth rate in the future. In other words, the GDP growth rate can be sustained only when the policy on protecting the quality of environment is in place and effectively implemented.

The ocean covers more than two thirds of our planet, and small island developing states (SIDS) are generally somewhere in the middle of it. Their environmental priorities concern the islands themselves and their immediate coastal areas, where the balance between population and resources is threatened by human intervention. Nevertheless, from the perspective of the island countries, the ocean is still an unlimited resource relative to the present scale of their human impacts. The problem starts because use of these resources is not sustainable. A comparison of the environmental concerns of small island developing

states with those of developed and other developing countries shows a profound difference of emphasis, at least in the short term. The pollution resulting from modern technological development on such islands is generally modest and much less important to them than the need for sustainable management of their natural resource base. Islands are thus a potential model for the future, facing now what must become the long-term preoccupation of the whole world, as resource degradation approaches the limits of the planet (Dahl 2006).

Global warming and climate-related changes have added new dimensions to environmental governance. Starting with Nordhaus (1982), the climate change economics literature recognises the international scope of the issue and the uneven distribution of policy benefits and costs across time and space. SIDS deserve a special treatment in this field. Small island countries are more exposed to the environmental challenges arising not from within their boundaries, but from the activities of other countries. The whole planet is under stress due to population growth, and rapid growth in consumption to attain rising standards of living adds to the stress. Many small islands are already nearing the limits of their environmental carrying capacity. It is not the case that the population and standard of living increase in such islands and therefore they should worry more about their survival. The tragedy of the situation is that with population growth and the rise in standards of living anywhere and everywhere, it is the whole global environment as a public good that suffers. The impact, however, is not equally distributed. Small tropical coastal islands are more exposed to sea level rise, other global warming induced vagaries of climate change and the decline of global photosynthetic capacity. In response to this, small islands can do only a few things. There has been some reorientation of fiscal policy towards environmental management, evident in budget statements in Papua New Guinea, Jamaica, Malta and Singapore, which are strongly favouring 'green policies' for renewable energy and for promoting environmental services, recycling and protected natural areas.

One may ask the question 'why save only small and island states'? It is possible that their problems are too small to be of global concern. Surely one may equally be disturbed when it comes to the big problems of some large countries in Africa. So when small is beautiful, big can be dreadful. It is nevertheless important to note that small islands have now big environmental problems. So the sequence is small–small, big–big and small–big. In other words, small islands face relatively bigger environmental challenges. Thus, smallness is a curse when we talk of environmental concerns. For SIDS, when the sea level rises it is not a question of adaptation or migration to higher ground, but it is their very survival which is at stake. To mitigate and adapt, small islands will have to survive first, which is the great challenge. Thus, their destiny is shared; to survive they must voice their concerns, but ultimately their future is at the mercy of larger and richer countries whether it is through aid, trade or global warming. The current economic crisis will aggravate these problems because of the decline in global finance for climate change mitigation projects and national and regional initiatives.

The stance of this book is that before we address saving the planet, we should first look at how to save small and island states. These states will be the first to show the benefits of environmental policy intervention and costs of any adverse side-effects. Thus, they can be a cost-effective laboratory for achieving a sustainable world.

The focus and usefulness of the present book

The study of environmental economics and policy is crucial for economic growth. This subject area cuts across different disciplines, namely economics, engineering, marine and environmental science and ecology. A number of researchers work in the field of marine biodiversity, environmentally friendly technology, international coastal tourism and forestry and fishery management. It is a meeting place for economists, engineers, technologists, biologists, and marine and agricultural scientists, whether working in the public or private sectors or with NGOs and international organisations. It is interesting to note that a special class of interest group has emerged as environmentalists, who may not be specialists but they are more concerned about the quality of environment as legitimate care takers.

This book is a collection of chapters written specially for this purpose, with a multidisciplinary focus. The book comprises 23 chapters arranged across five major sections and is preceded by a detailed overview by Dr John L Roberts. The first section is devoted to theoretical and conceptual issues in environmental and natural resource analysis. Different methods of valuation of environmental resources, including simple and strategic environmental assessments, are reviewed. The taxonomy and political economy of policy instruments are also examined to design 'command and control' and market-based instruments packages to control and mitigate the consequences of excessive use of these resources.

It may look unconventional but we found it worthwhile to include, in section two, four seminal published papers (small papers with hefty contents) as a bridge between the introductory and theoretical chapters and the later sections of the book. These are:

'How Economists See the Environment', Don Fullerton and Robert Stavins, *Nature* **395** (1998): 433–434
'The Obligations of a Policy Economist', Paul R. Portney, *Agricultural and Resource Economics Review*, **33/2** (2004): 159–161
'Economic Growth, Carrying Capacity, and the Environment', Kenneth Arrow et al., *Ecological Economics* **15** (1995) 91–95; *Science* **268**: 520–521
'Sustainability: An Economist's Perspective', Robert M Solow, *National Geographic Research and Exploration*: **8** (1992): 3–6

The third section presents case studies on valuation methods in small islands and environmental accounting of these resources for national income accounts. On policy instruments, there is a discussion of tax design for international tourists visiting small islands with the objective of recovering marginal social cost due to international tourism. Road transport, motorisation and pollution necessitate the use of both command and control and economic incentive based policy instruments. There is a case study of the excessive use of common pool resources causing the demise of the Aral Sea inviting international co-operation to address the issue.

The fourth section includes discussion of policies in action to preserve environmental quality. First, implications of climate change policy with reference to small islands are analysed utilising the materials from international agreements. Other policy interventions

are water resources development, coastal and marine resources management in different coastal islands, renewable energy from sugarcane bagasse, game-like policy solutions for environmental management, and disaster management practices with applications to environmental damage. International trade and environmental issues have also been captured.

The final part of the book explores the global dimensions of environmental management using illustrations from the MDGs and their adaptation to the needs of SIDS. This part concludes with the ways in which SIDS are responding to the challenges of achieving sustainable development through improving their resilience to external shocks and better management of their natural resources.

This book follows the scope and content of a combined lecture programme, which includes both theoretical analysis of issues and an exploration of the interface between theory and practical policy and intervention in a global setting, but with special emphasis on small states and small island developing states. The purpose of the book is to provide both a transparent document of the field of study for current and future master's students and a reader for college and university students and teachers in this field elsewhere. This book can also serve as a handy manual for policy-makers in small and island states. To provide a wider perspective, and to link with other master's programmes, the book also includes contributions, as chapters, by other experts in this and related fields. Other specialised contributions include a review of economic instruments for promoting sustainable development and their adaptation to the specificities of SIDS.

The content of the chapters is varied and includes exposition, case-studies, problem-setting exercises for students, references providing citations of the source of theoretical development concepts, research and field study evidence, plus further background reading and sources of data and information.

The main goal of the book is to enhance policy analysis, policy planning and programme evaluation and public administration capability. The precise objectives are:

- To provide a postgraduate level collection of papers for the benefit of those in employment in the public sector and for government officials in economic, social and public affairs ministries, non-profit organisations, parastatal autonomous bodies and local government and others in the private sector to acquire skills in policy-making;
- To prepare individuals to assume key positions of responsibility in government, international institutions and in the private sector by upgrading their knowledge and skills to comparable international standards;
- To develop the ability to identify problems and the capacity for decision-making, leading to practical solutions of local, national, regional and international problems;
- To enhance the individual's capacity to meet emerging challenges within an organisation with a view to increasing domestic and international competitiveness in a rapidly changing global environment; and
- To inform the users to be able to anticipate the often unanticipated consequences of alternative policies and local, national and international projects.

This product would have not seen the light of day without the support of my fellow editors,

namely Dr John Roberts and Dr Yeti Nisha Madhoo. On their behalf, I take this opportunity to thank all my fellow authors for their patience and support to this project. The Commonwealth Secretariat deserves special mention for organising the production and distribution of the book. Constance Vigilance of the Commonwealth Secretariat provided constant and unending support and encouragement across all stages of planning and producing this research output. We offer her our sincere thanks. We gratefully acknowledge the remarkable editorial assistance provided by Mr Anooj Ayrga. I have learnt one thing from him, that is, perseverance is a great asset.

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John L Roberts

Overview

So much of man's history has been about the achievement of technical progress in which marginal productivity continues to increase for the same levels of factors of production, that for centuries man has assumed this approach to development is incontestable. If he does not already live in the best of all possible worlds, then only time is arresting his inevitable progress to that end. People in small states and SIDS have for centuries enjoyed outstanding natural assets which are now increasingly threatened by an approach to economic development that values such natural wealth at zero. Such people, and the tourists who flock to their shores seeking a taste of paradise, seem too often bent on forms of development that are destroying these gifts of nature on which their survival depends. This book is offered as an antidote to this traditional western concept of progress and the narrow perspective of the liberalising march of history.

Paradigms for policy

Nath in Chapter 1 argues that the traditional vision as part of the former dominant social paradigm (DSP) has been challenged by the new environmental paradigm (NEP). The latter acknowledges the environmental impact of development and seeks to redress it by preventive and mitigating measures, which value natural resources and include them explicitly in the system of social welfare accounts.

Many natural resources are not renewable, and they decline in the face of economic development; others are lost, or threatened with extinction or degraded by past and existing processes of production of goods and services. Two factors are at work here. Increasing levels of consumption and production per capita and increasing global population. It is now more commonly recognised that the limited natural resources of this one planet, Earth, do not have the carrying capacity to absorb the combined impact of both these factors.

In 1900 this planet offered 8 hectares of land per person on which to thrive; by 1950, the population had increased to the point where the planet had only 5 hectares of land per person. By 2005, the ratio was 2 hectares of land per person. The present world population is about 7 billion, and is expected to increase to over 9 billion by 2050, shrinking available space to 1.5 hectares per person.

The Millennium Ecosystem Assessment in 2001 found that 60 per cent of ecosystem services have been degraded and are unsustainable in the face of a growing demand for food, fresh water, timber, fibre and fuel. This degradation, principally from over use, is exacerbated by pollution and by the process of climate change intimately linked to current patterns of production and consumption.

Since 1900, the global economic development gains have been immense in terms of income, trade, increased expectation of life and improved standards of living. These gains have, however, been unevenly distributed with the lion's share going to the lions, and at great loss to environmental resources in quantity and quality.

In small and island states, the drivers of change and their impacts are evident to all; smallness means few people escape the issues: isolation and fragmentation inhibit flight. Moreover, much of the inherited biodiversity remains, at least as vestiges of its past glory. Deforestation is tangible whilst some forest remains; damaged coral evokes commitment to rescue the remnants; the presence of fewer fish promotes the drive for regeneration; the lost dodo becomes a metaphor for the perils of inaction. The people of many of these small states leave a low ecological footprint, and follow a life that is not 'poor, nasty brutish and short' but that is rich in nature's delights, and pleasant to enjoy and long-lived. On the Happy Planet Index[1] they rate high in satisfaction, length of life and do less damage to the ecosystems that support them than their counterparts in many large developed countries. Being close to government, many people in SIDS readily press for policies that will preserve their inheritance for their children and grandchildren. But such awareness and drive are not universal and without these protective factors small and island states remain highly vulnerable to ecosystem collapse.

This book explores the nature of the quest for progress without ecological disaster in small and island states. It does so through the lens of economic theory and practice and with tools that policy-makers and their advisers are currently using or which are available to them. In addition, the book provides some evidence of the outcomes of the application of this science in small and island states, to indicate how much success has been achieved in preserving the beauty and fruitfulness of nature in many 'paradise' locations.

These small steps towards the goal of sustainable development are being made in the face of the global impact of unsustainable use of natural resources and unsustainable population growth. This raises the question whether action in small and island states, to choose pathways that curb their carbon intensive development, can help to avert the doomsday scenario for planet Earth and provide a model for others to admire and follow.

Part I Theory and its applications

Environment as capital

The theoretical underpinning for sustainable development is presented in this book in Part 1, linked to its application in the real world of policy development in small and island states. **Nath** in presenting *Concepts and public policy issues in environmental and natural resource analysis* includes natural resources as part of capital in environmental governance. This encompasses natural resources in a framework that requires both renewal and maintenance. This approach is distinct from the practice of the past centuries, under the frontier expansion model, in which the process was merely one of search for fresh natural resources, conquer and then exploit to the point of exhaustion.

Mitigating the externalities of economic development

Madhoo in her chapter on *Valuation of non-market environmental goods and services* addresses

a major aspect of environmental economics, presenting both technical methods of assessment and their value for decision-making. Her focus is on those elements in small and island states with positive values such as rivers, coral reefs, natural plants, and beaches, as well as those with negative values such as smoke and noise pollution from transport, which is supplied without any evident demand. She examines the choices of relevant values, in terms of direct use, indirect use, non-use and intrinsic use. She then explores technical methods of assessment using a broad conceptual framework.

In her subsequent chapter, *Impact assessment and biodiversity conservation: An application of EIA and SEA*, Madhoo sets out the role of environmental services as critical factors in sustainable development and explores the use of environmental impact assessment and strategic environmental impact assessment as tools available to policy-makers and managers. Experience from the Pacific region and from other countries in the use of these tools is cited, bringing into focus the strengths and weaknesses of the analytical methods applied to the management of fisheries, tourism and forestry. The value of these tools depends greatly on the political will to establish legal enforcement of their findings and to overcome pressure from interested parties to block effective implementation of biodiversity protection.

These issues are further examined by Madhoo in the chapter on *Environmental policy instruments and governance*. This follows through the commitment to the new environmental paradigm (NEP) to redress market failure. For guiding the choice of instruments, she sets out a taxonomy showing their objectives and operational characteristics within the context of the political realities of states and the constraints which often inhibit good governance for sustainable development. Policy failure is part of this reality. The chapter examines economic instruments and command and control measures, distinguishing between those concerned with outcomes and those addressing the implementation of technical equipment and process standards. The chapter explores the differing objectives that may be pursued in the choice of instruments including efficiency, effectiveness, equity, and health outcomes. Madhoo finds an empirical link between government effectiveness and transparency and the stringency of environmental regulations and their enforcement. This, she argues, arises from interacting political and social forces in the market for environmental regulation which determine the level of regulation in any state. The chapter concludes with the recognition that environmental control, in developing states, may be more effectively promoted through community-based management of natural resources.

Part 2 Seminal published papers

The exposition of theory and its application in the real world of development policy and practice is further illustrated through the section of seminal articles from published journals, which have become required background reading in this field, as they present in lucid and telling ways the underlying scientific and ethical issues compounded together, sometimes uneasily, in studies on sustainable development.

The mythology of economic analysis

Fullerton and Stavins in their chapter *How economists see the environment*, expose four principal myths in the way that others may perceive the economist's approach to the

analysis of environmental issues. In particular, they underline the interest of economists in market and non-market solutions to issues and the importance of equity as a guide to the distribution of costs and benefits and as a counterweight to the application of the concept of efficiency in resource use. They call for greater transparency, better communication and closer joint working between environmentalists and economists in studying the field of environmental policy.

At the interface of theory and practice

Portney in *The obligations of a policy economist*, reinforces this perspective with his elegant reflections on the obligations of a policy economist providing advice for improving governance, whether in the public sector, private sector or in civil society. He describes as 'poppycock' the notion that allocative efficiency is a sufficient basis for decision-making and he calls for economists to even-handedly present the wins and the losses in any assessment of the likely outcome of policy, asserting: 'I have never seen a win-win policy in which someone doesn't lose his shirt'.

Finally, he urges economists '… to roll up their sleeves and work with the lawyers and others who are charged with the actual drafting of environmental and natural resource policies'.

It is a brief paper that comes from many years of experience of the friction that exists at the interface between the design of policy derived from theoretical principles and its successful implementation in the real world of powerful interest and pressure groups.

The planet's carrying capacity

The joint paper by **Arrow** and colleagues from academic centres for economics, meteorology, ecological economics, zoology and entomology, *Economic growth, carrying capacity, and the environment*, calls for the environment to take front and centre stage in the examination of economic growth. They base their argument on the view that the carrying capacity of the environment has critical finite limits that are not acknowledged in the long-term positive association, formerly asserted, between economic growth and environmental quality. The paper calls for economists to address the development of measures: 'to promote greater efficiency in the allocation of environmental resources at all income levels … (that would) assure a sustainable scale of economic activity within the ecological life-support system'.

Nailing sustainability

The concluding paper in the set of seminal published contributions to the theoretical underpinning of natural resource analysis comes from Robert Solow. He is a Nobel prize-winner for his contributions to the theory of economic growth and the critical importance of technological innovation, the so-called 'Solow residual'.

In his witty paper *Sustainability: An economist's perspective*, originally presented as a lecture at the Woods Hole Oceanographic Institute in Massachusetts in 1991, **Solow** addresses the issue of defining the concept of sustainability claiming,'… it is very hard to be against sustainability. In fact, the less you know about it, the better it sounds'.

He tersely dismisses received definitions from distinguished bodies such as UNESCO and UNEP claiming that they press us to do things which he claims are either not feasible or not desirable. In particular, he hits out at the paradox of using sustainability as a concept to focus on the interests of some people being short-changed by our actions now, namely people in the future. To which he responds: '… then I think you are really obligated to ask, "well is anybody being short-changed right now?"'.

This is the issue of resolving both inter-generational equity (our concern for those who might lose out in the future population of the planet) and intra-generational equity (our neglect for those who are losing out now). He asserts that poor people today want children as an insurance against old age, meaning they want consumption rather than investment; whilst rich people want to curb population growth in the third world and to deny poor people the use of the cheapest sources of energy, such as coal, because this will undermine the interest of generations to come. Solow denies that sustainability can be defined and measured exactly, but urges its continued use as a general guide to review policies that have to do with investment, conservation and resource use.

These four papers bring into sharp focus five principal issues confronting those concerned with the pursuit of sustainable development: the assessment of current and of future welfare, the carrying capacity of the planet, growth in both population and in consumption, and equity.

Part 3 Case studies: Valuation, policy instruments and projects

Within this broad context of theoretical concepts for policy review, the book offers, in Part 3, a series of case studies covering the practical use of valuation methods, policy instruments and interventions through projects, to illustrate both the range of themes being addressed in natural resource analysis and the situations in which they are being applied in small and island states.

Aversion to risk

Munro in his chapter on *Environmental valuation methods in SIDS* emphasises the importance of valuation for the design of economically efficient and socially relevant policy. He critically reviews progress in valuation methodologies applied to SIDS in recent decades, through critical review of technical methods and by the use of case studies arising from the special features and vulnerabilities of SIDS. Recognising that SIDS have higher economic and ecological risks than many other states, and that their economies increasingly depend on tourism, he presents the core analytical issue as the exploration of the economic function of risk and risk aversion in the principal beneficiary groups. Defining risk as the variance in the probability of an event, he illustrates the challenges of valuing the outcomes of investing in risk reduction in terms of improving the utility of both the resident and the non-resident populations of beneficiaries.

Munro's review succinctly explores pricing, revealed preference, and stated preferences, mitigation costing and the importance of the dose-response relationships in exposure and in intervention, and examines the strengths and weaknesses of the methods commonly

adopted. His apt choice of case material drawn from SIDS illustrates the increasingly recognised importance of critical factors in differentiating social preferences, for example in the valuation of increasing protected marine areas and securing safer bathing water. His chapter concludes with some searching questions for students of the subject.

Internalising the environmental impact

Nath and Schroeder in *Tax instruments for environmental management in tourist destinations* look at the opportunities and some results of introducing environmental tax instruments. They argue that the externalities of tourism should be borne by the tourists and not the resident population of tourist destinations. The externalities include depletion of biodiversity and the ozone layer and the contribution of these locations to climate change by rising consumption of fossil fuels. Measurable adverse impacts can be seen in pressure on scarce water resources, reduction in land quality, through built infrastructure, soil degradation, air pollution, and damage to flora and fauna, including the destruction of coral reefs. The impact on natural resources is critical where the adverse effects exceed the rate of regeneration. They argue that whilst regulation can be used to curb the excessive increase in tourism, Pigouvian-type taxation can help to preserve the environment by funding better environmental management. The authors propose a tourist property tax and a tourist business district authority for its management.

Clearing the fog

Ayrga in *Road transport, motorisation and pollution* reviews policy initiatives being taken in the island state of Mauritius for controlling pollution from road transport. He finds a positive association between the density of roads and economic growth in SIDS in all three regions, but shows that for Mauritius the extensive road network is dominated by private transport over public transport, and the efforts to control the externalities of air pollution with regulations on emission standards have not been integrated with other effective polices to reduce pollution and intensive private motor transport use. The four-fold increase in carbon emissions in the past twenty years in Mauritius and increased traffic congestion present formidable challenges to government with an adverse impact on human and natural resources of the country.

The tragedy of a lost sea

Madhoo's final case study in Part 3 re-visits Hardin's iconic moral tale of the tragedy of the commons, in *An illustration of the tragedy of the commons: The demise of the Aral Sea*. This chapter takes the story of this major environmental degradation as a metaphor for the ultimate stage of market and policy failure; the end-state of unregulated pollution and dereliction of governance. This case study highlights the emergence of a trans-boundary natural resource problem and the significance of international co-operation in alleviating the grave damage done to the gift of nature for selfish and unco-ordinated economic motives.

The case studies presented in Part 3 illuminate the conceptual basis of natural resource analysis, the techniques of measurement, evidence emerging from projects and the implications for policy. This serves as a prelude to Part 4, which explores what happens

when people try to do something to save small and island states from the ecologically destructive impact of man.

Part 4 Policy in action

Now we move on to the more general perspective of the wider application of policies in the real world, including policies on climate change, disaster risk management, the evidence base for decision-making, intellectual property rights, the environmental implications of patterns of trade, water management, coastal ecosystems and sustainable and renewable energy. These chapters examine the specificities of small and island states which present particular challenges to policy-makers in adapting global trends in 'greener' policy to the local and special needs of these most vulnerable economies and environments.

Global warming

Munro in *Climate change and SIDS* reviews the action being taken by SIDS to mitigate the impact of climate change and adapt to its consequences drawing on the reports of the IPCC. He examines the evidence for the Environmental Kuznets Curve and the reduction in pollution as countries become more developed, but his view is clear-cut: 'though some individual countries have begun abating or controlling emissions, overall the world level continues to rise, fuelled by population growth and economic prosperity'.

He broadly endorses the guidelines set out on climate change in the UN 2005 SIDS Mauritius Strategy, which are to promote measures for:

- greater energy efficiency and development of renewable energy sources;
- dissemination of new technologies and ideas to SIDS;
- raising the scientific capacities of SIDS with the support of the IPCC; and
- greater investment in monitoring of global and local climate changes.

However, in the face of the options of fight or flight and the history of denial of the doomsday environmental scenario, he sees the case for flight for people to escape from their most vulnerable locations, for, he stresses: 'Many SIDS are highly exposed to the risks created by climate change. For low-lying atoll islands the risks from sea-level rise are particularly acute … . They may also suffer from the consequences of the policies taken by other countries, particularly if tourism demand weakens. … The most economically efficient way of adapting may not involve hard structures or protecting existing infrastructure and lifestyles. Instead, retreat and accommodation may be more sensible, particularly when population density is low or existing infrastructure is limited.'

Migration and evacuation are currently options being seriously considered for some of the most vulnerable islands both in the Indian Ocean and the Pacific.

Avoiding disasters

Roberts in *Disaster risk reduction: Practical adaptive options* considers the nature and extent of disaster risk in SIDS by comparison with other causes of premature death, injury and damage, and the international framework and guidelines for policy response. He identifies

the need for greater attention to be given to evidence-based policy, the better assessment of risk and a more thorough evaluation of both the cost-effectiveness of intervention and the opportunity cost having regard to other areas of investment for increasing human welfare. The chapter poses questions for students to explore aspects of hazards, vulnerability and capacity for effective response. Disasters, like wars, capture the headlines; this chapter puts the issue of disasters into the broader perspective of the management of natural resources for sustainable development.

Building on scientific knowledge

Morrison and Kaly in *Coastal lagoon management in three Pacific Island situations: Is scientific knowledge used effectively?* examine how far policy development exhibits effectiveness in the use of scientific knowledge for coastal marine management of tourist areas in SIDS. The growth in tourism and urbanisation in and around coastal lagoons is producing one of the most threatened global environments. The chapter explores the evidence base for action being taken in Fiji, Tonga and Tuvalu and the extent of integration of information gathering for effective management. This chapter paints a sad story. It tells of the fragmented state of local relevant scientific studies, the lack of integration between national and local planning functions, and the absence of key skills. It records the slow pace of response to international recognition of the need for integrated coastal zone management in SIDS. Timely action is needed to avert the rising impact of the pollution and the degradation of the natural resources and environmental services, such as water, air and coastal areas. The authors conclude that until such issues are addressed: 'management of the lagoons will continue to be ineffective and the overall quality of the local environment must deteriorate, to the detriment of both the human residents and the ecosystems as a whole'.

Safe water for all

Mycoo reports on the progress made in water policy development in an island state in the West Indies, in *Environmental policy for water resources development: A case study of Trinidad*. The government is committed to improving water quality and equity in access to water and sanitation, promoting water conservation, and achieving the optimal use and management of the nation's limited water resources. It has developed a range of policies and plans which head in this direction, but which have been mostly blocked or diverted. Policy pronouncements and laws articulate the need for effective water resources management to no avail. At the heart of the problem is the lack of integrated management arrangements for water resources.

As the author states: 'Water resources management responsibilities are scattered amongst a plethora of government departments and statutory authorities that restricts the systematic application of these official policies'. The UN 2005 SIDS Mauritius Strategy recognised the importance of such facilities as follows: 'The access to safe drinking water, the provision of sanitation and the promotion of hygiene are the foundations of human dignity, public health and economic and social development and are among the priorities for small island developing states'.

The UN SIDS Mauritius Strategy called for countries to provide integrated programmes of

water management by 2006. Much remains to be done. The story from Trinidad and Tobago highlights many of the testing issues of water governance where action fails to follow the policy directions set.

Renewable energy islands – Is it a dream?

The chapter by **Deepchand and Nath**, *Sustainable energy from renewable biological resources: Sugarcane bagasse energy cogeneration in Mauritius*, introduces the concept of the ultimate dependence of GDP on the invisible hand of the photosynthetic product of the planet (PPP). This product is the primordial source of global natural wealth and the sustainability of life. The authors suggest that the principal global threat comes not so much from global warming as from the degradation or depletion of the earth's critical natural capital. This chapter examines the credentials of increasing the supply of energy through the highly energy efficient and renewable resource of sugarcane bagasse[2]. Using a process of cogeneration of energy, combining bagasse with other sources, such as coal, the authors use data from Mauritius to demonstrate the potential for technical transfer of best practice to other small and island states with a history of sugarcane production. This fresh development in sugarcane products comes at a time when many of these countries are facing decline in demand and less favourable trading arrangements for sugar itself. The authors call for an 'aggressive renewable energy policy' in Mauritius and other island states where the 'sea coastal location and access to other renewable energy sources, namely solar, wind, and sugarcane bagasse, should constitute an integrated renewable energy package. The success of bagasse-based energy cogeneration can provide avenues to move towards the objective of becoming a renewable energy island[3] (REI) in the near future'. Thus, the demise of the sugar trade becomes an opportunity for saving small and island states in a new era of renewable energy production, with at its core, harvesting the yield of PPP.

Trading off nature for wealth in the Caribbean

In *Trade liberalisation and environmental considerations for the Caribbean*, **Scott Vaughan** and his colleagues show why the sustainable development of SIDS must be closely integrated within the framework of international, regional and national policy on global trade policy. It critically reviews the story of trade liberalisation and its impact on environmental and natural resources. The focus is on the need in the Caribbean for better environmental laws and tighter enforcement of environmental standards. The authors examine threats to the environment from both exports and imports. But they see the opportunities for trade to enhance environmental quality. They present case material from the US ban on fish imports from the Caribbean islands whose fishing methods for shrimps failed to comply with the CITES[4] principles for protecting endangered species of turtle. Opportunities for developing trade in environmental goods and services are also examined as potential areas for new economic ventures that can benefit both Caribbean trade and the environment.

The authors stress the following areas for priority development most relevant to their region: sound management of agro-chemicals; the effective enforcement of environmental laws; market-based approaches to the conservation of biological diversity; strengthening environmental education, and the dissemination of a 'tool kit' on trade and sustainable development. This is advice relevant to the wider world of trade in all small and island states.

Protecting a brain child

Gangopadhyay and Gangopadhyay in *Intellectual property rights and anti-competitive behaviour: Major deterrents to ecology and economic progress of SIDS* show these two developments having emerged as two major deterrents for their economic progress and ecological balance. The authors demonstrate how game theory can be applied as the basis of an outline for policy to protect SIDS from expropriation of their intellectual property in the face of their evident vulnerability to outside predators in this field.

In this part, the examples show policy in action as it emerges from its conceptual and theoretical phases. In addition to the thematic issues, this exploration of policy in action demonstrates how national specificities can give rise to the emergence of inter-state, regional and international consensus on policy development and its evidence base. However, the variable international political geometry of the pursuit of national interests does not inevitably coincide with the regional patterns of geographical alignment. South–South technical exchange occurs in response to common interests, leadership and the serendipity of opportunities.

Part 5 Global issues and environmental management

Roberts in this final part in the book explores the planetary dimensions of environmental management with a series of illustrations from the use of MDGs and their adaptation to the needs of SIDS; the use of standard analytical methods and performance indicators; concluding with the ways in which SIDS are responding to the challenges of sustainable development through improving their resilience to external shocks and better management of their natural resources.

Annexes

The annexes to the book are provided as aids to students and policy-makers. They include an annotated glossary of the key concepts and players in the field, a record of the milestone events in the elaboration of global policy, and a mischievous exercise in scenario development for policy players, either to aim to save or to destroy a vulnerable island state.

Notes

1 See http://www.happyplanetindex.org
2 Bagasse is the fibrous residue remaining after sugarcane or sorghum stalks are crushed to extract their juice. Sugar cane is one of the plants with the highest bioconversion efficiency in terms of using solar energy for photosynthesis; this plant is able to fix 55 tonnes of dry matter per hectare of land on an annually renewable basis.
3 An island with 100 per cent energy produced from renewable sources.
4 UN Convention on International Trade in Endangered Species

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Chapter 1

Concepts and public policy issues in environmental and natural resource analysis

Introduction

This chapter introduces the relevant concepts in environmental and natural resource analysis and brings out why there is a need for governmental regulation and policy for environmental management. Classification and definitions of environmental goods and services are presented in the second section. In the third and fourth sections, an attempt is made to discuss environmental goods as a necessity or an amenity and as public goods and to examine the major characteristics of these goods. In the fifth section, policy context is examined. Given the public goods nature of environmental resources, the importance of conscious policy on use and conservation is highlighted. Concluding remarks are contained in the last section.

Definition of environmental goods and services and natural resources

Webster New World Dictionary defines environment as the 'conditions, circumstances, and influences surrounding, and affecting the development of an organism or groups of organisms'. For our purpose, organisms are primarily human beings and ecosystems. Whether they are man-made such as agriculture or occur naturally as biodiversity, they impact human well-being. These resources are useful in the same way as manufactured capital stocks, such as roads, buildings, and machinery are utilised in production. However, environmental and natural resources, because of their open access nature, are more freely available to anyone. This open access property makes these resources more vulnerable to excessive use and degradation.

In economics literature, there are five factors of production: land, capital, labour, organisation and entrepreneur (Samuelson and Nordhaus, 2007). Land is important in the present context because it is a part of the environment and is defined to include the surface of the land, anything residing below land and anything coming to the land surface from above. Thus, soil, surface water and groundwater, sunrays, rainfall, atmosphere and climate are different forms of land and are examples of environmental goods. Natural capital is a wider term to capture all forms of environment, environmental goods and natural resources that are derived from nature. Natural resources are further divided into exhaustible and non-exhaustible. Minerals and oil are exhaustible natural resources, and forest, bio-diversity and river water, underground water and ocean water are examples of non-exhaustible natural resources. The latter can be replenished under given conditions.

Site-specific characteristics of a natural resource system (soil, ground water, and hydrology) determine its capacity to support the ecosystem. For example, an agricultural farm is one form of natural resource system, which produces output and also provides ecosystem services. The beneficial outcomes that result from ecosystem functions are better fishing and hunting, cleaner water, better scenic views, and reduced human health and ecosystem risks. The value of an ecosystem is measured in terms of its beauty, its uniqueness, support to human habitat and health, and contribution to commercial and recreational activities. Economic values of ecosystem services can be expressed in relative terms using indicators of willingness to pay (WTP) for their environmental services.

Since markets do not exist for many environmental goods and services, hypothetical markets are created to know what prices to put on these non-market resources. In the absence of real world markets, we can depend either on the invisible hand for the management of these hypothetical markets or government intervention is needed. Leaving everything to the invisible hand assumes that market forces work. The efficient functioning of market forces would, however, require that buyers and sellers' property rights are well defined, which is not the case with most environmental goods. Because of the public good nature of these goods, such property rights are not well defined. Open access renders these goods as common pool resources and their over use causes decline and decay. This is described as the tragedy of the commons as developed by Hardin (1968).

Rainfall and climate are some other interesting environmental goods. Rainfall contributes to output growth and scenic beauty. But it can be viewed as an environmental bad if it causes flooding and landslides and soil erosion. Similarly, climate is an environmental good. But if we consider the effects of climate on output, productivity and health (human and animal), it can have adverse effects, particularly in tropical countries. This effect seems to be strongly related to the presence of malaria, which may be a proxy for a range of tropical maladies that are geographically associated with that disease. Moreover, geographic location of countries will have differential effects on growth. Access to the coast seems to matter for growth because it lowers transport cost and creates agglomeration economies (Gallup et al., 1999, 151).

The significance of services has expanded in recent years but the environmental dimensions of various services have not attracted similar attention particularly because these are much more difficult to measure. Commonly defined as 'anything that you can't drop on your feet', services might initially appear as intangible and therefore environmental concerns emanating from them are likely to be underplayed. In reality, however, the production, consumption and distribution of many services have large ecological footprints in terms of pollution and degradation, and other services by their nature would involve environmental mediation or protection. Transportation services – everything from trucking food to shipping steel – are important sources of greenhouse gases and other air pollution. Uncontrolled tourist development threatens some of the world's most sensitive ecosystems. Waste management and disposal services, water distribution, sewage and sanitation if not adequately addressed can damage human health and the health of the environment.

Pollution is an important by-product of human intervention and technological growth. If pollution is an environmental bad, it will be useful to call all such goods and services,

which help in environmental conservation and protection, as environmental goods and services. With this extension of the list of environmental goods and services, environmental technologies for the abatement of pollution and other negative effects will also be included in the list of environmental goods and services. The interesting part is that such goods and services are tradeable in the market and therefore in such cases property rights are well defined.There are attempts to create tradeable permits in CO_2 emissions both within a country and between countries.

OECD classification of environmental goods and services

According to OECD and Eurostat experts, the environmental goods and services industry consists of activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use. OECD classified environmental goods and services into four groups:

The pollution management group includes goods that help control air pollution, manage wastewater and solid waste, clean up soil, surface and groundwater, reduce noise and vibrations, and facilitate environmental monitoring, analysis and assessment.

Cleaner technologies and products are goods that are intrinsically cleaner or more resource-efficient than available alternatives. For example, a solar photovoltaic power plant is fundamentally cleaner than a coal-fired one.

Goods under the category of resource management are used to control indoor pollution, supply water, or to help farms, forests or fisheries to become **sustainable**. This group also includes goods used to conserve energy (such as double-paned windows), and goods that help prevent or reduce the environmental impacts of natural disasters, such as fire-fighting equipment.

The fourth category consists of **environmentally preferable products** that cause significantly less environmental harm at some stage of their life cycle than alternative products that serve the same purpose. Examples would include improved solid-fuel cooking stoves and reusable shopping bags made of canvas or jute rather than plastic or paper.

United Nations Environment Programme (2005) has developed the following classification of goods and services in order to facilitate preferential treatment of goods and services in international trade.

- Goods destined to be used in environmental remediation or clean up (e.g. oil spill remediation equipment), prevention of environmental damage in industrial processes (e.g. air pollution control, waste management, energy savings), or equipment for environmental monitoring and analysis.
- Technologies and products that, in their use, are more environmentally friendly than the norm. This includes consumer goods such as electric cars, and producer goods such as wind turbines and technology for cleaner burning of coal.
- Goods and services that have been produced in environmentally friendly ways (e.g. organic produce, recycled paper).

Box 1.1. Some interesting questions on UNEP's classification

a In the first category, a thermostat is an apparatus for heat/energy savings and management but it has other uses not related to environmental management. How will you justify that it is an environmental good?
b In the second category, an electric car is a good candidate for environmental good. But what about other fuel-efficient cars?
c Is eco-tourism an environmental good?
d In the third category, how will you treat transportation services, medical tourism and filmmaking and entertainment services?

Environmental goods as a necessity or an amenity

In the conventional environmental economics literature, environment is treated as an amenity for human enjoyment. According to Carson (1962), the disappearance of birds brought about by pollution was regarded as a loss of important amenities. It was considered as the degradation of the beauty of the nature, and if the degradation continued, people would no longer have the pleasure of watching and listening to birds each spring. When Holling (1994) analysed the disappearance of migratory birds in North America, he looked at the effects on insect populations and the possible destruction of boreal forests from the increasing number of these pests. The same cause would have two different impacts, one (the loss of timber) can be measured but the quantity and quality of the other (the loss of amenity) can only be guessed at. But both the loss in amenity and the loss in timber production will reduce well-being of the rich and the poor differently. Therefore, it is important to distinguish between value of an amenity and value of an environmental resource as an input in production.

Environment as an input in production

If an environmental resource is only being used in production, there may not be any amenity value for purposes of environmental accounting and the value of the environment as an input is equal to the value of (marginal) productivity of that environmental resource. It is important to note that physically invisible environmental resources such as climate and atmosphere cannot be ignored in the production process. Nordhaus (1993) studied the role of climate (latitude and average temperature) on income but its effect may be swapped by other variables. He reports that incomes per square kilometre vary from a low of $31 in China to a high of about $36,000 in Hong Kong and from $37 in Indonesia to $6,200 in Japan. In fact, latitude explains less than 1 per cent of the variance in income per capita and per area. According to computations by Gallup et al. (1999), average GDP per capita in tropical countries in 1995 was $3,326 as against $9,027 for non-tropical countries.

But when we discuss the use of environmental resource by households, there is a need to distinguish between production value and amenity value. Let us compare two households, rich and poor with different willingness to pay (WTP) for an environmental resource. Now we should expect that as income rises, the value of the resource as input

also rises. Mailer (1997) concludes that input environmental resources are more important for the poor than for the rich. The relationship between mangroves and fisheries is quite instructive. Fishers are quite aware that the destruction of mangrove forests means the destruction of their fisheries, which will force them to pursue other economic activities or to become almost permanently unemployed. In this example, the income elasticity of an environmental resource will be negative, that is, as income increases, the demand for an environmental resource as input decreases. This is for the fact that environment as an open access resource will be more important for the less rich households. Here, such an environmental resource is a necessity for the poor and again these resources will suffer from excess use and degradation. Besides this, once these resources are useful in production directly or invisibly, both quantity and quality will be under the pressure from human needs.

Environment as an amenity

In developed countries, particularly in Europe and North America, environmental resources are generally considered as amenities, which are luxury goods. In other words, their income elasticity should be greater than one. But empirical estimates have revealed some interesting facts. Kristrom and Riera (1996), using contingent valuation surveys in Europe, in almost all cases, found income elasticity to be less than one. Kannanien and Kristrom (1993) analysed data sets from Africa and the United States to find essentially the same results.

In the light of these results, that is, income elasticity of environmental resource less than one, it can be argued that even environmental quality is not a luxury good. It is a necessity for all. This makes the case for environmental conservation and protection. Nevertheless, protection of environmental quality will benefit poor families more than high-income families. Since low-income families use environmental resources more for their short term survival, they degrade more and adversely affect the photosynthetic product of the planet; hence protection of environmental resources will be justified on both efficiency and equity grounds. If the decline of the photosynthetic product of the planet is reduced, the growth of GDP will be higher. Thus, growth-promoting environmental care is efficient. It is equitable as well because poor families benefit more from environmental protection because they need the environment more than rich families for their livelihood and survival.

Environment as a public good

Most environmental goods are different from private goods. Private goods (e.g., apples) are characterised as rival goods where one person's consumption reduces the amount available to others. But environmental goods are non-rival or public goods where it can be assumed that their use is equally available to everyone. Given this feature, many environmental goods, such as clean air and water, and scenic beauty are not traded in the market. In such cases, they are non-market goods and their economic values can be expressed in terms of the affected party's willingness to pay (WTP). Nevertheless, there are other environmental goods, for example, various elements of biodiversity such as fish, natural plants and

wildlife populations that are traded in national and international markets. While they have public good properties they become semi-private goods through some institutional arrangements. This is possible only by redefining property rights so that they become market goods.

Another feature of environmental resources is that people cannot be excluded from enjoying them and any attempt to exclude people would be prohibitive. So non-exclusion and free-riding would not allow any form of transactions through markets. The free-rider problem makes the task impractical for farmers to recoup the cost of on-farm conservation investments from those who benefit from such environmental improvements. Nevertheless, through government intervention, and by the use of subsidies, taxes or other incentives and controls, non-farm direct beneficiaries can be called upon to share the burden of private farm investments.

When the use of environmental goods is uncontrolled due to open access and free riding, and negative externalities are generated by production and consumption activities, these would tend to create risks for human beings and ecosystems. It is such negative externalities that constitute the foundation of environmental economics and applied welfare economics, and which form the basis of government intervention and environmental governance.

The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 advocates the following objectives of environmental policy (UNCED, Agenda 21, Chapter 8, p. 85):

1 To incorporate environmental costs in the decisions of producers and consumers, to reverse the tendency to treat environment as a 'free good' and pass these costs on to the other parts of the society, other countries or to future generations.
2 To move more fully towards the integration of social and environmental costs into economic activities, so that prices will appropriately reflect the relative scarcity and total value of resources and contribute towards the prevention of environmental degradation.
3 To include, wherever appropriate, the use of market principles in the framing of economic instruments and policies to pursue sustainable development.

To provide such policies, it is important to determine the appropriate unit for environmental governance. According to the principle of subsidiarity, environmental decisions and implementation should be assigned to the lowest level of government capable of handling it without significant residual externalities. In other words, these allocations should be based on which layer of government would have the most information on those issues. For local reservoir pollution, the appropriate authority is the local government. For air pollution and natural degradation problems having regional effects, regional and provincial governments are appropriate. If these degradations cross provincial boundaries, central government or inter-provincial boards appointed by the central government become an appropriate authority. Environmental problems of a trans-boundary nature, such as acid rain, coastal zone degradation with effects on neighbouring countries, river pollution involving more countries, climate change, ozone layer depletion and biodiversity loss can

be handled by bilateral and multilateral co-operation and intergovernmental entities such as the United Nations.

Determining the level of government that is more suited for pollution abatement policy making and implementation within a country is a complex issue. While the stock of information available within the government is important, technology and administrative capability can be more pertinent. Governments at different levels will possess varying amounts of information, technology and administrative capability. Given that environmental externalities may not be aligned with the administrative boundaries of a government, institutional co-operation between governments at different layers is warranted. As regards the significance of information about environmental dynamics and degradation, a sharing mechanism can be designed.

Andersen and Jensen (2003) have shown that the central government can introduce a flexible grants-in-aid system that induces the local authority to mix local and central information. According to this study, if the central authority is highly uncertain about the environmental effects of a specific pollutant, the tax-subsidy scheme can be designed to allow local information to play an essential role in the environmental policy. If the central authority is certain that a pollutant must not exceed a specific limit, the tax-subsidy scheme should minimise the local influence on the environmental policy.

Sigman (2007) has explored the empirical relationship between decentralisation and environmental public goods, such as water quality in rivers at monitoring stations around the world. In this research, pollution levels and spatial variability of pollution within a country are examined both as a local and a regional pollutant. The results suggest higher pollution levels with greater decentralisation because of inter-jurisdictional spillover and free-riding across jurisdictions. It is concluded that since decentralisation allows policies more tailored to local conditions, it will be desirable that management functions of regional pollutants are assigned to higher level authorities.

Global environmental externalities and global public goods

International trade in hazardous chemicals, engendered species and contaminated goods, greenhouse gas emissions, ozone depletion and biodiversity loss are global environmental 'bads'. Since the effects of these bads are not felt on a uniform basis across nations, each country's interest may differ in controlling such international trends. It is also possible that controls in trade of such goods may hamper growth in low income countries, and therefore there may be a conflict of interests between developed and developing countries just on the basis of economic growth. This is besides the fact that such activities may not be environmentally friendly.

The Rio Declaration of 1992 advocates the following principles for international co-operation on environmental issues:

Principle 2: States have the sovereign right to exploit their own resources pursuant to their own environmental and development policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states.

Principle 6: The special situation and needs of developing countries, particularly least developed and those most environmentally vulnerable, shall be given special priority.

Principle 7: States shall co-operate in a spirit of global partnership to conserve, protect and resolve the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, states have common but differentiated responsibilities.

The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 9: States should co-operate to strengthen endogenous capacity building for sustainable development by improving scientific understanding through exchange of scientific and technological knowledge and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 13: States should co-operate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problem of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a misguided restriction on international trade.

There has been steady progress on international co-operation in terms of multilateral agreements, namely the Uruguay Round on international trade in goods and services, the Montreal Protocol on ozone depletion, the Convention on Biological Diversity, the UN Framework Convention on Climate Change and the Kyoto Protocol. Capacity building and financial support initiatives to environmental management programmes in developing countries have made good ground. Nevertheless, only limited success has been achieved in the field of transfer of environmentally friendly technologies to developing countries. Climate change and global warming are causing sea levels to rise, thereby threatening the very existence of small islands. In this story, the role of small islands is minimal. When the carbon emissions of developed countries are higher than that of LDCs and small and island states, the price that small and island countries are paying in terms of bigger environmental challenges is disproportionate. They are suffering not because they are polluting but because other countries are producing higher growth rates and polluting. The international dimensions of global public bad are therefore more challenging than local dimensions, which may be trivial. It is vital to argue that when we are talking of a global carbon tax, there will be a case for compensating small and island economies for such vulnerabilities for which they are not responsible.

The environment as an important public policy issue

According to the dominant social paradigm (DSP), which reflects the view of the industrial era, economic and population growth and continued exploitation of natural resources can continue without damage to the environment (Pirages and Ehrlich, 1974). The new environmental paradigm (NEP) (Dunlap and Van Liere, 1978) that emerged in

the mid-to-late twentieth century challenged this perspective and offers instead the view that more emphasis must be placed on environmental protection and the development of a systematic way to address the depletion of natural resources. In short, where the DSP emphasised development and production, the NEP has promoted conservation and sustainable development.

We know that natural resources and the state of the environment are under tremendous stress. Wherever there are externalities, particularly negative externalities, the market fails and government intervention is needed until government itself fails to control them. It is important to note that when government fails, it is not inevitable that markets will start working again. So when both markets and the government fail, there will be a need to devise a strategy of government regulation, which can provide good governance and also introduce incentives so that markets for environmental management are revived.

In the presence of positive externalities arising from an economic activity, social benefit is higher than private benefit, and the private optimum level of output will be lower than the social optimum level of output. The role of public policy then will be to provide incentives to expand private output. This is the basis of **subsidy policy**. It is important to note that a public policy in the form of granting subsidies to activities, which produce negative externality, will be misplaced. For example, many governments granted subsidies to fertilisers and pesticides to boost agricultural output, which damage land quality and lower water quality. This policy was based on the DSP whereas following the NEP, in the recent past, there is paradigm shift and such subsidies are being withdrawn in a phased manner. The approach now is to encourage proper or environmentally safe use of fertiliser inputs.

Similarly, when there are negative externalities, social cost is higher than private cost and hence the private optimum level of output will be higher than the social optimum level of output. This will require policies designed to discourage or regulate production so that the extent of negative externalities (pollution) can be reduced. The basis of tax policy in this case, is to provide disincentives to production of goods and services that harm human health and the health of the environment. Such taxes on polluting activities are called green taxes. These taxes entail 'double dividends' in the sense that they control polluting activities as well as raise revenue to finance government expenditure on pollution abatement. Ideally, the proceeds of green taxes should be spent on environmental management by earmarking, but, in practice, they are spent on other expenditure heads. Nevertheless, green tax revenues act as a dividend to provide relief on account of some other taxes. In other words, the potential growth of some other taxes will reduce due to revenue from green taxes. If the government does not trade green taxes with other taxes, they do provide additional revenue to the exchequer, in addition to some expected reduction of pollution and damage to the environment. There are other ways for a government to control negative externalities such as through the use of command and control tools by fixing physical standards and ceilings, or through revival of markets.

Well-designed regulation policy to control environmental damage is a public good because benefits will flow to all parties. However, conflicting objectives may frustrate the environmental goals. While discussing the complexity of environmental policy-making in the United States (it may also be relevant to any other country), Sussman (2005) writes

that 'the environmental movement is represented by a variety of groups that differ in size, tactics and strategies. Business and industry have substantial resources to support their attempt to shape environmental policy in their favour. Property rights groups that maintain a strong anti-federal government orientation prefer that state and local governments make environmental policy'.

'The science and politics problem is an integral part of the environmental policy-making process. On the one hand scientists collect data, employ the scientific method and replicate their studies. Politicians, on the other hand, are guided by factors including electoral considerations, pressure from interest groups and uncertainty. While scientists are guided by objectivity, politicians may view environmental issues through the prism of ideology or partisanship. Where scientists may need more time to experiment, politicians might need an answer before the next election. In short, science may be integrated effectively into public policy or it might be ignored or politicised to meet the needs of those in public office.'

In most developing countries, weak property rights and rapid population growth are major sources of environmental degradation. As the environment is degraded, there is a need to exploit these resources more to meet the requirement for food, energy production and shelter. Here there is apparently a vicious circle that affects mainly the poor: environmental degradation increases poverty, which increases degradation. In such economies, population control and poverty alleviation constitute major policy inputs to environmental improvements. It is contended that with economic growth, the magnitude of these problems would reduce and the pressures on the environment would be eased.

There is another strand in the literature called the 'Environmental Kuznets curve'. This curve explains a relationship between increases in per capita income and environmental quality. It is posited that as per capita incomes rise, the environment gets worse but with further increases in per capita incomes, environmental quality tends to improve. In other words, we produce and pollute more initially but as growth proceeds, the demand for a cleaner environment increases and also the capacity to take up environmental challenges increases. In this scenario, economic growth is a major vehicle to address the environmental problems in developing countries. In this framework, however, environmental policies can take the back seat.

The environmental Kuznets curve has not proved suitable for all environmental concerns. Moreover, this approach does not take into account the fact that environmental problems present themselves differently in different situations. Even though some of the environment may be a renewable natural resource, the rate of resource depletion may exceed the rate of regeneration and this may reduce net improvement. Technologies for the regeneration of natural capital are not well researched, though greater attempts are being made in this direction. For example, the global problems of deforestation, water and air pollution, greenhouse gas emissions, ozone depletion and biodiversity loss are the result of economic growth. Further economic growth may aggravate these problems and the cost of damage management may become prohibitive and complex. This is despite the fact that more resources and new technologies consequent upon further growth will be available. The upshot is that the policies to protect and regenerate environmental and natural resources without reducing economic growth may seem infeasible.

Arrow and others (1995) have described the role of Environmental Kuznets curves very aptly by noting that economic growth is good but not a panacea for environmental quality. According to them, what matters is how environmental resources are being used and depleted, and the quantum of the waste products that have to be disposed of in the environment. A 'Wait and see' policy and 'staying put and doing nothing' may not be helpful in crucial matters like the environment and natural resources. Thus Benjamin Franklin aptly wrote, 'It is not until the well runs dry that we know the worth of water'.

Concluding remarks

In this chapter an attempt has been made to define environmental goods and services. A distinction is drawn between environmental goods with positive externalities and environmental bads with negative externalities. In the absence of markets for most environmental resources, attention is drawn to such goods in international trade and the importance of policy making is discussed in the contexts of both environmental goods and services and environmental problems in developed and developing countries. It is noted that economic growth is not a panacea for all environmental problems, which reinforces the relevance of environmental governance.

It has been argued that environmental goods and natural capital, whether they are necessity or amenity, are subject to excessive use and degradation. Given that the income elasticity of environmental resource is less than one, it can be argued that even environmental quality is not a luxury good. It is a necessity for all. Hence the case for environmental conservation and protection in both developed and developing countries

While environmental goods are nature's product, it is brought out in the analysis that technologies and services that are designed to protect the quality of environment and natural capital are also environmental goods. With the expansion of the list of environmental goods and services, the role of markets as an instrument of policy increases. There is a need to design policies separately for non-market and market environmental goods and services.

It is argued that while economic incentives and command and control tools are important policy instruments, tax policy in particular has played a major role in environmental governance. The basis of tax policy in environmental governance is to provide disincentives to the production of goods and services that harm human health and the health of the environment. Such taxes on polluting activities are called green taxes. The interesting part of these taxes is that they entail 'double dividends' in the sense that they control polluting activities, as well as raise revenue to finance government expenditure on pollution abatement.

The chapter also distinguishes between different types of environmental public goods having local, regional, national and global jurisdictions. This distinction makes a case for different levels of government and inter-governmental coordination in environmental governance. The significance of international agreements and collaboration is highlighted. Further research initiatives are needed because when it comes to environmental concerns, 'we know what we know but we do not know what we do not know'. Therefore, information sharing is the kingpin of environmental and natural resource management.

Climate change and global warming are threatening the very existence of small islands. Given that the quantum of carbon emissions of developed countries is higher as compared with emissions of LDCs and small and island states, the price that the latter are paying in terms of bigger environmental challenges is disproportionately high. It is vital to argue that when we are talking of global carbon tax, there will be a case for compensating small and island economies for such vulnerabilities for which they are not responsible. Given that these countries are small in terms of geographical area and population, the degree of vulnerability they invite can be relatively larger. This will require the design of well informed environmental policy to meet the global challenges locally.

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Chapter 2

Valuation of non-market environmental goods and services

Introduction

Environmental goods and services are shown as amenities having impact on an individual's welfare. Some are goods and services in the traditional economic sense, for instance, food, timber, recreation, materials and technology. Such goods and services enter the market place where demand and supply forces determine their price. Markets can be local, national and international. When environmental goods and services are traded, their valuation is done in international prices using the exchange rate of countries involved. Valuation of marketed goods is less complicated because markets reveal information about supply of, and demand for, these goods and services.

Many environmental goods and services, however, lack characteristics of private, tradeable commodities. Examples are coral reefs, sea, beaches, rivers, wetlands, mangroves, watersheds, clean air and freshwater. These goods and services carry with them values which cannot be easily quantified using the formula of the marketplace. This is because both demand and supply are ambiguous. Nature provides these environmental facilities for which production processes remain unknown. Moreover, markets for these amenities are often non-existent. It is only through the users' perceptions that some monetary value can be put on these facilities. We call them non-market environmental resources.

The value of non-market environmental resources is adversely affected due to human intervention and economic activities such as manufacturing, farming, transportation and tourism. So, while valuation of stock and flow of these resources is important, valuation of loss of such resources is equally important. For example, smoke and noise pollution created by automobiles run by fossil fuels degrade the quality of environmental resources. If carbon emissions are traded in the market, it will be less difficult to evaluate decline in environmental quality due to automotive pollution. Strictly speaking, it is not carbon emissions that are traded but a corresponding value of the clean air 'equivalent' that has been lost. The value of this loss can be imputed from the market price of the 'pollution permit' that polluters are willing to pay.

Real world markets for environmental quality are, however, rarely found. Thus, while supply of pollution is spontaneous, demand remains ambiguous. In other words, there is a virtual demand, which is forced upon others. Depending upon the intensity of preferences for clean air, charges may be devised in the form of fees and taxes and levied on polluters. Revenue generated from these charges can be spent on pollution abatement, which is

expected to compensate for the loss of clean air. The setting of an optimum charge would require that policy-makers be able to ascertain affected parties' and polluters' preferences for the environment.

Valuation of non-market environmental goods and services constitutes a major area of investigation in environmental and resource economics. This chapter aims at analysing different methods of assigning monetary value to such goods and services. Before attempting to compare different methodologies and case studies along with their limitations, the usefulness of undertaking valuation of these resources is discussed. A case is made as to why there is a need for placing a number on non-use and non-market values of such public goods.

Why place a value on environmental goods and services?

Sustainable development, which would ensure quality of life, requires that depletion, damage and depreciation of the environment be measured. Real and sustainable growth rate calculations would need information on depreciation of physical as well as natural capital. In conventional calculations, only depreciation of physical capital is considered. But it is important to note that the use of the environment in the production or for enjoyment by societies will lead to environmental degradation and thereby depreciate the natural capital. Since the resources emanating from natural capital are used in the production of goods and services, their degradation will eventually limit a country's growth and welfare performance. To put it technically, while an economy produces GDP, the planet produces photosynthetic product (PPP). The latter contributes to the production of GDP. As GDP increases, PPP would tend to depreciate. If depreciation of the PPP is not addressed, GDP growth in the future is likely to be compromised.

Society has limited resources to allocate over projects to meet the objectives of economic growth, poverty alleviation and environmental conservation. These objectives can also be conflicting. For example, construction of dams for irrigation and agricultural development may conflict with the preservation of natural wildlife areas. Valuation of natural resources is vital to show their potential contribution to economic growth and ecological balance. In the absence of such information, environmental objectives will always be undermined by the supremacy of other social and economic objectives.

Valuation of existing environmental resources in the present and in the future (inter-temporal valuation of environmental resources) is important for taking decisions regarding environmental conservation for future generations. Some of these decisions can be highly desirable when it comes to the use of exhaustible natural resources, which cannot be reproduced and therefore must be preserved.

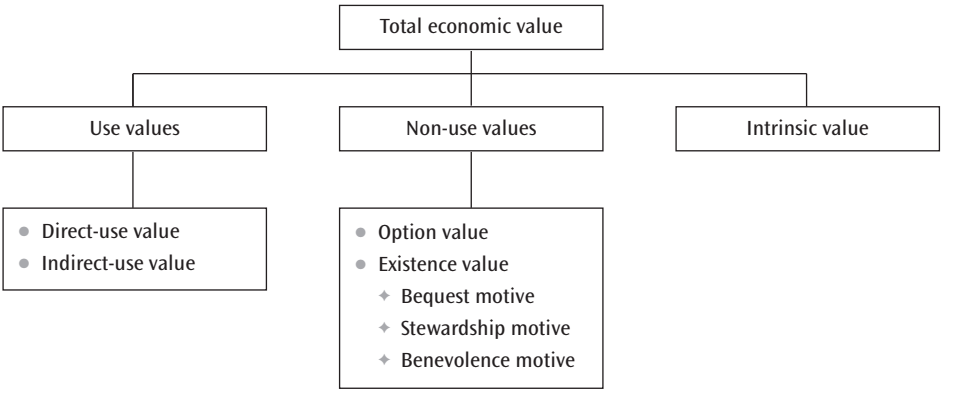
Valuation of environmental goods and services provides information on total and lost values of such resources. This is one of the crucial exercises in environmental accounting. These calculations are further utilised in building green national income accounts following the United Nations System of National Income Accounts (UNSNA), by taking into consideration damages to the environment.

Valuation is also essential to implement the 'polluter pays' principle. The essence of this principle is to shift the responsibility of environmental degradation from the government (or general taxpayers) to entities producing the damage. Thus, those who are responsible for pollution should bear the cost of that damage. One such method is to implement a pollution tax. The issue of a tax on international tourists who contribute to environmental degradation during their stay in a tourist destination is discussed in Chapter 10. These tourists pay for the private goods and services but generally it is difficult to tax them for the use of environmental public goods and services (scenery, forests and wetlands, pyramids, pollution created by congestion on the road and sea beaches, etc.). To impose any tax to recover the social cost generated by them, there will be a need to value the damages and calculate the external marginal cost. In other words, implementation of environmental taxes would require valuation of environmental goods and services.

Which values are relevant for environmental governance?

The environment can be a source of welfare to different individuals and in various ways. For instance, a forest can simultaneously provide timber for loggers, ecosystem services for the local community, genetic resources for pharmaceutical companies and also serve as carbon sinks for global carbon dioxide emissions. A taxonomy of different concepts of environmental values relevant for policy analyses is presented in Figure 2.1. Total economic value encompasses direct-use value, indirect-use value, non-use value and intrinsic value. Use values are the more direct and quantifiable environmental values. Examples are products (e.g. edible, ornamental, medicinal and inputs into production process), recreation, research and education (for a good description of different environmental values, see NOAA Coastal Services Centre Website, 2007; Spurgeon, 1998).

Figure 2.1. Concepts of environmental values



Indirect-use values associated with coastal areas include biological support (species and habitat), physical support (coastal defence function), climate modulation, and global life support functions that aid in supporting life on the Earth. These values are extremely difficult to measure and continue to be an area of professional challenge to scientists and

economists. In many cases, there is a need for international co-operation and scientific information-sharing among nations.

Non-use values are less direct, less tangible benefits to society and include option and existence values. The option value is the value an individual places on the future use of the resource, for example, benefits a beach would offer during future trips to the coastal area. Existence values include bequest, stewardship and benevolent motives. Bequest value is the satisfaction gained through the ability to endow a natural resource on future generations. The stewardship motive is derived from an altruistic sense of responsibility towards the preservation of the environment and a desire to reduce environmental degradation. The benevolence motive reflects the desire to conserve an environmental resource for potential use by others.

Box 2.1.

Economic value of clean air and water, quality of atmosphere and climate.

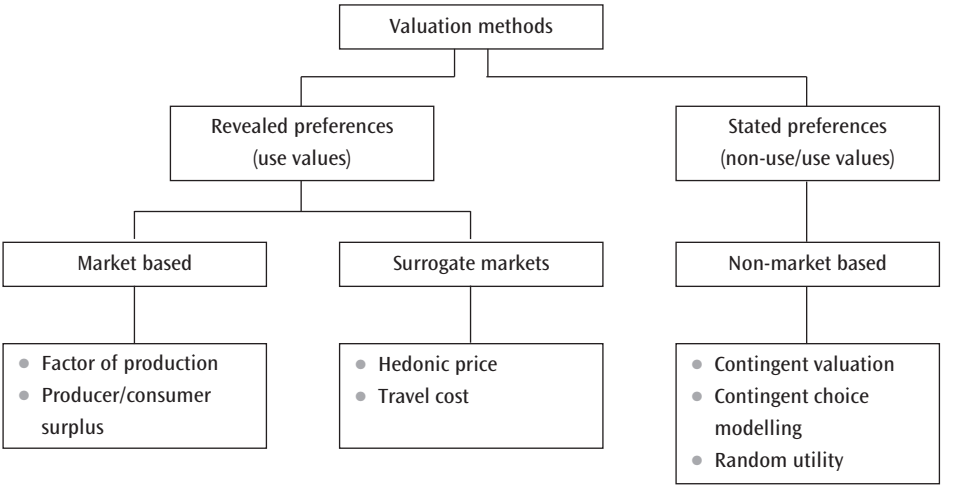
The value of these environmental goods and services can be defined in terms of the opportunity cost that would arise in the absence of such life-supporting natural functions. From this angle, the total economic value of these environmental forces is immeasurably large because extreme degradation of either would result in irreversible and catastrophic damage to the capacity of this planet to support human and other life. Thus, by polluting these natural systems within a limit, an attempt is made to reduce such opportunity costs.

Good examples of existence value are Antarctic glaciers and Amazonian rain forests. As pointed out earlier, if we ask people to contribute some money for the preservation of these environmental assets, there is high probability that many of them would show some willingness to pay, although they may never visit these places. The only justification is that they would need these assets to exist. It is also a good example of intrinsic value of nature that reflects the belief that all living organisms are valuable regardless of the monetary value placed on them by society.

Methods of valuing non-market environmental resources

Economists have devised different techniques to measure the economic value of an environmental asset. Monetary values can be derived based on information collected from individuals benefiting from environmental resources. Individuals will reveal their preference for an environmental good or service either in real or hypothetical market conditions. In market conditions, they reveal their willingness to pay for gains from an environmental resource in actual transactions. In non-market or hypothetical market conditions, they reveal their willingness to pay (WTP) for environmental gains as well as their willingness to accept compensation (WTA) for environmental losses due to degradation. The two methods are also called 'revealed preference method' (market based) and 'stated preference method' (non-market based), respectively (See Figure 2.2).

Figure 2.2. Environmental valuation methods



Market-based methods

- **Factor of production approach**

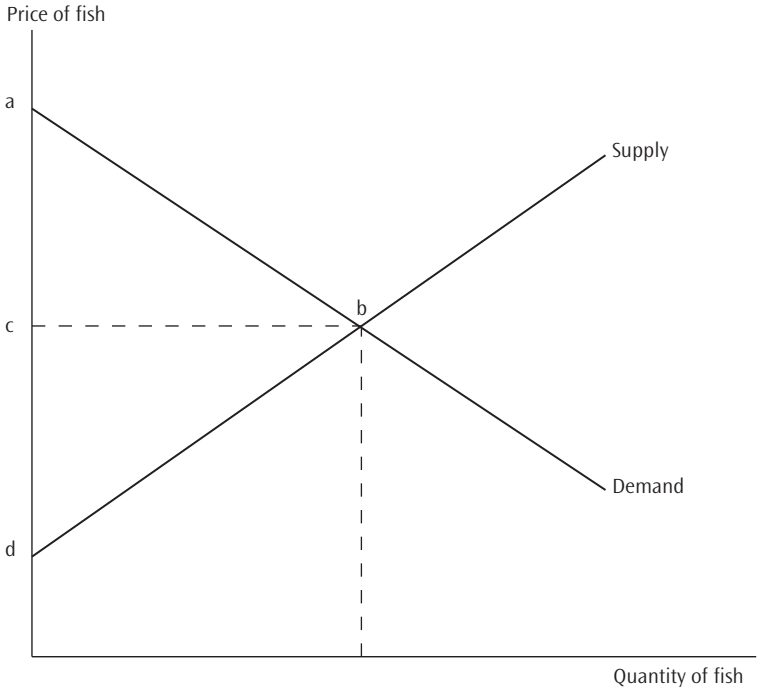
The value of an environmental resource can be monetised based on its value as an input like other material inputs. When a resource has a direct value as a factor of production and it can be obtained from market sources, it may be straightforward to know its value. Similarly, when the impact of environmental degradation on future output using that resource can be measured, the estimated value of the decline in output or higher cost of production can be obtained. This loss would be borne by the producer or the polluter depending on the situation. But this method is applicable to those situations where output can be traded in domestic or international markets.

- **Producer/consumer surplus approach**

When the product using an environmental resource is sold in markets, there is an alternative way to capture the impact of changes in environmental quality and the resultant gain or loss due to that asset. In this method, net economic benefit is calculated by taking into account producer surplus and consumer surplus of a sale. Consumer surplus is the difference between what a customer is willing to pay and what she actually pays. It is represented by area abc in Figure 2.3. On the other hand, producer surplus is the difference between what a producer is paid for fish and what it costs to produce, that is, area bcd in Figure 2.3.

Imagine an open access resource such as a coastal area with a rich fish population. Now the fish biodiversity of the coastal zone declines due to increased tourism and fishing. The degraded fish habitat reduces the rate of fish catch. This will have an impact on producer and consumer surplus. To ascertain the impact of decline in environmental quality on producer and consumer surplus, econometric investigations can be carried out with selected variables and increased fishing (Lipton et al., 1995). The negative impact of fish habitat degradation on total economic value (consumer and producer surplus) would indicate value forgone, which is a measure of economic value of environmental resource.

Figure 2.3. Producer and consumer surplus in the fish market



Surrogate-market methods

In the surrogate-market method, an attempt is made to capture the impact of environmental resources in terms of value created that is capitalised in the values of properties and picnic spots in different geographical regions. The two interesting methods that are used in this approach are hedonic price method (HCM) and travel cost method (TCM).

- **Hedonic price method**

Housing and property markets are typical examples. There is no market for different types of good and bad environmental amenities. But their value is camouflaged in the value of houses and properties. High quality of air and water is supplied by nature. Similarly, polluters supply polluted air and contaminated water. The high and low value of such environmental features cannot be assessed separately. However, since these features are reflected in the value of properties, properly specified hedonic functions can help ascertain values of such environmental resources. Similar houses in two localities with different environmental attributes will fetch two different prices. The difference in housing prices under different environmental features can be used as a measure of the value of environmental resources.

The price of a house close to an airport must be lower than that of another house which is not affected by noise pollution. The price difference can be attributed to noise pollution. If the airport was built after the housing colony, legal property rights may allow for compensation payable to house owners from an airport authority. House owners may, however, get compensation to keep quiet, or accept the noise pollution level to the extent of price difference with respect to houses not affected by this pollution, and the airport continues its operations.

A properly specified hedonic price function can be estimated econometrically in which different environmental qualities can be used as separate arguments to estimate their separate values (see example in Box 2.2).

Box 2.2. Amenity value of an urban forest

Tyrväinen (1997) estimated the effects of urban forests on property prices in Joensuu town, Finland. A hedonic price model was formulated as follows:

$P = f(A_i, L_i, E_i)$

where P represents the price of apartment i, **A** is a vector of apartment characteristics such as size, age and type, **L** is a vector of locality attributes including accessibility to town, school and shops and **E** is a vector of environmental characteristics describing environmental quality in the housing district, namely accessibility to watercourse, recreation areas and relative amount of green spaces. The author estimated the above model using property prices of 1,006 apartments and finds that the variables describing urban forest benefits generally had the *a priori* expected sign and had a positive and significant influence on apartment price. On average, the amount of forested areas in the housing area as well as nearness to watercourses and recreation areas increased apartment prices. Thus, the findings indicate that maintenance of urban forests are capitalised into house prices. The model further enables us to estimate the economic impacts of land use changes in that area.

This information can also be used to know people's willingness to pay for high or low environmental quality. It is important to note that the reliability of such estimates will depend upon the proper specification of hedonic price function, the quality of data that are obtained from market and non-market sources and the method of estimation. Estimates can be sensitive to the method and sample used.

- **Travel-cost method (TCM)**

This method is employed extensively in the literature to place a value on environmental goods and services located at recreational sites and in natural parks (see example in Box 2.3). TCM is suitable to value resources for which significant costs have to be incurred to visit them. Expenditure by different travellers is used as an estimate of willingness to pay for those environmental assets. A central assumption is that of weak complementarity between travel costs to visit a site and utility derived from environmental goods and services at that location. Thus, if people do not visit a site, TCM would attribute a value of zero to environmental assets on the site. In this way, existence value and other non-use values are not captured.

Box 2.3. Measuring economic value of viewing elephants

Brown (1993) used TCM to estimate the benefits of safaris and derived from there the value of viewing elephants that was over and above the travel costs. It was found that viewing elephants was a source of 12.6 per cent of the total value of the trip – equivalent to US$23–27 million. By demonstrating the economic loss associated with declines in elephant population, the results were used to marshal resources necessary to reduce poaching.

Costs of travel comprise distance costs (e.g. petrol and depreciation of vehicle), on-site expenditures and time cost (i.e. opportunity costs of visiting the site). Data on the number of trips made and travel costs are collected by surveying visitors to a recreational site. An implicit demand curve for a recreational site can be generated by examining the relationship between travel costs incurred and total number of trips taken by visitors in different expenditure categories. Once a demand curve is traceable, it will be easy to calculate the consumer surplus and value of that site.

Econometric estimations of trip functions in which cost of travel are arguments can give an idea of the demand for environment (visits to the site) as the cost of travel rises. A well-specified demand curve should, however, also include income and other socio-economic determinants, such as level of education, age and household size. Availability and attributes of substitute sites may also be important, having impact on the frequency of visits. A typical trip generating function (to a recreational site) can be postulated as follows:

> No. of visits = f (cost of travel, income, socio-economic variables determining demand for environmental assets/services, attributes of substitute sites)

Limitations of this approach having impact on the reliability of WTP estimates include multipurpose visits to a site (i.e. enjoying the environment is not the sole reason of visit to a site), choice of functional form, measurement issues (e.g. estimating time cost is difficult), and other econometric problems. Moreover, like the hedonic price method, TCM is unable to estimate non-use values, which can be important for many environmental goods and services. When this is the case, stated preference techniques of valuation are preferred.

Hypothetical-market methods

Optimum allocation of resources to various purposes requires that the external benefits and costs associated with any policy change are adequately taken into account. While market forces facilitate allocation of resources to private goods and services, such allocation mechanisms are generally absent in the case of environmental public goods and services. Public and environmental economists attempt to undertake such tasks by creating market-type conditions to collect requisite data about environmental resources. Such valuation methods are discussed below with their policy implications.

- **Contingent valuation methodology (CVM)**

Contingent valuation of environmental resources is a most popular method involving the use of surveys and interviews to obtain information about monetary values of environmental assets and associated policy changes. It is different from other survey methods where individuals are faced with actual situations. In contingent valuation, respondents are asked to state their preferences in terms of willingness to pay (WTP) for an improvement in quality of the environment or willingness to accept compensation (WTA) for accepting a deterioration. The entire procedure involves the simulation of a hypothetical market situation and solicits individuals to express WTP/WTA, contingent upon the market described to them.

CVM is most suitable for valuing environmental goods and services having non-use values,

namely existence value, option value and bequest value. Some of these resources are within the reach of individuals while other environmental assets are valuable for their existence even if they cannot be visited (e.g. Antarctic glaciers). The fundamental assumption is that the value of all goods can be expressed in money-equivalent terms and value is based on goods giving utility to users. Thus, there are three important assumptions: that utility functions exist; that these utility functions can value non-market goods in rank order; and that these value rankings of non-market goods can be empirically identified.

The target population of interest is identified and respondents are randomly selected. A questionnaire is employed as a survey instrument to elicit respondents' willingness to pay for an improvement or willingness to accept a compensation for a decline in environmental quality, WTP or WTA, which are expressed in monetary terms only. Even 'Yes' and 'No' answers are automatically converted into monetary values.

There is an ongoing theoretical debate concerning the use of WTP versus WTA as the most appropriate valuation method for non-market goods (see Venkatachalam, 2004 for an extensive review of the literature). In theory, these two values should converge. However, a large disparity is found to exist with WTA being significantly greater then WTP. This is attributed to the income effect where a respondent's budget constraint becomes binding when she states her WTP whereas it is not binding when accepting compensation. Hanemann (1991) further shows that for some environmental amenities, such as the Grand Canyon, even if income is held constant, absence of close substitutes would cause WTP and WTA to diverge. This is the substitution effect. WTA also often results in unrealistically high bids when interviewees insist that the loss is priceless. Consequently, most CVM practitioners use the lower but more feasible WTP.

The questionnaire to elicit respondents' WTP or WTA can be mailed, directly served to respondents or administered by phone. Bidding questions can take the following forms: open ended, referendum, payment card and bidding game. In an open-ended question, the respondent is asked to state his maximum willingness to pay (MWTP) for the improved quality of the environment. Referendum or dichotomous choice format presents the respondent with a bid choice that she can accept or reject. Payment card is another commonly used alternative in CVM where the respondent has to choose one of the stated bids on the card. The last technique is a bidding game in which bids are offered in sequence so that the respondent's maximum bid is finally known (such as, would you accept $20? If yes, would you accept $30? If the respondent answers no to the last question, then MWTP is inferred to be $20).

The bidding vehicle has to be clearly stated in the questionnaire. It can be a tax or a fee levied by the government, a private body or an NGO; or alternatively, a voluntary contribution to some organisation for preserving nature. The vehicle selected should be generally uncontroversial for a successful CVM. This can be elicited during preliminary research through trials with focus groups. These groups would yield information about respondents' knowledge about the issue studied, their beliefs, and the credibility of the hypothetical scenario presented. The survey questionnaire can be refined using inputs from the pilot survey(s) before a final version is ready for implementation.

The collected data are econometrically treated. WTP/WTA functions are postulated and estimates of mean and median willingness to pay for improvement or willingness to accept compensation for deterioration are obtained. WTP functions are also able to capture the effects of socio-economic factors like income, age, household size, education and rural/urban location. Aggregation of mean WTP would approximate total population values.

Limitations of CVM results for policy analysis

Because CVM relies on the stated preference of individuals rather than actual revealed behaviour, WTP/WTA values generated using this method are often the subjects of controversy. Biases introduced at different stages of the survey or through respondent's strategic behaviour could adversely impact the precision, credibility and reliability of the WTP estimates (Diamond and Hausman, 1994). These biases have to be addressed when designing the survey (see application in Box 2.4; also, Mitchell and Carson, 1989 for a good treatment of this issue and recommendations to improve reliability of CVM results).

Strategic bias can occur where the respondents may believe that their response will be used for some change in policy and they under-estimate or over-estimate their willingness to pay to achieve their desired objective. In other words, the respondent's stated value may have little relation with his/her WTP or WTA. A similar situation arises when respondents feel too good or too bad while thinking of paying for a public good. For instance, a participant may state a high value because he feels a 'warm glow' from expressing concerns about the environment. In this case, since WTP responses reflect general attitudes rather than true economic preferences for the environmental good, the values are likely to be insensitive to scope (Kahnemann and Knetsch, 1992). For example, stated WTP to save 100 turtles is the same as that to save 10,000 turtles.

The hypothetical nature of CVM also poses significant challenges when respondents do not correctly understand the good being valued or cannot accurately state WTP in monetary terms. Information bias arises when respondents have to express their opinion on something about which they do not know enough. Lack of information and misconceptions about environmental quality can result in such biases. Moreover, there are situations when respondents indicate the same willingness to pay for avoiding degradation of whole or part of the environmental asset. That is, they feel concerned about the total damage. This is called the 'embedded effect'.

Box 2.4. An application of CVM to subsidise clean technology in agriculture

Hite et al. (2002) conducted a contingent valuation survey in Mississippi to assess public willingness to pay (WTP) for a subsidy to agricultural producers for the adoption of variable-rate technology (VRT) to reduce agricultural pollution of freshwater. Producers were generally reluctant to adopt this technology given high fixed cost and uncertain impact on profitability.

Methodology

Single price referendum contingent valuation (CV) was used to elicit public willingness to pay a one-time tax to subsidise agricultural producers' cost of purchasing VRT equipment.

To provide a framework for the valuation question, respondents were informed about current water quality in Mississippi.

Versions of the questionnaire assumed 10 per cent and 20 per cent levels of pollution reduction in order to test for scope bias. A 10 per cent reduction suggested by simulation studies was used as a baseline. Respondents at all price levels were randomly assigned 10 per cent and 20 per cent abatement levels and were asked to vote for a bid runoff pair consisting of a one-time tax payment and a runoff reduction percentage (e.g. $50 tax and 10 per cent runoff reduction, $50 and 20 per cent runoff reduction, etc.). The possible answers to the WTP question were 'Yes', 'No' and 'Don't know'.

The referendum prices in the survey were based on estimates of the cost of implementing the VRT adoption programme divided by the number of individual taxpayers ($25, $50, $100 and $150). The authors chose telephone surveys as the administration method following a very low response rate from mail surveys. Pre-test analyses were conducted to evaluate respondents' understanding of questions. The survey sample consisted of 1,024 respondents with a response rate of 79%. The data for the two levels of abatement (10 per cent and 20%) were segmented into two sub-samples.

The exercise passed scope tests: WTP for 20 per cent abatement level was found to be significantly greater than WTP for 10 per cent abatement level. This suggested that the survey was successful in the programme benefits of incremental water quality to respondents. Because of the dichotomous nature of the dependent variable (WTP =1 if answer to bid question is 'Yes' and WTP = 0 if the answer is 'No' or 'Don't know'), a probability model (probit) was specified to obtain estimates of WTP. Control variables in the model include beliefs about the impact of agriculture on water quality and biodiversity, as well as socio-economic and demographic variables. The effective sample was reduced to 762 because of non-response on certain explanatory variables.

Results and policy implications
Results show positive and significant impacts of the following attitudinal factors on WTP for subsidising the pollution reduction technology: beliefs that agricultural practices result in pollution (AG_POL), beliefs that agricultural practices reduce biodiversity (AG_BIO), and that technology can be used to achieve cleaner environment (BLV_TECH). WTP was also found to be higher for people having very important environmental concerns (captured by variable ENV_GOAL). The estimated WTP from the study ranges from $52 million to $122 million. This finding suggests that the subsidy could cover a sizeable proportion of the programme's cost thereby providing incentives to agricultural producers to adopt this precision technology.

Biases due to subjectivity are more prominent when people have to choose between present use and future use of environmental resources. Respondents may distort their willingness to pay for improvements benefiting future generations due to uncertain future. Such biases are generally present when the objective is to generate existence value, option value and bequest value.

Another important bias is introduced when respondents are asked about their preference

for payment vehicle. For example, they may be averse to certain taxes and fees, and they may have a preference for local government as against central government. These issues have to be addressed during the pre-testing stages of the questionnaire so as to come up with a vehicle that is acceptable to most people. If vehicle bias is still suspected, different sub-samples may be used and presented with alternative vehicle scenarios but the same bidding amounts. Significant differences in WTP between the samples would imply sensitivity to vehicle scenarios used, rendering the estimates unreliable.

Whittington (1998) argues that a good CV scenario must be designed to appear realistic for respondents to take the 'hypothetical' choice seriously. In practice, the more seriously a respondent considers the choice posed, the less hypothetical the scenario is likely to seem. This is particularly true for goods and services with large use values that are commonly provided by the government such as infrastructure services. Moreover, if different sub-samples are given different hypothetical prices in order to improve the reliability of responses, it may create confusion that differential prices would be charged for the same amount of public services. If this is the case, then the whole purpose of contingent valuation is defeated.

There is another criticism from non-economists, namely sociologists and anthropologists, that researchers extract data from respondents and give them nothing in return. The solution to this problem is not simple. Whether payments to respondents will increase co-operation or improve quality of results is not known. But payments to respondents will definitely complicate the choice of respondents and may hamper smooth administration of survey designs. The issue of payments to subjects is simple in market and business surveys but researchers in the field of public policy and administration generally lack funds for their projects.

To address the methodological challenges of CVM, the NOAA guidelines (Arrow et al., 1993) provide the following suggestions to improve the quality of responses:

i face-to-face interviews are better than other methods;
ii WTP estimates to prevent a future incident are better than WTA for an incident that has already happened;
iii a dichotomous choice referendum is less vulnerable to strategic bidding behaviour than, for example, an open-ended elicitation format;
iv it is preferable to present an accurate and understandable description of the programme or policy under consideration and the associated environmental benefits in each of the two scenarios, that is, with and without the policy;
v an effort should be made to make such a hypothetical exercise resemble as closely as possible an actual market transaction; and
vi a follow-up exercise should be done to ensure that respondents understood the questions and choices well.

- **Contingent choice and random utility models**

When one-shot responses are not sufficient as in CVM and when several alternatives and trade-offs are involved, the contingent choice method (CCM), also known as co-joint analysis, is preferable. Respondents are asked to choose from among different alternatives

of environmental goods and services in a simulated or hypothetical market. Each alternative is a package of different environmental characteristics and payments. Thus, choice experiments assign independent values to the individual attributes of an environmental policy or programme. The emphasis on examining the different attributes of a project avoids the possibility of overstating WTP in a simulated market and focuses attention on what really matters to the respondents.

Box 2.5. Contingent choice modelling of community water management

Choice experiments were applied to the assessment of water supply options for the Australian Capital Territory (ACT). The objective of the ACT choice experiment study was to examine community preferences relating to various options for supply water necessary to meet the demands for the area's growing population, while focusing attention on resultant environmental costs (Blamey et al., 1999). The study examined five options, including damming, water recycling, and demand management, and assessed community preferences relative to (a) water availability for household use, (b) water quality, (c) cost of water to household, (d) impact on the aquatic and riparian environment, and (e) maintenance of animal habitat. By examining the attributes associated with water supply options rather than the options themselves, the study was able to avoid 'hot-button' emotional responses to damming and focus on what actually mattered to respondents. Based on the application of the choice experiment approach, a combined demand management/water recycling approach was designated as the preferred option.

Source: http://www.csc.noaa.gov/coastal/economics/envvaluation.htm

In this method, the environment is treated like any other commodity and its value is broken down into many attributes. For example, a coastal area is partitioned into beaches, sea view, fish, crabs, recreation and bird watching and willingness to pay for upgrading the coastal zone can be ascertained by knowing respondents' preferences for these attributes. There are several alternative formats to carry out contingent choice analysis. Contingent ranking requires ranking of alternatives; paired rating involves comparing two alternatives and rating them in terms of strength of preference; and discrete choice involves choosing the most favoured one among all alternatives. Since price is one of the characteristics of the alternatives, the choices are easily converted into a monetary measure of willingness to pay.

It may be noted that derivation of WTP from the data collected through contingent choices is relatively difficult. Discrete choice analysis encompassing sophisticated experimental design techniques and statistical procedures helps to analyse the data and determine WTP. In this way, CCM is a more powerful technique that can be applied to valuing environmental goods irrespective of whether they are marketed or not. But the complexity of this method would increase exponentially when alternatives and trade-offs start multiplying.

Random utility models (RUM) are econometric models that permit the estimation of preferences for different recreational sites with varying characteristics. Consider three beaches with different characteristics in terms of location, water quality, landscape, access, and wash facilities. These characteristics can be transformed into discrete and continuous vari-

ables and are used to assess consumer preferences by examining location preferences and the total costs of trips taken. Different sites are surveyed and collected data are utilised in RUM to estimate probability that an individual will visit one site out of three sites based on their characteristics. By varying the quality of those characteristics, an analyst can assess how recreational visitors value changes in environmental quality at particular sites.

The benefit transfer or comparison method

Sometimes when there is little time to conduct a study or when the expenses involved are exorbitant, the results of similar studies in similar locations or cases can be utilised as a quick reference point. The underlying assumption is that costs and benefits and utility functions of affected parties are either similar or comparable. If these assumptions are not satisfied, the estimates may not yield the desired results. Nevertheless, this method may offer some benchmark estimates of the significance and benefits of environmental resources, called 'priors'. These 'priors' can be modified in the light of new information yielding the 'posterior' values of crucial significance for environmental valuation.

Defensive expenditure as an alternative to valuation of damages

Most proposals of environmental accounts, including the system of integrated environmental and economic accounts, suggest that environmental degradation should be measured by obtaining estimates of restoration costs rather than by attempting to quantify the effects of degradation (Harrison, 1993). Feather et al. (1995) discuss the significance of defensive expenditures to prevent or counteract the adverse effects of environmental degradation. Actual defensive or preventive expenditure methods can be employed to measure restoration costs to maintain the environment. The requisite information for environmental preservation can be obtained from budgetary sources when costs are incurred by the public sector and from project files under the management of corporations and private agencies.

It is argued that there will be an element of arbitrariness in the mandated government expenditures since these may reflect built-in biases in government's judgement about the net benefits of restoration. But there can be operational strengths on the implementation front because such expenditures are usually project based and therefore more focused. Examples include beach nourishment, replanting seagrasses, and water purification devices. These projects have the explicit objective of reviving the environmental quality in the affected areas. Estimates of defensive expenditures can be derived from costs of replacement or restoration of total or parts of facilities.

Summing up

What is important to note here is that valuing environmental benefits and costs is not a simple exercise. There are economic, ecological and social dimensions of environmental dynamics, which have local, national and international consequences. Restoration expenditures make the life of decision-makers comfortable because some expenditure levels would emerge out of the budgetary process. But these expenditures should have some relation to benefits that it will generate or will restore benefits that would have been for-

gone. This simply means that there should be some value against which it is possible to feel bad when we degrade a natural resource.

This chapter has discussed different methods of valuing goods and services that do not enter into markets. In such cases, it is difficult to know the demand and supply processes which play important roles in the determination of prices and values. Researchers use different methods to put a number on the non-market values of environmental goods and services but contingent valuation and contingent choice methodologies are more popular. These are survey techniques which are carried out very scientifically and then collected data are analysed with the help of econometric tools and empirical methodologies.

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Chapter 3

Impact assessment and biodiversity conservation: An application of EIA and SEA

Introduction

One of the objectives underlying the valuation of environmental goods and services (which do not enter the market place) is to highlight their significance in economic and social terms. Moreover, such information is used to estimate the potential loss of these resources if conservation attempts are lacking. It has been discussed in the earlier chapter that putting a number on environmental resources is a stupendous task. For example, evaluation of damages to biodiversity is not only extremely difficult, but it would also lack scientific precision. Environmental impact assessment techniques are employed to directly assess damage to the natural, economic and social environment due to developmental proposals. They are intended as instruments of preventive environmental management. Biodiversity conservation initiatives internationally advocate the extensive use of environmental impact assessments to design effective strategies and plans.

Threats to biodiversity worldwide are attributed mainly to human activities causing habitat damage or loss. The decline in biodiversity at the global level is cause for concern since it affects the supply of ecosystem services, such as water, clean air, food and fertile soil that support people's livelihood and quality of life. The Millennium Ecosystem Assessment (2003) reports that 60 per cent of ecosystems examined have been extensively and unsustainably degraded. In the sections that follow, we provide a brief overview of environmental impact assessment (EIA) and strategic impact assessment (SEA) processes and examine the role of each in promoting biodiversity conservation. The strengths and weaknesses of the two approaches are highlighted based on country practices and experiences.

A brief overview of EIA and SEA

The International Association for Impact Assessment (IAIA) defines environmental impact assessment (EIA) as 'the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals'. The aim is to help policymakers consider these effects before major decisions are taken and commitments made regarding a proposed project. Strategic impact assessment (SEA), on the other hand, is a procedural tool for examining the impacts of policies, plans and programmes on the environment (see Box 3.1 for a definition of these concepts). The crux of the SEA process is the preparation of a report that includes baseline data, an assessment of significant environmental impacts, identification of alternatives and mitigation measures (Brown and Farmer, 2007).

Box 3.1. Defining policies, plans and programmes

Policy: A general course of action or proposed overall direction that a government or organisation is, or will be, pursuing, and that guides ongoing decision-making. It may take the form of a law, document, statement or precedent. Typically, policy is implemented by plans and programmes.

Plan: A purposeful forward-looking strategy or design, often with co-coordinated priorities, options and measures that elaborates and implements policy.

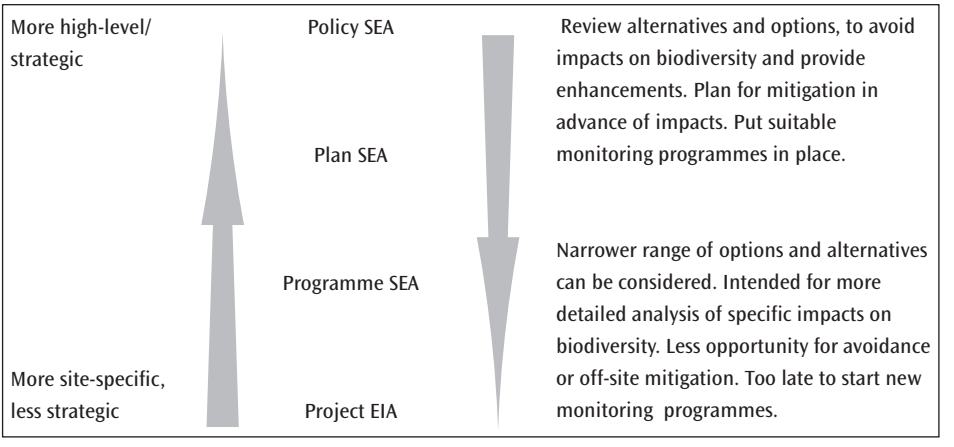
Programme: A coherent, organised agenda or schedule of commitments, proposals, instruments and/or activities that elaborates and implements policy.

Source: Sadler and Verheem (1996); UNEP (2004)

The SEA process extends the aims and principles of EIA upstream to the higher pre-project level of decision-making when major alternatives are still open and there is greater scope than at the project level to integrate environmental considerations into development goals and objectives (UNEP, 2004). The relationship between EIA and SEA is illustrated in Figure 3.1.

Policies shape plans, while programmes and projects put these policies into action. As we move down the hierarchy depicted in Figure 3.1, the nature of decision-making changes, as does the type of environmental assessment required. At the policy level, a wide range of scenarios is considered to avoid harmful impacts to biodiversity or provide enhancements to biodiversity. At the planning stage, mitigation measures can be identified, which would be followed by putting in place suitable monitoring programmes. Project-level assessment, on the other hand, is more specific and provides less opportunity for avoidance or off-site mitigation. The advantage of using SEA over EIA is that threats can be identified at an earlier stage. More specifically, policies, plans and programmes (PPPs) are more strategic since they determine the general direction or approach to be followed towards broad goals.

Figure 3.1. Characteristics of SEA in relation to EIA



Source: Treweek et al. (2005)

EIA v. SEA for biodiversity conservation

Project-based environmental impact assessment (EIA) used to evaluate the impact of specific developments on the environment have not been effective in incorporating biodiversity and ecological considerations (Treweek, 1999). This is because project boundaries rarely match patterns of biodiversity distribution. For instance, to assess the impacts of a project on biodiversity, it may be necessary to understand the biodiversity operating within a whole catchment area, ecosystem or even a country. Moreover, biodiversity is vulnerable to cumulative threats and pressures, and additional disturbances beyond some threshold may have sudden detrimental effects on the natural environment. This aspect of biodiversity is missed out by the EIA process, which essentially looks at the effects of individual projects in isolation. Treweek et al. (2005) identify five important dimensions that are typically lacking or inadequately addressed in project-based EIAs:

i Long-term trends
ii Ecosystem processes and interactions
iii The full range of cumulative threats and pressures acting on biodiversity resources
iv Implications of proposals for current and traditional uses of biodiversity
v Monitoring data needed to understand baseline trends and predict impacts

SEA is recognised by a growing body of literature as an alternative to overcome the limitations of EIA by allowing consideration of biodiversity at higher tiers of decision-making and planning. It thereby provides a process for integrated pursuit of biodiversity and sustainability goals in policy-making and planning. Unlike EIA, SEA adopts a long-term and broad approach by taking into account macro-implications of a proposed project in terms of meeting balanced environmental, economic and social objectives (Table 3.1.). Moreover, SEA also incorporates considerations of cumulative impacts and a broad range of alternative scenarios, making it preferable to EIA (OECD, 2006). The likelihood of success in promoting biodiversity is further enhanced as SEA facilitates greater transparency and more effective public participation by different stakeholder groups at the strategic level. In this way, disputes at the project level can be minimised. EIA decisions, on the other hand, are often subject to controversy and criticism since they are influenced by recommendations in the reports prepared by the project proponents themselves.

The use of SEA as a tool of impact assessment is highlighted in international agreements related to the sustainable use and conservation of biodiversity such as the Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands, and the Convention on Migratory Species (CMS).

Given numerous advantages and the growing number of proponents of SEA, one question which can emerge at this stage is: Is EIA then totally useless? SEA and EIA can be used as two complementary instruments that can help countries to ensure sustainability of their development plans. For the most part, an SEA is conducted before a corresponding EIA is undertaken. This will mean that information on the environmental impact of a plan will be able to cascade down through the tiers of decision-making and be used in an EIA at a later stage (refer to Figure 3.1).

Table 3.1. SEA and EIA compared

EIA	SEA
Applied to specific and relatively short-term (life-cycle) projects and their specifications.	Applied to policies, plans and programmes with a broad and long-term strategic perspective.
Takes place at early stage of project planning once parameters are set.	Ideally takes pace at an early stage in strategic planning.
Considers limited range of project alternatives.	Considers broad range of alternative scenarios.
Usually prepared and/or funded by project proponents.	Conducted independently of any project proponent.
Focus on obtaining project permission, and rarely with feedback to policy, plan or programme consideration.	Focus on decision on policy, plan and programme implications for future lower level decisions.
Well-defined, linear process with clear beginning and end (e.g. from feasibility to project approval).	Multi-stage, iterative process with feedback loops.
Preparation of an EIA document with prescribed format and contents is usually mandatory. This document provides a baseline reference for monitoring.	May not be formally documented.
Emphasis on mitigating environmental and social impacts of a specific project, but with identification of some project opportunities, off-sets, etc.	Emphasis on meeting balanced environmental, social and economic objectives in policies, plans and programmes. Includes macro-level developmental outcomes.
Limited review of cumulative impacts, often limited to phases of a specific project. Does not cover regional-scale developments or multiple projects.	Inherently incorporates considerations of cumulative impacts.

Source: OECD (2006)

The following sections examine challenges in using SEA in practice to promote biodiversity and identify key principles that need to be taken into account so that biodiversity concerns are adequately addressed at different stages of the SEA process.

Challenges for effective implementation of SEA

Efforts to integrate biodiversity concerns in strategic decision-making and planning face two broad challenges. The first challenge is to ensure that the SEA process remains focused on biodiversity uses and values, and involves the active participation of people (present and

future generations) who depend on these resources for their livelihoods. The second challenge is to ensure that a robust analysis of biodiversity impacts due to planned changes is conducted as part of the SEA process.

Stinchcombe and Gibson (2001) identify ten general barriers to effective implementation of SEA as follows:

- Limited information and unavoidable uncertainties
- Boundary-setting complexities
- Primitive methodologies
- Difficulties in defining the proper role of public participants and ensuring effective involvement
- Coordination and integration of strategic assessment with assessment processes at other levels
- Institutional resistance
- Conflict between integrated assessment and bureaucratic fragmentation
- Jurisdictional overlap
- Limitations of the standard rational planning and policy-making model
- Resistance to integration of strategic assessment in core decision-making.

The effectiveness of SEA, as for EIA, would be compromised by lack of timely and adequate information, and post-decision follow-up and monitoring. This is even more critical in the case of biodiversity, the dynamics of which require on-going monitoring and assessment. The difficulty in predicting impacts is exacerbated in SEA since the scale considered is much larger. Complexity, uncertainty and assessment costs would increase as boundaries expand and with longer time frames. Proponents of SEA, however, argue that the conjunctive use of SEA and EIA might achieve environmental objectives at reduced cost. SEA can speed up EIA procedures and streamline their costs by ensuring that project proposals are set within a policy framework that has been subject to environmental scrutiny (OECD, 2006).

Significant barriers to the practice of SEA relate to policy-makers' aversion to public scrutiny and involvement. Voluntary adoption of SEA and self-assessment is unlikely to be fruitful unless an effective legislative 'stick' exists. The exercise becomes even more complex due to coordination problems across and between institutions, as well as the influence of lobbies and interest groups.

Incorporating biodiversity in SEA

In order to overcome these barriers, it is important to develop comprehensive guidelines so that key biodiversity considerations can be included at various stages of the SEA process with feedback at each stage. The following insertion points for biodiversity can be identified:

- **Screening**: Is SEA required? What are the purposes of the proposed policy/plan/programme and how do these relate to biodiversity?
- **Scoping**: How should SEA be carried out? (See Box 3.2 for an example of a scoping checklist incorporating biodiversity issues).

- **Baseline conditions**: Collect information on the state of the environment in the absence of the plan and identify biodiversity risks. Some additional study might be required to predict how biodiversity might evolve without the plan (for example due to climate change).
- **Identification of options/alternatives**: Is the best biodiversity option being considered?
- **Assessment**: Identification, prediction and evaluation of biodiversity and other environmental impacts of the policy/plan/programme and the alternatives.
- **Mitigation measures**: How can the impacts be avoided, reduced or compensated for?
- **Monitoring**: Follow-up of the plan to compare predicted and actual effects on biodiversity.
- **Consultation and decision-making**: Identification of stakeholders; who are those dependent on biodiversity for their livelihoods? How can they participate effectively in the decision-making process?
- **Preparation of a report**

SEA must ensure that proposed policies and plans are consistent with existing mechanisms for biodiversity conservation, from the international to the local level (Treweek et al., 2005). This might include international obligations under global conventions as well as any national policies for environmental and biodiversity protection. For example, requirements relating to protected areas should be respected when new development is being planned. Opportunities for consideration arise at the screening stage, at the scoping stage (Box 3.2), when considering alternatives or when designing mitigation measures.

To be effective, SEA should be undertaken as an integral part of plan development and findings from the SEA exercise be allowed to feed back into the design of the plan. Supporting institutions should be in place that have the mandate, the capacity and the willingness to follow up on the key results of the actions agreed in the SEA (Verheem et al., 2005). Moreover, stakeholders should be both willing and able to participate without risk.

The importance of political economy factors in policy formulation is an acknowledged fact. Effective SEA depends 'on an adaptive and continuous process focused on strengthening institutions, governance and decision-making processes rather than just a simple, linear, technical approach focused on impacts, as is often found in EIA' (OECD, 2006). The World Bank is testing and validating an 'institutions-centered' approach to SEA as opposed to the traditional 'impact-centered' SEA, which focuses largely on impacts and how to mitigate these impacts (World Bank, 2005). The institutions approach emphasises improved governance, social accountability and social learning on a continuous basis to improve the design of public policies and raise awareness on environmental issues. It involves assessing a country's environmental management capacity to address the effects of policies on identified environmental priorities, which may include biodiversity. If a country's environmental management capacity is inadequate, a set of institutions and governance strengthening requirements to address these effects are warranted.

Box 3.2. Scoping checklist for biodiversity

1 Are there any protected areas or species within the area affected?

2 Consider biodiversity values and uses within the plan area.

3 Consider biodiversity at the following levels. Are there possible impacts at these levels? Which level(s) can be studied most effectively?

Bioregion	Habitat	Population	Landscape	Community
Individual	Ecosystem	Species	Gene	

4 Address the following questions to determine the scope of the SEA in relation to biodiversity composition, structure and function:

Composition

- What are the main components of biodiversity affected by the plan (see above)?
- What is the distribution pattern and richness/abundance of biodiversity?
- How does biodiversity composition in the study area compare with that outside the study area? (For instance, are there components that are unique?)
- Which biodiversity components are particularly vulnerable/sensitive to proposed plan activities?
- How does biodiversity composition in the study area compare with that outside the study area? (For instance, are there components that are unique?)
- Which biodiversity components are particularly vulnerable/sensitive to proposed plan activities?
- What are trends in compositions? (For instance is biodiversity organisation and composition stable or subject to rapid change?)

Structure

- Structural relationships include: connectivity, patchiness, fragmentation, vertical habitat differentiation, distribution of key physical features, availability of niches, water availability.
- How are biodiversity components organised in time and space?
- What are the requirements or 'drivers' for high or characteristic biodiversity to be maintained (e.g. environmental gradients)?

Function

- Consider how current levels and types of biodiversity are being maintained. Take an ecosystem perspective to identify important functional relationships like dependence of wetlands on hydrological processes; relationship between aquatic invertebrates and water quality.
- What processes maintain boundaries and structure (competition, herbivory, predation, dispersal)? What role do biodiversity components play in maintaining these processes and dynamics or supporting other biodiversity components (for instance, the role of vegetative cover in retarding surface water run-off, habitat in providing refuge for certain species)?
- Are there any threatened components present? What is their functional role? What are their requirements?
- What are the demographic processes determining the status of species populations?

Source: Adapted from Treweek et al. (2005)

International experiences of EIA and SEA in achieving biodiversity goals

EIA is practised in more than 100 countries worldwide (Donnelly et al., 1998). Huge differences in EIA systems are found to exist between and within countries both in the developed world and in the developing world. Within Africa, for example, the South African EIA system is found to have the sophisticated attributes of a developed-country EIA (Wood, 2002), while EIA is now becoming important in Ghana but is almost non-existent in Somalia (Wood, 2003). The variation in EIA in developing countries is attributed to the existing political and administrative systems, availability of resources, the social and cultural systems as well as the level and nature of economic development (George, 2000).

Despite large variations between individual countries, a general distinction can be drawn between the practice and performance of EIA in developed countries as opposed to developing countries (LDCs). EIA systems in LDCs are not well-embedded in the development process and usually lack the adequate institutional and legislative frameworks generally found in developed countries to ensure effective EIA. In these low- and middle-income countries, EIAs are generally carried out as a requirement by development assistance agencies on a project-by-project basis. The methodologies used tend to miss out cumulative impacts on the environment (Lohani et al., 1997), which are crucial in the case of biodiversity preservation. Political economy considerations, such as vested interests of powerful stakeholders and politicians having influence on the decision-making process, constitute additional limitations of the EIA process. These factors appear to play a big role in LDCs where there is no tradition of consultation and participation of all the stakeholders, big and small.

While the ineffectiveness of EIA in developing-country contexts is well-documented in the literature (Wood, 2002), there is an ongoing debate about the suitability of SEA in these countries. To date, undertaking SEAs has been largely confined to developed countries, more specifically Australia, Canada, the Netherlands, the USA and the UK (see example in Box 3.3). SEA in developing countries is gradually increasing and, like EIA, is mostly conducted as part of the lending requirements of international donor agencies such as the World Bank and, more recently, the Asian Development Bank (see Boxes 3.4 and 3.5).

Box 3.3. Strategic assessment of Australian fisheries plans

Issue: In order to ensure sustainable development of fisheries, the Australian Commonwealth has made it a requirement to conduct impact assessment of fisheries plans similar to SEAs required by the EU. The impact assessment should include identification and description of environmental characteristics that are likely to be affected by the fishery plan, such as protected areas, components of biodiversity, threatened and protected species, and coral reefs.

Outcome: Early identification of management regimes (mitigation measures) to ensure an ecologically sustainable development of fisheries, namely, licensing systems (to control access to fisheries) and imposing conditions upon operators.

Source: Based on Brown and Farmer (2007)

Box 3.4. Achieving positive revision to forest policies in Ghana

Issue: An examination of the Ghana Poverty Reduction Strategy (GPRS) identified potential conflicts between the forest policy (aimed at broadening the resource base of the wood industry) and environmental protection of river-system bank-side ecosystems. As a result, Ghana's forest policy was modified. In less than six months, the government had set up nurseries to raise bamboo and rattan plants to increase the supply of raw materials for the industry, thereby helping protect river banks from uncontrolled harvesting of wild bamboo and rattan.

Key benefits

- Reduce pressure on primary forests and fragile river ecosystems
- Creation of new timber resources
- Employment

Source: OECD (2006)

A rising number of developing countries are introducing legislation or regulations to undertake SEA – sometimes in EIA laws and sometimes in natural resource or sectors laws and regulations (OECD, 2006). In South Africa, for instance, some sectoral and planning regulations identify SEA as an approach for integrated environmental management. In the Dominican Republic, legislation refers to strategic environmental evaluation or SEA. Elsewhere, the existing EIA legislation requires an SEA-type approach to be applied either to plans (e.g. China), programmes (e.g. Belize) or both policies and programmes (e.g. Ethiopia). Nevertheless, the effectiveness of SEA is still under scrutiny.

Box 3.5. A strategic environmental assessment of Fiji's tourism development plan

Background and issue: Tourism is the fastest growing sector in Fiji, with potentially significant impacts on the natural and social environment. The World Wide Fund for Nature – South Pacific Programme (WWF-SPP) and the Asian Development Bank (ADB) formed a partnership to carry out an SEA of Fiji's tourism development plan (TDP), which aimed at large-scale growth of that industry. The SEA exercise was intended to inform the Ministry of Tourism and its partners about the environmental and social impacts of the TDP. This information would enable sustainable plans and policies to be adopted when the TDP is reviewed.

Method: The SEA was carried out by comparing baseline environmental, economic and social conditions with likely trends under the TDP to determine whether the TDP is sustainable. Moreover, a critical component of the SEA consisted of consultations with groups of people representing a whole range of stakeholder interests.

Major findings of the SEA report on environmental, economic and social impacts:

- Tourism development is causing severe environmental degradation. In fact, many environmental pressures, such as on coral reefs, are close to levels at which irreversible damage would occur.
- Growth in tourism under the TDP is highly demanding on the environment in terms of resource use and pollution generated.

- While the economic benefits of tourism are considerable, an estimated 60 per cent of the money coming in leaks out of the country.
- Rapid growth of tourism is likely to lead to mounting tensions between tourism developers, local communities and landowners.

Some conclusions and recommendations

- Implementation of institutional and regulatory frameworks for environmental assessment and management is a prerequisite for sustainable tourism.
- A fully effective system for enforcing the findings of the impact assessments must be in place.
- Universal standards for minimising environmental impacts should be set which all developers must comply.
- An Environmental Fund must be established from user fees collected from visitors.

Source: Levett and McNally (2003)

Many of the weaknesses pertaining to effective EIA also apply to SEA. The existing legal and institutional frameworks as well as availability of resources (financial and human) emerge as real constraints in many developing countries, in particular, where funds and necessary skills to conduct SEA might be lacking. Moreover, lobby groups including industrialists may try to block changes in the legal system which would enable effective implementation of SEA if they perceive that these rules would increase their private production costs, for instance, by enforcing compliance to mitigate. Despite the various problems relating to the use of SEA in LDCs, the potential advantages are also greater because of the quick pace of development in many areas. SEA could be employed to generate integrated and sustainable development plans and strategies. In this case, international donors and NGOs would act as important pressure groups favouring implementation of SEA in these developing countries.

Concluding remarks

Biodiversity goals should not be addressed in isolation and must be considered as an important component of a sustainable development strategy. SEA is found to have a considerable advantage over EIA in this respect by requiring identification of environmental impacts (including biodiversity) at an early stage of the proposed plan and its alternatives. Moreover, SEA allows for consideration of cumulative impacts on biodiversity when deciding to go ahead with a plan. The literature supports the use of EIA and SEA as complementary instruments to achieve sustainability. Despite its advantages, the practice of SEA is not widespread. Moreover, there is recognition that EIA needs to be strengthened at basic levels in many developing countries. Institutional pre-conditions in LDCs constitute an important hurdle to the introduction of SEA, which is still a relatively new assessment tool. However, lack of political will emerges as the main constraint to effective implementation of both EIA and SEA in developing countries. This would highlight the role of international donors and NGOs in helping these countries choose sustainable development paths, taking into account the environmental, economic and social goals.

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Chapter 4

Environmental policy instruments and governance

Introduction

The major justification for environmental regulation stems from the public interest theory where environmental policy aims at promoting societal welfare by addressing various sources of market failure. For example, regulatory measures can be used to curb negative externalities like pollution or to control overuse of environmental resources having public goods or open access characteristics (see Chapter 1 for an excellent discussion of these issues). We begin with an overview of the various classes of environmental policy instruments. Next, criteria for choice between these instruments are discussed. The fourth section reviews practical considerations for effective implementation of environmental policies. More specifically, we seek to probe into causes of policy failure which is characteristic of developing countries and therefore a cause of concern for their sustainable development. This part of the discussion takes us to another strand of the economic literature which emanates from the 'public choice' school of thought. In essence, the conflicting interests and rent-seeking behaviour of agents emerge as important constraints of environmental policy-making and implementation. The final section summarises the main issues.

Taxonomy of environmental policy instruments

The existing literature distinguishes between three main classes of regulatory instruments, namely market instruments, 'command and control' and economic instruments (see Box 4.1). In the case of externalities, market instruments can be used where the polluter has a legal right to pollute or, alternatively, the affected parties have a right to no pollution. Let us consider the first instance. If a polluter can legally pollute, then the victims would like to 'compensate' the polluter in order to reduce pollution levels. Negotiations between the two parties would take place to determine the amount of compensation to be paid subject to some 'optimum desired level of pollution' acceptable to both the parties. Coase (1960) predicts that this kind of bargaining process will result in welfare maximising the level of pollution where the marginal benefits to the polluter just equals the marginal cost of the victims. Similarly, if the affected party has a right to no pollution, then firms (or polluters) may like to bribe or compensate the affected party so they can go ahead with production along with associated levels of pollution. Here again, an equilibrium will be achieved where incremental benefits to the polluters just equals marginal cost to the victims. Thus, irrespective of who has the rights, markets will work so as to achieve a socially optimal outcome.

Coase's theorem, however, rests upon a number of restrictive assumptions, such as the small size of groups and near-zero transaction costs. In practice, however, transaction costs are often prohibitive and government has to intervene. Two major approaches to environmental regulation are the use of command and control (CAC) instruments and economic instruments (EI). Command and control methods such as pollution standards and targets are most commonly found in developed countries as well as developing countries (LDCs). Actors who fail to meet the levels specified by the standard are liable to sanctions. This is in contrast to economic instruments which work by modifying markets and the incentives of agents in order to achieve socially desirable levels of pollution.

Box 4.1. Environmental policy tools

Market instruments – By establishing property rights, these instruments enable the use of the legal system.

Economic instruments – Also known as incentive mechanisms. Examples include taxes, subsidies on abatement technologies, pollution permit trading systems and transferable quotas, deposit-refund systems e.g. on bottles and packaging, performance bonds such as afforestation bonds. Examples of environmental taxes, also known as green taxes, include petroleum taxes, selective production and input taxes, tax on international travel based on carbon footprints, and so on.

Command and control – Standards and quotas; prohibition of inputs, processes or products.

Liability rules – Precedents from previous cases create expectations about penalties for future transgressors.

Education, information and communication – Information to polluters, investors and consumers.

Support for R&D to promote cost cutting, environmentally friendly technologies.

Generators of **renewable energy** (wind, solar, etc.) receive a Renewable Energy Credit for each megawatt of electricity generated from renewable energy sources.

Encouragement of voluntary participation or co-operation – at the local, state or global level depending upon the dimension of the environmental or natural resource issue.

Table 4.1 provides a taxonomy of regulatory instruments in terms of specification of goals and methods of implementation. The strictest type of command and control instruments are located in the space where levels of pollution are specified as well as methods on how to achieve these pollution targets. In the USA, for instance, auto-pollution regulation specifies tailpipe emission standards of pollutants like carbon monoxide and nitrogen oxide (the 'what'). Additionally, cars must have catalytic conversion exhaust systems (the 'how'). Other forms of CAC tools may indicate the method only without mention of the target pollution level, for example technology standards. Alternatively, the target level of environmental damage can be specified while leaving the regulated party free to choose the method of pollution control. In contrast to CAC, pure economic instruments neither specify the level of pollution to be achieved nor the means of controlling pollution. These

act upon the incentives of agents to find an optimal and cost-effective means of polluting given their preferences.

Table 4.1. Taxonomy of regulatory policy instruments

Specification of goal or objectives		
Specification of implementation	Specifying **what** is to be achieved by the regulated party	**Not** specifying what level is to be achieved by the regulated party
METHOD		
Specifying how to control pollution	Input, product or practice ban E.g. US auto-pollution control with equipment requirements and discharge standards	**Technology standards** pollution control equipment fishing gear BMP for agriculture landfill construction rules Liability rules **with** minimum standards of care
NOT specifying how to control pollution	Discharge standard based on • technology • AEQ per cent reduction Limit on fish/game take per fishermen/hunter Limit on logs taken per forest	**Charge per unit of environmental damage** • discharge • fish taken **Provision of information** • to public • to polluters or farmers, technology transfer **Overall limit on damage** • AEQ standard without implementation of effort • Overall fishery limit Liability rules **without** minimum standards of care Product taxes or input taxes

Source: Russell and Powell (1999) BMP: Best management practices, AEQ: Ambient environmental quality, TRI: Toxic Release Inventory

The regulation of incentive is concerned with the design of regulatory schemes that use economic instruments such as prices, taxes, subsidies, bonds, liability, or markets to align individual incentives in favour of environmental quality. There have been several policy experiments with marketable quotas or allowances, including individual transferable quotas (ITQs) used in fisheries management, marketable development rights, and marketable pollution allowances. Tradeable pollution credits are created when an individual pollution source reduces its emissions below some individual source-specific target. A cap-and-trade system sets an **aggregate** rather than an individual cap on emissions, and tradeable allowances take the form of **individual quota shares** to the aggregate emissions cap.

As regards global environmental problems, such as ozone depletion, global warming and the depletion of marine fish stocks, international co-operation is mandatory. Carbon trading is a good example (Box 4.2). The Aral Sea post-decline environmental management, discussed in Chapter 12, is another illustrative case study.

Box 4.2. Greenhouse Gas Emissions Trading

Countries that ratified the Framework Convention on Climate Change established a joint implementation programme in the 1995 Berlin Conference of the Parties. The 1997 Kyoto Protocol allows Annex B countries (countries that have an agreed ceiling on emissions) to meet their ceiling by way of emissions trading with other Annex B countries, and through joint implementation programmes (which may occur in developing countries). In the pilot joint implementation programme, Annex B countries finance projects in other countries that reduce emissions of greenhouse gases, and these emissions reductions are then credited toward meeting the Annex B country's ceiling.

The **Clean Development Mechanism (CDM)** is an arrangement under the Kyoto Protocol that allows industrialised countries with a greenhouse gas reduction commitment (called Annex B countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emissions reductions in their own countries.

Other ways of controlling environmental damage are education and the use of different methods of communication. These may prove to be effective where environmentally unfriendly behaviour results from a lack of information about the consequences of agents' actions. Moreover, government policy to support R&D would help to promote cost-cutting, environmentally friendly technologies. Voluntary compliance and community involvement are also increasingly advocated at the local level in regulating the use of natural resources in LDCs where poor governance structures have witnessed failure of traditional policy instruments, i.e. EI and CAC (see page 63).

Choosing between regulatory instruments

Policy-makers have an array of tools at their disposal to address various kinds of environmental problems. Environmental policy objectives or goals can be broadly categorised as: efficiency, cost-effectiveness, distributional equity, variability reduction and the achievement of certain health parameters (Zilberman, 2005; Goulder and Parry, 2008). Criteria for choice between tools would be guided by the achievement of policy outcomes subject to informational constraints, resource availability (both human and financial) as well as institutional constraints. As regards efficiency, policy outcomes are mainly derived from the impact of environmental instruments on an agent's behaviour. We can distinguish between short-run impacts on existing consumption and production patterns and long-run impacts on the adoption of new 'clean' practices and 'green' technology. Strict regulation on pesticide regulation, for example, may reduce the use of pesticides in the short run and lead firms to invest in alternative methods of pest control, which are less damaging to the environment, or to the development of pest-resistant species.

Policy outcomes that have attracted less attention in the economic literature include

effects on income distribution and any resulting change in resource allocation. For instance, certain policies may transfer benefits to lower income groups. Moreover, a tax on an environmentally intensive activity like agriculture may reduce the land allocated to that activity, which may then be used to provide environmental services. This is an example of natural capital augmentation. Government policies may also result in changes in physical and human capital. Physical capital is essentially the infrastructure while human capital refers to transfer of knowledge or skills. Building dams to reduce variations in water availability is an example of physical capital expansion. An educational effort to improve water use efficiency, on the other hand, is an improvement in human capital.

Table 4.2 considers criteria for choosing between the two most widely used instruments, namely EI and CAC. Overall, EI is found to be superior to CAC. EI gives the 'double dividend' effect of generating government revenue (which may be used to attenuate tax distortionary effects) and inducing, in the long run, cost savings from more efficient production and abatement technologies. This is contrary to CAC where the ratchet effect may prevail. In other words, the fear of more stringent environmental regulations from innovation may discourage research in new ways of abatement. CAC may be preferred for perceived administrative ease in terms of achieving fast results and having less demanding monitoring requirements. These perceptions are, however, not clearly supported by evidence (see Table 4.2). Moreover, information intensity is found to be equally important for EI and CAC in practice. The major constraint behind the implementation of EI versus CAC would appear to be the regulatee burden, that is, opposition by firms due to higher perceived costs. It is important to note that evidence appears to support this view (Keohane et al., 1998; Russell and Vaughan, 2003; Harrington, Morgenstern and Sterner, 2004). Furthermore, CAC has shown flexibility by integrating with economic instruments, such as systems of tradeable permits and quotas. These mixed instruments, which may be classified as impure economic instruments, are increasingly supported by the literature as clubbing together the advantages of EI and CAC.

Environmental policy in practice: Governance and political economy issues

Efficiency-enhancing environmental regulations would appear to have little importance in practice. As observed earlier, CAC instruments are most popular in both developed economies and their less developed counterparts. This may be indicative of a higher perceived administrative ease of CAC and/or the power of polluting firms which work to oppose the implementation of EI. Even mixed instruments, such as transferable quotas or pollution permits, are found to have limited implementation in developed countries and are almost non-existent in LDCs.

Where environmental regulation exists, the success of policies across the world and, in particular, LDCs is questionable. In Mexico, for instance, where there are stringent environmental laws, we also find severe air pollution in the capital city and over-exploitation of forest resources. One possible explanation as noted in Chapter 1 would stem from the public goods nature of various environmental problems and the difficulty in monitoring access to natural resources. For example, bans on over-exploitation of marine fish stocks

Table 4.2. Criteria for choice: EI v. CAC

Criteria for choice	Superiority of EI v. CAC (Theory)	Remarks/Evidence
Static efficiency	EI preferred to CAC.	EI instruments more cost effective than CAC in achieving a given level of emission reduction.
Information requirement	EI requires less information to achieve reductions in emissions in a cost-effective manner.	EI needs aggregate information on marginal damage and marginal abatement costs. CAC needs information required by EI plus individual sources' marginal abatement cost. Evidence, however, shows that all policies turn out to be information intensive.
Dynamic efficiency	EI better than CAC (especially in the long run).	EI provide continuous incentives to reduce emissions permitting flexibility in methods. Thus, EI encourage more efficient production and abatement technology. Direct regulation on technology may discourage research in new abatement methods. Moreover, the ratchet effect may result as new ways of abatement provoke more stringent standards.
Effectiveness	CAC is likely to achieve results faster and with greater certainty then EI.	Evidence supports the contrary, i.e., EI are generally more effective than CAC.
Regulatee burden	Regulated firms are more likely to oppose EI than CAC due to higher perceived costs.	Evidence supports this view.
Administrative burden	Costs under direct regulation probably exceed costs under an emissions fee.	Evidence on this is mixed. There are examples where costs of EI have been found to be higher.
Monitoring requirements	More demanding for EI than for CAC.	EI require credible and quantitative emission estimates. Evidence: Requirements for both EI and CAC are found to be exacting.

Tax interaction effects	Adverse effects for both; but larger for EI as compared to CAC for same level of emission reduction.	In general, EI aggravate distortionary effects of existing taxes. However, revenue from EI may be used to partly offset the distortionary price impacts of the regulation.
Altruism	Not clear.	Context CAC: pollute less than what regulation allows. With EI: marginal abatement cost is higher than the emissions fee or permit price.
Adaptability	EI can be changed more readily in response to changing economic conditions than CAC.	CAC policies primarily show adaptability by adopting economic instruments e.g. systems of tradeable permits and quotas.
Cost revelation	Easier with EI v. CAC.	According to theory, a firm's marginal cost is equal to the rate of an emissions fee, or to the permit price under a tradeable permits system. Under CAC system, marginal cost is not directly observable. Firm has to reduce emissions by a prescribed quantity.

Source: Based on Harrington, Morgenstern and Sterner (2004) and Russell and Vaughan (2003)

are generally not effective due to high (if not prohibitive) costs of exclusion. FAO's concern over declining world fishery stocks is justified since illegal fishing activities can thrive. Moreover, even if international treaties for the protection of the environment exist, countries may not want to adhere to those agreements if costs of regulation would hamper their economic growth.

Even where exclusion is possible, regulatory policies are rarely effective. Bad governance is often found to be at the root of these policy failures. Politicians may not work to promote welfare; they pursue their own self-interests. It is evident that big industrialists are promoted who are also polluting firms. Corruption, poor design and implementation of environmental laws, as well as ineffective enforcement due to lack of adequate funds or lack of will of the policy-makers, contribute to the problem. Misspecification of the appropriate level of management may also compound the problem. For instance, certain problems of a more

widespread nature may require centralised control while other problems such as water pollution may be better addressed at the local or state level.

Table 4.3 illustrates the relationship between institutional quality and effectiveness of environmental regulation and management. Measures of the effectiveness of environmental governance include stringency of regulations and perceived degree of enforcement of regulations. Indicators of institutional quality are government effectiveness and transparency.

Table 4.3. Standardised average scores on institutional quality and environmental regulation

Group of countries	Government effectiveness (2007)	Transparency (2006)	Stringency of environmental regulation (2007)	Enforcement of environmental regulation (2007)
High income OECD (23)	1.35	1.40	1.45	1.35
High income non-OECD (16)	0.70	0.70	0.31	0.43
Upper middle-income (26)	–0.05	–0.23	–0.19	–0.26
Lower middle-income (35)	–0.63	–0.61	–0.61	–0.62
Low income (25)	+0.98	–0.85	–0.72	–0.60

Source: Author's computation from data compiled by Kaufmann et al. (2008) for Government Effectiveness scores; Transparency International (2006) for Transparency index; and from World Economic Forum (2008) for data on environmental stringency and enforcement.
Figures in ( ) parentheses show the number of countries in each group.

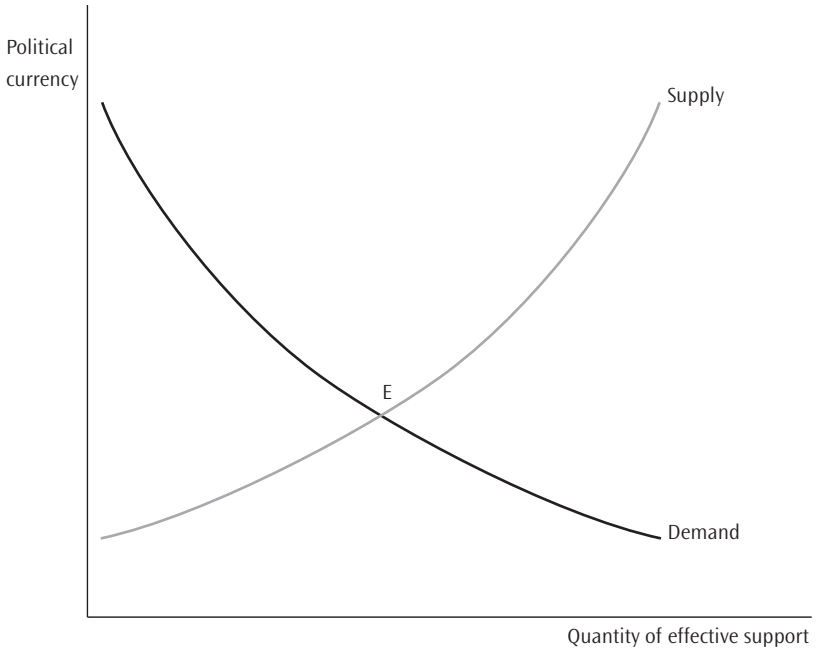
Government effectiveness captures the efficiency and impartiality of the civil service, the quality of public infrastructure and the bureaucratic framework. The index increases with higher levels of good governance. An increase in the transparency indicator, on the other hand, indicates decreasing levels of corruption. The scores have been standardised to reduce deviations and for ease of comparison. Findings from the table tend to support the hypothesis that good governance and effective environmental management go hand in hand. More specifically, we observe that higher income countries with better quality institutions are characterised by more stringent environmental regulations and are also able to successfully enforce these regulations. Environmental problems would appear to be significantly more acute in lower middle-income and low-income countries. These countries also have very poor governance structures and high levels of corruption (well above the mean for the whole sample). It may be conjectured that government failure due to low institutional quality and political will would give rise to more regulation. Moreover, in all likelihood, the legislative supply of regulation will be guided by self-interest and partisan motives.

Political economy of environmental policy

The political economy school justifies regulatory policy as an outcome of the political process reflecting various economic forces at play. The political economy of regulation

takes two major views. One explains the existing level of regulatory control using a market framework of demand and supply for regulation (Stigler, 1971; Keohane et al., 1998). Demand for any regulatory measure derives from various interest groups served by the regulation such as firms, consumer groups and environmentalists. Firms may organise themselves as trade groups and lobby for regulations which reduce their production costs, provide subsidies, constrain substitutes or erect barriers to entry. Environmentalist groups would demand regulations that protect or restore the environment, while consumers may organise themselves as groups to obtain quality assurance or reductions in process. The supply of regulations is provided by politicians who may be motivated by the opportunity cost of effort to shepherd the legislation, psychological costs and the probability of re-election. In Figure 4.1, political currency represents political gains (revenues, rents, votes, etc.). As the quantity of political gains increases, supply of regulation increases. On the other hand, decline in political currency will increase the demand for regulation. The equilibrium E corresponds to the observed level of regulation, which is the outcome of bargaining forces between the various agents.

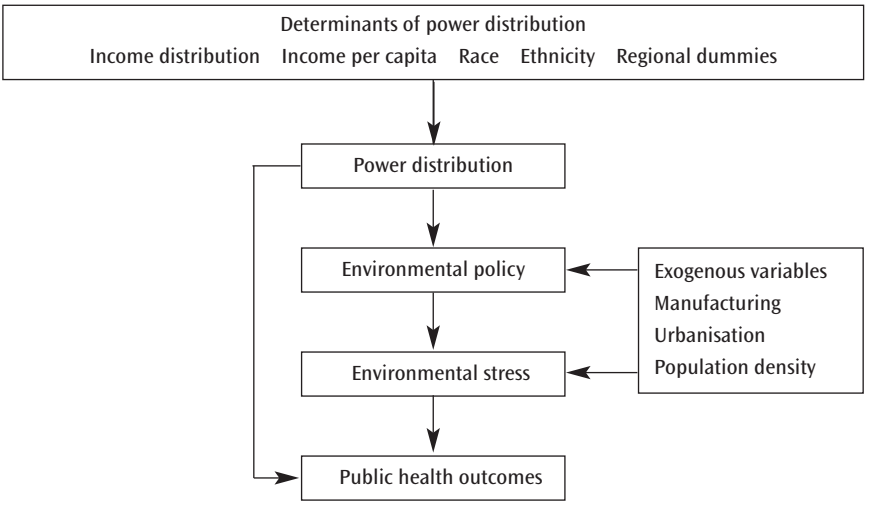
Figure 4.1. The political market for regulation



The capture theory – a formalisation within this framework – shows the power of an interest group to influence policies as rising with the amount of resources available to that group and inversely related to the size of group (Stigler, 1971; Peltzman, 1976; Becker, 1983). This is because small groups are better organised and can reach agreements faster than larger groups. In the above framework, firms have typically more resources than consumer groups and environmental NGOs. Further, the size of trade groups is likely to be small compared to that of consumers. Thus, the above model predicts the prevalence of producer protection over consumer interests. The limited success of environmentalists can also be explained within this framework.

Boyce et al. (2002) develop a model to explore the political economy dimensions of environmental policy in various states in the USA (see Figure 4.2). They construct a measure of power distribution using four variables: voter participation, tax fairness, Medicaid accessibility and educational participation. Voter participation and Medicaid accessibility are assumed to reflect the influence of power distribution on the revenue and expenditure sides of state fiscal policies, respectively. Power inequality would be higher where (i) voters/consumer groups are heterogeneous and conflict-prone due to high income inequality and (ii) levels of education attainment are low. Their findings show that environmental policies tend to be weaker where there is more power inequality. Weak policies in turn lead to higher environmental stress. Moreover, power inequality and environmental stress are shown to have adverse impacts on public health.

Figure 4.2. Power – environment – health model



Source: Adapted from Boyce et al. (2002)

The second view in the political economy literature emanates from the public choice school, which is concerned with collective decision-making in a democratic system of self governance (see Hackett, 2006, for an interesting discussion). This strand of the literature develops the link between voting rule systems (institutional attributes) and the characteristics of user groups to predict whether policies will be incentive compatible or whether they will generate conflicts and thereby fail. This approach has been used together with insights from game theoretic literature to study the conditions for the effective local or community management of natural resources by voluntary organisations. Box 4.3 summarises the major factors affecting local organisations.

The degree of co-operation within the community would be influenced positively by:

- Small size and homogeneity of a group
- High degree of communication between players
- Long time horizon – which may facilitate detection of defaulters
- High degree of trust and mutual expectations

- Willingness to try co-operation
- Catalysts to start co-operation
- Stability of group – which allows continuous interacting over a long time horizon
- Non-anonymous relationship between members
- Social norms of fairness

Box 4.3. Physical and technical characteristics of the resource

Degree of excludability of the resource; Degree of rivalry; Size of the resource system; Availability of substitutes; Technology (for harvest or exclusion)

Characteristics of user groups

Users' demand for, or dependence on, the resource; Number of users; Size of group; Degree of homogeneity of group; Proximity to other users; Culture; Openness and stability of the community

Institutional arrangements

- Operational rules – member access rules, appropriation rules, monitoring mechanisms, penalty rules, conflict resolution mechanisms
- Collective choice rules (the decision-making process) – guidelines for formulating, changing and enforcing operational rules
- Governance structure
- External arrangements – Includes any public regulation of relevance, e.g., property rights, delegation of management at the local level, economic conditions; legal and political environment

Source: Adapted from Rasmussen and Meinzen-Dick (1995)

Given the 'right' environment, self-governed organisations can minimise free-riding behaviour and provide effective solutions for natural resource management. However, the above conditions are rarely met and there is an important role for policy initiatives at the government level and at the international level to facilitate the operation of these local organisations.

Concluding remarks

Command and control and economic instruments are the most widely used environmental policy instruments. Theory indicates the superiority of EI – which are incentive-based instruments – over CAC in terms of efficiency and achieving the 'double dividend' effect. The latter refers to immediate benefits conferred in terms of revenue generation to the government plus the added advantage of cost reduction in the long term due to incentives for firms to embark on R&D in an attempt to reduce environmental damage. Despite its superiority, EI is less popular than CAC in both developed countries and LDCs. One explanation may be due to the higher monitoring burden of EI as opposed to CAC. Equally, if not more important, is the influence that firms have on policy-makers in the choice of instruments. Firms would tend to oppose EI in favour of CAC due to higher perceived costs. They can form groups and mobilise resources in order to influence politicians to

favour their interests. From political economy models, we find that the efficacy of company pressure groups stems from their small size. Evidence further demonstrates that firms may have more leverage on the success of environmental policies where the quality of governance is low and corruption is high. This is more significant in lower income countries. Moreover, political economy models also demonstrate that higher income inequality and lower educational levels may give more leverage to politicians to support firms' interests.

Environmental stress would result from weakly implemented policies. We would conjecture that economic development of the low-income countries is environmentally intensive and environment may be more of an input in the production process. The design of appropriate environmental policy instruments is absolutely essential for these countries. The importance of involving community and voluntary participation in environmental management is highlighted. NGOs would have a big role in bringing groups together and government policies would act as important support mechanisms. International cooperation in tackling global environmental stress has been emphasised in recent years because developed countries are found to be contributing proportionately much more to atmospheric degradation. This alternative method of controlling environmental and natural resource damage, namely community and voluntary participation and cooperation, is increasingly supported by the literature, in the light of the poor performance of traditional methods of regulation and the way incentives have gained more significance in both local and global contexts.

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Don Fullerton and Robert Stavins

Chapter 5

How economists see the environment[1]

On a topic such as the environment, communication among those from different disciplines in the natural and social sciences is both important and difficult. Economists themselves may have contributed to some misunderstandings about how they think about the environment, perhaps through enthusiasm for market solutions, perhaps by neglecting to make explicit all the necessary qualifications, and perhaps simply by the use of jargon.

There are several prevalent myths about how economists think about the environment. By examining them here, we hope to explain how economists really do think about the natural environment.

Myth of the universal market

The first myth is that economists believe that the market solves all problems. The 'first theorem of welfare economics', as taught to generations of economics students, is that private markets are perfectly efficient on their own, with no interference from government, provided certain conditions are met.

This theorem, easily proved, is exceptionally powerful, because it means that no one needs to tell producers of goods and services what to sell to which consumers. Instead, self-interested producers and consumers meet in the market-place, engage in trade, and thereby achieve the greatest good for the greatest number, as if 'guided by an invisible hand'[2]. This maximum general welfare is what economists mean by the 'efficiency' of competitive markets. Economists in business schools are particularly fond of identifying markets where the necessary conditions are met, such as the stock market, where many buyers and sellers operate with good information and low transaction costs to trade well-defined commodities with enforced rights of ownership.

Other economists, especially those in public policy schools, have a different approach to this theorem. By clarifying the conditions under which markets are efficient, the theorem also identifies the conditions under which they are not. Private markets are perfectly efficient only if there are no public goods, no externalities, no monopoly buyers or sellers, no increasing returns to scale, no information problems, no transaction costs, no taxes, no common property and no other 'distortions' between the costs paid by buyers and the benefits received by sellers. Those conditions are obviously very restrictive, and they are usually not all satisfied simultaneously in the real world.

When a market thus fails, this same theorem offers guidance. For any particular market, it asks whether the number of sellers is sufficiently small to warrant antitrust action, whether the returns to scale are great enough to justify tolerating a single producer in a regulated market, or whether the benefits from the good are public in a way that might justify outright government provision of it. A public good, like the light from a lighthouse, benefits additional users at no cost to society.

Environmental economists are interested in pollution and other externalities, where some consequences of producing or consuming a good or service are external to the market (not considered by producers or consumers). With a negative externality, such as environmental pollution, the total social cost of production may exceed the value to consumers. If the market is left to itself, too many pollution-generating products are made.

Similarly, natural-resource economists are interested in common property, or open-access resources, where anyone can extract or harvest the resource freely and no one recognises the full cost of using the resource. Extractors consider only their own direct and immediate costs, not the costs to others of increased scarcity ('user cost' or 'scarcity rent'). The result is that the resource is depleted too quickly.

So, the market by itself demonstrably does not solve all problems. Indeed, in the environmental domain, perfectly functioning markets are the exception rather than the rule. Governments can try to correct these market failures, for example by restricting pollutant emissions or limiting access to open-access resources, which can improve welfare and lead to greater efficiency.

Myth of market solutions

A second common myth is that economists always recommend a market solution to a market problem. Economists tend to search for instruments of public policy that can fix one market essentially by introducing another, allowing each to operate efficiently on its own. If pollution imposes large external costs, for example, the government can establish a market for rights to emit a limited amount of that pollutant. Such a market for tradeable emission permits will work if there are many buyers and sellers, all are well informed, and the other conditions of the 'first theorem' are met. In this case, the government's role is to enforce the rights and responsibilities of permit ownership, so that each unit of emissions is matched by the ownership of one emission permit. Then the market for the output will also work, as the producer has to pay a price for each permit that reflects the social cost of the associated pollution. Equivalently, producers can be required to pay a tax on their emissions that reflects the external social cost. Either way, the result in theory will be the efficient amount of pollution abatement, undertaken at minimum aggregate abatement cost.

This tradeable-permit approach has much to recommend it, and can be just the right solution in some cases, but it is still a 'market'. Therefore the outcome will be efficient only if certain conditions are met. But these conditions are not always met[3]. Could the sale of permits be monopolised by a small number of buyers or sellers? Do problems arise from inadequate information or significant transaction costs? Will the government find it too costly to measure emissions? If the answer to any such question is yes, the permit market

may work less than optimally. The environmental goal may still be met, but at more than minimum cost.

As an example, to reduce acid rain in the United States, amendments to the Clean Air Act of 1990 require electricity generators to hold a permit for each tonne of SO_2 they emit. A robust market for the permits has emerged, in which well-defined prices are broadly known to many potential buyers and sellers. Through continuous emissions monitoring, the government can track SO_2 emissions from each plant. Equally important, penalties are significantly greater than incremental abatement costs and hence are sufficient to ensure compliance. Overall, this market works; acid rain deposition is being reduced by 50 per cent in a cost-effective manner.

A permit market achieves this efficiency through trades because any company that has high abatement costs can buy permits from another that has low costs, so reducing the total cost of abating pollution. These trades also switch the source of the pollution from one company to another, which is unimportant when any emissions equally affect the whole trading area. This 'perfect mixing' assumption is certainly valid for global problems such as greenhouse gases or the effect of chlorofluorocarbons on the stratospheric ozone layer. It may also work reasonably well for a regional problem such as acid rain, because acid deposition in downwind states of New England is about equally affected by SO_2 emissions that were traded among upwind sources in Ohio, Indiana or Illinois. But it does not work perfectly, as acid rain in New England may increase if a plant there sells permits to a plant in the mid-west.

At the other extreme, many environmental problems might not be addressed appropriately by tradeable-permit systems or other market-based policy instruments[4]. One example is a hazardous air pollutant such as benzene that does not mix in the airshed and so can cause localized 'hotspots'. Because a company can buy permits and increase local emissions, permit trading does not ensure that each location will meet a specific standard. Moreover, the damages caused by local concentrations may increase nonlinearly. If so, then even a permit system that reduces total emissions might allow trades that move those emissions to a high-impact location and thus increase total damages.

The bottom line is that no specific policy instrument, or even set of policy instruments, is a panacea. Market instruments do not always provide the best solutions, and sometimes not even satisfactory solutions.

Myth of market prices

The next myth is that, when non-market solutions are considered, economists still use only market prices to evaluate them. No matter what policy instrument is chosen, the environmental goal of that policy must be identified. For example, should vehicle emissions be reduced by 10, 20 or 50 per cent? Economists frequently try to identify the most efficient degree of control that provides the greatest net benefit. This means, of course, that both benefits and costs need to be evaluated. True enough, economists typically favour using market prices, whenever possible, to carry out such evaluations, because

these prices reveal how members of society actually value the scarce amenities and resources under consideration.

Economists are wary of asking people how much they value something, as respondents may not provide honest assessments of their own valuations. Instead, actions may reveal their preferences, as when individuals pay more for a house in a neighbourhood with cleaner air, all else being equal[5].

This is not to suggest that economists are concerned only with the financial value of things. Far from it. The financial flows that make up the gross national product represent only a fraction of all economic flows. The scope of economics encompasses the allocation and use of all scarce resources. For example, the economic value of the human-health damages of environmental pollution is greater than the sum of health-care costs and lost wages (or lost productivity), as it includes what lawyers would call 'pain and suffering'. Economists might use a market price indirectly to measure revealed rather than stated preferences, but the goal is to measure the total value of the loss that individuals incur.

To take another example, the economic value of part of the Amazon rainforest is not limited to its financial value as a repository of future pharmaceutical products or as a location for ecotourism. That 'use' value may only be a small part of the properly defined economic valuation. For decades, economists have recognised the importance of 'non-use' value of environmental amenities such as wilderness areas or endangered species. The public nature of these goods make it particularly difficult to quantify these values empirically, as we cannot use market prices! The important fact is that benefit–cost analysis of environmental policies, virtually by definition, cannot rely exclusively on market prices[6].

Economists insist on trying to convert all these disparate values into monetary terms because a common unit of measure is needed to be able to add them up. How else can we combine the benefits of ten extra miles of visibility plus some amount of reduced morbidity, and then compare these total benefits with the total cost of installing scrubbers to clean stack gases at coal-fired power plants? Money, after all, is simply a medium of exchange, a convenient way to add together or compare disparate goods and services.

Myth of efficiency

The last myth we address here is that these economic analyses are concerned only with efficiency rather than distribution. Many economists do give more attention to measures of aggregate social welfare than to measures of the distribution of the benefits and costs of policies among members of society. The reason is that an improvement in economic efficiency can be determined by a simple and unambiguous criterion – an increase in total net benefits. What constitutes an improvement in distributional equity, on the other hand, is inevitably the subject of considerable dispute. Nevertheless, many economists do analyse distributional issues thoroughly. The more difficult problem, not yet solved in a satisfactory manner, is how to combine efficiency and distributional issues in a unified analysis.

Available data often permit reliable estimates of the impacts of environmental policies on

important subgroups of the population[7]. On the other hand, environmental regulations are neither effective nor efficient tools for achieving redistributional goals. The best economic analyses recognise the contributions and limitations of efficiency and distributional measures.

Where does this leave us?

To summarise, economists do not necessarily believe that the market solves all problems. Indeed, many economists, ourselves included, make a living out of analysing market failures such as environmental pollution in which laissez-faire policy leads not to social efficiency, but to inefficiency. When economists identify market problems, their tendency is first to consider the feasibility of market solutions because of their potential cost-effectiveness, but market-based approaches to environmental protection are no panacea. When market or non-market solutions to environmental problems are being assessed, economists do not limit their analysis to financial considerations but use money as a unit of measurement in the absence of a more convenient unit. And although the efficiency criterion is by definition aggregate in nature, economic analysis can reveal much about the distribution of the benefits and costs of environmental policy.

Having identified and sought to dispel four prevalent myths about how economists think about the natural environment, we acknowledge that our profession bears some responsibility for the existence of such misunderstandings. Like their colleagues in other social and natural sciences, academic economists focus their greatest energies on communicating to their peers within their own discipline. Greater effort can certainly be made to improve communication across disciplinary boundaries.

Notes

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Paul R Portney

Chapter 6

The obligations of a policy economist[1,2]

It is impossible for me to begin this short talk with anything other than a heartfelt thank-you to the members of this association for making me the recipient of this year's Award for Outstanding Public Service Through Economics. I'm not the kind of person who gets awards and, as with many of the honours given to government figures in Washington, DC, from which I hail, it's undeserved! You should note, however, that I came to Halifax yesterday afternoon to be sure I was here to receive the award today, so I hope you know how pleased and honoured I am to be here.

My interest in economics dates back to the summer of 1953, an easy date to remember, this year, because it was exactly three cycles ago of the 17-year cicada infestation we have been enduring in my part of the world. After the cicadas had almost all died, I collected hundreds of them in a large glass jar and went door-to-door in my neighbourhood in Park Forest, Illinois, trying to sell them. My mother, who had never gone to college, much less taken an economics course, took me aside after a day on which I'd come home disconsolate, having sold not a single cicada carcass. She said, 'Paul, if anyone is silly enough to want dead cicadas, there are millions of them lying around. They're not going to fetch a very good price, and you might want to consider something different to earn money for your baseball cards'. Thus was the iron law of supply and demand first driven home to me!

My interest in putting economics to the service of public policy came much later in life, and it is attributable to two things. The first is the well-known economic doctrine of comparative advantage: while I was a perfectly competent researcher, I never felt I was as good a theoretician or applied econometrician as my wonderfully bright colleagues at Resources for the Future (RFF). I was *relatively* better, though, at thinking about how the tools and techniques they were developing could be used to improve the country's policy 'toolkit', and interested as well in how this could be explained to non-economists in such a way as to whet their appetite for what I considered to be more enlightened public policy. A second impetus to policy involvement, of course, was the advantage of working six blocks from the White House and three short miles from both the Capitol and the Environmental Protection Agency (EPA). Believe me when I say that I have seen far too many examples of misguided policy in my nearly 33 years in Washington not to want to at least try to improve things a little.

I have chosen as the subject of this short talk today, 'The obligations of a policy economist'. It is my hope to exhort rather than to preach, and I'll be pleased if my remarks give

you pause to think about the way you lead your professional life, even if they do not spur you to make any changes.

The first obligation I want to identify is straightforward enough: be very clear about what economics can and cannot tell us, and clear as well about the premises upon which it is based. For example, I occasionally hear economists talk as if – or even say directly that – a benefit-cost analysis is a sufficient basis for making an environmental policy decision. In my view, and I hope in the view of all of you here, this is poppycock. To be sure, a good benefit-cost analysis can be and, I would argue, should be a part of the information base upon which any important environmental or natural resource decision is made. But anyone who believes that allocative efficiency is or even ought to be the only basis for policy-making will find little support from most good economists. Naturally, we might all prefer a world in which pure distributional politics plays a smaller role in environmental and natural resource policy than it does today. But it's hard to deny the importance of taking into account the identity of those who win and those who lose from even an efficient policy change.

Other considerations matter, as well. For instance, society would no doubt always prohibit the selling of one's vote, even if a benefit-cost analysis suggested there were enough eager buyers and sellers that such a measure might pass the test. Finally, laws are sometimes written in such a way as to preclude the consideration of costs in environmental standard-setting, as is the case under Section 109 of the Clean Air Act in the United States. In these cases, not only is benefit-cost analysis an insufficient basis for decision-making, it would be illegal to use it even as one input in that process.

We also have an obligation to be open and honest about the assumptions on which such tools as benefit-cost analysis are based. For instance, we economists generally accept without much thought that the social value of a proposed policy change at any one time is the sum of the values attached to that change by the individuals who comprise the society. But this means, of course, that in a society of philistines in which no individual cares a whit about the Grand Canyon, there is no value to preserving it in the face of a proposal to convert it to a parking lot for Las Vegas. Non-economists find this notion quite troubling, and we need to acknowledge and confront this. Similarly, the benefit from protecting a super-rich rock star from an air pollution-related health risk will, technically speaking, be greater than that of protecting a poor day-labourer because willingness to pay is contingent upon one's income. If I'm not the only one here uncomfortable with that notion, I'll be quite surprised. Policy economists often gloss over the value-laden assumptions upon which applied welfare analysis is based, even when we shouldn't.

A second obligation of policy economists is to fully portray both the pros and the cons (the benefits and costs, that is) of the policy options under consideration. This is easy to do if one is undertaking an analysis on one's own, as in an academic paper. In such cases as these, there is no reason to give short shrift to one or another policy consequence. Indeed, we often undertake studies like this to answer for ourselves the question, 'Hmmm, I wonder if this is a good idea or not'.

More often than not, though, one undertakes economic analysis for a client or sponsor. This might be a government agency, a philanthropic foundation, a corporation, or perhaps a pub-

lic-interest advocacy organisation. In these cases, our client has a 'horse in the race', to use an old expression, and is probably hoping our analysis will come out in a particular way. It's the job of the policy economist to speak truth to power, as the late Aaron Wildavsky put it, and make clear not just the beneficial effects of the favoured policy option, but also its costs.

This has become particularly important in what I'll call the 'win-win era', a time in which favoured policy options are generally described as benefiting everyone – rich and poor, black and white, tall and short, etc. But I've never seen a win-win policy in which at least someone doesn't lose his shirt. To be sure, sometimes the losers are not particularly sympathetic parties. Doing away with agricultural subsidies is often described as being a win-win policy – good, that is, for both the environment and for those farmers in underdeveloped countries who can't make a living in agriculture because of the competition from subsidised agriculture in the United States and Europe. But doing away with such subsidies is surely a loss for the farmers *receiving* them – generally the wealthy owners of large, corporate-like farms, since they get the largest subsidies. I may not lie awake at night worrying about their fate, but they would surely be losers from that particular win-win policy nonetheless.

Consider another example. During the nearly two years I spent as Chief Economist at the Council on Environmental Quality in the Executive Office of the President, I was once asked to write something glowing about what would today be called a 'win win-win' policy (a 50 per cent improvement on the simple win-win!). The idea was to have the government subsidise through income tax credits the cost of corporate investments in pollution control. This was an idea that had enthusiastic support from the manufacturing sector (for obvious reasons), from organised labour (which believed that there would be fewer jobs lost in manufacturing due to regulation-induced plant closures), and from environmentalists (who wouldn't have to fight so hard with business over the high cost of pollution control). From the standpoint of the champion of this idea, truly a win-win-win. The trouble with such tax credits, of course, was that they would have promoted more investment in polluting industries than was optimal, and left taxpayers paying for a share of pollution control, rather than either those buying the products of the polluting firms or the shareholders of those firms. I said that I would have to include a discussion of these latter effects in any serious analysis of the subsidy idea, for which I was scolded for not being a team player.

A third obligation of a policy economist, I believe, requires us to do something that doesn't come naturally to many of us. It is to think beyond 'this is the optimal policy' to 'here's how it might be designed to work in the real world', and even occasionally to 'here's what could be done to lessen the burdens on (and blunt the political opposition from) those who would lose from the proposed policy change'. In fact, I think the single greatest failing of most policy economists – myself included, certainly – is an unwillingness to roll up our sleeves and work with the lawyers and others who are charged with the actual drafting of environmental and natural resource policies. In other words, it is often unnatural for us to immerse ourselves in the institutional details of lawmaking and regulation-writing. And sometimes the professional payoffs from doing so, especially for economists in academia, are small or even non-existent.

Believe me, it's a very long journey indeed from the insight that the issuance of marketable permits for CO_2 emissions (or the imposition of a carbon tax) is the best way to control that pollutant to the actual legislative and regulatory language that spells out how a carbon mitigation programme will work. Unless policy economists are willing to stay involved in this process throughout, it is likely that language will be written which, either wittingly or unwittingly, creates a radical departure from the intellectually appealing policy that one of us has concocted. During the debate in 1989–90 about the form that a sulphur dioxide emissions trading programme would take in the revised Clean Air Act, it was the advocacy group Environmental Defense, more than Resources for the Future or any other group of academic economists, that played a key role in the legislative design which proved to be so successful. We are fortunate it is one of the few such advocacy groups that has always employed well-trained economists to help advance its work.

Policy economists should be involved as well in figuring out ways to compensate the losers from an efficient policy: this is often seen as much less interesting than designing the policy – beneath us, even. Yet how many times have we seen a policy with significantly positive net benefits *not* enacted because the prospective losers are identifiable and well organised, while the winners are dispersed and unorganised? Isn't this exactly why it is so difficult to do away with the agricultural subsidies I mentioned above, as well as those in forestry, grazing, and water policy, to name but a few?

There are some examples from which we might learn. When the Redwood National Park was created in the United States some years back, the loggers whose jobs would disappear as a result of curtailed logging were compensated for their loss with a gradually decreasing series of payments over a five-year period. Similarly, when the Clean Air Act Amendments of 1990 were written, a $500 million fund was created to compensate high-sulphur coal miners whose jobs were affected by the shift from high- to low-sulphur coal in utility boilers throughout the midwestern and eastern United States. Far from being a mundane task, policy economists ought to relish the challenge of designing compensatory schemes that make it possible for their ideas to be implemented in the real world, rather than exist as mere *curiosa* in classrooms, journal articles, and textbooks.

I have identified here three obligations of policy economists. I suppose I could have identified more, as might each of you, though I think the ones I have touched upon would be near the top of anyone's list. As your lunchtime speaker this afternoon, and especially as your honoree this year, I have a fourth obligation – one I am delighted to discharge. That is to thank you once again for asking me to be with you here today and to say how grateful I am to you for having done so.

Notes

1 Published with permission from *Agricultural and Resource Economics Review*, **33/2** (2004): 159–161.

2 This paper was presented by the author at the June 21 2004 Awards Luncheon of the Northeastern Agricultural and Resource Economics Association (NAREA) annual meetings, held in Halifax, Nova Scotia.

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Chapter 7

Economic growth, carrying capacity, and the environment[1]

National and international economic policy has usually ignored the environment. In areas where the environment is beginning to impinge on policy, as in the General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA), it remains a tangential concern, and the presumption is often made that economic growth and economic liberalisation (including the liberalisation of international trade) are, in some sense, good for the environment. This notion has meant that economy-wide policy reforms designed to promote growth and liberalisation have been encouraged with little regard to their environmental consequences, presumably on the assumption that these consequences would either take care of themselves or could be dealt with separately.

In this article we discuss the relation between economic growth and environmental quality, and the link between economic activity and the carrying capacity and resilience of the environment[2].

Economic growth, institutions, and the environment

The general proposition that economic growth is good for the environment has been justified by the claim that there exists an empirical relation between per capita income and some measures of environmental quality. It has been observed that as income goes up there is increasing environmental degradation up to a point, after which environmental quality improves. (The relation has an 'inverted-U' shape.)

One explanation of this finding is that people in poor countries cannot afford to emphasise amenities over material well-being. Consequently, in the earlier stages of economic development, increased pollution is regarded as an acceptable side effect of economic growth. However, when a country has attained a sufficiently high standard of living, people give greater attention to environmental amenities. This leads to environmental legislation, new institutions for the protection of the environment, and so forth.

The above argument does not, however, pertain to the environmental resource basis of material well-being, a matter we shall return to subsequently.

So far, the inverted U-shaped curve has been shown to apply to a selected set of pollutants only[3, 4]. However, because it is consistent with the notion that people spend proportionately more on environmental quality as their income rises, economists have conjectured

that the curve applies to environmental quality generally[5]. But it is important to be clear about the conclusions that can be drawn from these empirical findings. While they do indicate that economic growth may be associated with improvements in some environmental indicators, they imply neither that economic growth is sufficient to induce environmental improvement in general, nor that the environmental effects of growth may be ignored, nor, indeed, that the Earth's resource base is capable of supporting indefinite economic growth. In fact, if this base were to be irreversibly degraded, economic activity itself could be at risk[6].

There are other reasons for caution in interpreting these inverted U-shaped curves. First, the relation has been shown to be valid for pollutants involving local short-term costs (for example sulphur, particulates, and faecal coliforms), not for the accumulation of stocks of waste or for pollutants involving long-term and more dispersed costs (such as CO_2), which are often increasing functions of income[7].

Second, the inverted-U relations have been uncovered for emissions of pollutants, not resource stocks. The relation is less likely to hold wherever the feedback effects of resource stocks are significant, such as those involving soil and its cover, forests, and other ecosystems.

Third, the inverted-U curves, as they have been estimated, say nothing about the system-wide consequences of emission reductions. For example, reductions in one pollutant in one country may involve increases in other pollutants in the same country or transfers of pollutants to other countries[8].

And fourth, in most cases where emissions have declined with rising income, the reductions have been due to local institutional reforms, such as environmental legislation and market-based incentives to reduce environmental impacts. But such reforms often ignore international and intergenerational consequences. Where the environmental costs of economic activity are borne by the poor, by future generations, or by other countries, the incentives to correct the problem are likely to be weak. The environmental consequences of growing economic activity may, accordingly, be very mixed.

The solution to environmental degradation lies in such institutional reforms as would compel private users of environmental resources to take account of the social costs of their actions[9]. The inverted-U relation is evidence that this has happened in some cases. It does not constitute evidence that it will happen in all cases or that it will happen in time to avert the important and irreversible global consequences of growth.

Carrying capacity and ecosystem resilience

The environmental resource base upon which all economic activity ultimately depends includes ecological systems that produce a wide variety of services. This resource base is finite. Furthermore, imprudent use of the environmental resource base may irreversibly reduce the capacity for generating material production in the future. All of this implies that there are limits to the carrying capacity of the planet. It is, of course, possible that improvements in the management of resource systems, accompanied by resource-conserving

structural changes in the economy, would enable economic and population growth to take place despite the finiteness of the environmental resource base, at least for some period of time. However, for that to be even conceivable, signals that effectively reflect increasing scarcities of the resource base need to be generated within the economic system.

Carrying capacities in nature are not fixed, static, or simple relations. They are contingent on technology, preferences, and the structure of production and consumption. They are also contingent on the ever-changing state of interactions between the physical and biotic environment. A single number for human carrying capacity would be meaningless because the consequences of both human innovation and biological evolution are inherently unknowable. Nevertheless, a general index of the current scale or intensity of the human economy in relation to that of the biosphere is still useful. For example, in 1986 Vitousek et al.[10] calculated that the total net terrestrial primary production of the biosphere currently being appropriated for human consumption is around 40 per cent. This does put the scale of the human presence on the planet in perspective.

A more useful index of environmental sustainability is ecosystem resilience. One way of thinking about resilience is to focus on ecosystem dynamics where there are multiple (locally) stable equilibria[11]. Resilience in this sense is a measure of the magnitude of disturbances that can be absorbed before a system centred on one locally stable equilibrium flips to another[12]. Economic activities are sustainable only if the life-support ecosystems on which they depend are resilient. Even though ecological resilience is difficult to measure and even though it varies from system to system and from one kind of disturbance to another, it may be possible to identify indicators and early-warning signals of environmental stress. For example, the diversity of organisms or the heterogeneity of ecological functions have been suggested as signals of ecosystem resilience. But ultimately, the resilience of systems may only be tested by intelligently perturbing them and observing the response with what has been called 'adaptive management'[13].

The loss of ecosystem resilience is potentially important for at least three reasons. First, the discontinuous change in ecosystem functions as the system flips from one equilibrium to another could be associated with a sudden loss of biological productivity, and so to a reduced capacity to support human life. Second, it may imply an irreversible change in the set of options open both to present and future generations (examples include soil erosion, depletion of groundwater reservoirs, desertification, and loss of biodiversity). Third, discontinuous and irreversible changes from familiar to unfamiliar states increase the uncertainties associated with the environmental effects of economic activities.

If human activities are to be sustainable, we need to ensure that the ecological systems on which our economies depend are resilient. The problem involved in devising environmental policies is to ensure that resilience is maintained, even though the limits on the nature and scale of economic activities thus required are necessarily uncertain.

Economic growth and environmental policy

We conclude that economic liberalisation and other policies that promote gross national product growth are not substitutes for environmental policy. On the contrary, it may well

be desirable that they are accompanied by stricter policy reforms. Of particular importance is the need for reforms that would improve the signals that are received by resource users. Environmental damages, including loss of ecological resilience, often occur abruptly. They are frequently not reversible. But abrupt changes can seldom be anticipated from systems of signals that are typically received by decision-makers in the world today. Moreover, the signals that do exist are often not observed, or are wrongly interpreted, or are not part of the incentive structure of societies. This is due to ignorance about the dynamic effects of changes in ecosystem variables (for example, thresholds, buffering capacity, and loss of resilience) and to the presence of institutional impediments, such as lack of well-defined property rights. The development of appropriate institutions depends, among other things, on understanding ecosystem dynamics and on relying on appropriate indicators of change. Above all, given the fundamental uncertainties about the nature of ecosystem dynamics and the dramatic consequences we would face if we were to guess wrong, it is necessary that we act in a precautionary way so as to maintain the diversity and resilience of ecosystems.

Economic growth is not a panacea for environmental quality; indeed, it is not even the main issue. What matters is the content of growth – the composition of inputs (including environmental resources) and outputs (including waste products). This content is determined by, among other things, the economic institutions within which human activities are conducted. These institutions need to be designed so that they provide the right incentives for protecting the resilience of ecological systems. Such measures will not only promote greater efficiency in the allocation of environmental resources at all income levels, but they would also assure a sustainable scale of economic activity within the ecological life-support system. Protecting the capacity of ecological systems to sustain welfare is of as much importance to poor countries as it is to those that are rich.

Notes

1 Printed with permission from *Ecological Economics* **15** (1995) 91–95; *Science* 268; 520–521.

2 This is a report of the Second Asko Meeting, held 31 August to 2 September 1994, in the archipelago outside Stockholm, Sweden. The meeting was organised by the Beijer International lnstitute of Ecological Economics, Royal Swedish Academy of Sciences, Box 50005, S10405 Stockholm. Sweden. The aim of the meeting was to establish a substantive dialogue among a small group of ecologists and economists to gauge whether an interdisciplinary consensus exists on the issues of economic growth, carrying capacity, and the environment and to determine what could be said about the joint development of economic and environmental policy.

3 Phenomena for which the relation holds most clearly include poor sanitation, impure water supplies, suspended particulates, SO_2, NO_x, and CO (3). G.M. Grossman and A.B. Krueger, in *The U.S. Mexico Free Trade Agreement*, P. Garber, (Ed.) (MT Press, Cambridge, MA, 1993), pp. 165–177.

4 N. Shaflk and S. Bandyopadhay, 'Economic growth and environmental quality, time series and cross country evidence'. Background paper for the World Bank, *World Development Report*, Washington, DC 1992.

5 W. Beckerman, *World Dev*. **20**, 481 (1992).

6 A. M. Jansson, M. Hammer, C. Folke, R. Costanza, Eds, *Investing in Natural Capital: the Ecological Economics Approach to Sustainability* (Island Press, Washington, DC, 1994).

7 N. Shaflk and S. Bandyopadhay (3) find that CO_2 emissions are an increasing function of per

capita income. W. Moomaw and M. Tullis [in *Industrial Ecology and Global Change*, R. Socolow, C. Andrews, F. Berkhout, V. Thomas, Eds. (Cambridge University Press, Cambridge, 1994), pp. 157–172] show that while cross-sectionally CO_2 emissions per capita rise with income per capita, the experience in individual countries over time is highly variable, depending on the structure of individual economies. They conclude that there are many different development paths, some of which can de-link economic growth from CO_2 emissions, but adequate institutions are required and it is by no means an automatic consequence of growth.

8 R. Lopez, *Journal of Environmental Economics and Management*. **27**, 163 (1994); T. M. Selden and D. Song; *ibid.*, p. 147; K. Anderson and R. Backhurst, Eds, *The Greening of World Trade Issues* (Harvester Wheatsheaf, Hemel Hempstead, Herts, UK, 1992).

9 A related issue is the measurement of economic growth at the macro level, The conventional measure, GNP, is far from adequate as a measure of true economic performance. We need a more comprehensive index that includes the flow of environmental services as well as the value of net changes in the stocks of natural capita so that the true social costs of growth can be internalised. With this improved index, many of the apparent conflicts between 'growth' and the environment would disappear because environmental degradation would be subtracted from the Index. [See, for example, P. Dasgupta and K G Maler, *The Environment and Emerging Development Issues*, Proceedings of the Annual Bank Conference on Development Economics, 1990 (Supplement to the World Bank Economic Review, 1991).]

10 P.M. Vitousek, P.R. Ehrllch, A.H. Ehrch, P. A. Matson, BioScience **36**, 368 (1986).

11 Another way is to focus on ecosystem dynamics in the neighbourhood of an equilibrium. The object here is to measure the resistance of a system to disturbances and to determine the speed with which it returns to equilibrium. [See S.L. Pimm, *Nature* **307**,321 (1984).]

12 C.S. Holling, *Annual Review of Ecology and Systematics*. **4**, 1–23 (1973).

13 Adaptive management views regional development policy and management as 'experiments', where interventions at several scales are made to achieve understanding, to produce a social or economic product, and to identify options. [See, for example, C.S Holling, Ed., *Adaptive Environmental Assessment and Management* (Wiley, London, 1978); C.J. Walters, *Adaptive Management of Renewable Resources* (Macmillan, New York, 1986); K. Lee, *Compass and the Gyroscope* (Island Press, Washington, DC, 1993).]

Robert M Solow

Chapter 8

Sustainability: An economist's perspective[1,2]

This talk is different from anything else anyone has heard at Woods Hole; certainly for the last two days. Three people have asked me, 'Do you plan to use any transparencies or slides?'. Three times I said, 'No,' and three times I was met with this blank stare of disbelief. I actually have some beautiful aerial photographs of Prince William Sound that I could have brought to show you, and I also have a spectacular picture of Michael Jordan in full flight that you would have liked to have seen. But in fact I don't need or want any slides or transparencies. I want to talk to you about an idea. The notion of sustainability or sustainable growth (although, as you will see, it has nothing necessarily to do with growth) has infiltrated discussions of long-run economic policy in the last few years. It is very hard to be against sustainability. In fact, the less you know about it, the better it sounds. That is true of lots of ideas. The questions that come to be connected with sustainable development or sustainable growth or just sustainability are genuine and deeply felt and very complex. The combination of deep feeling and complexity breeds buzzwords, and sustainability has certainly become a buzzword. What I thought I might do, when I was invited to talk to a group like this, was to try and talk out loud about how one might think straight about the concept of sustainability, what it might mean and what its implications (not for daily life but for your annual vote or your concerns for economic policy) might be.

Definitions are usually boring. That is probably true here too. But here it matters a lot. Some people say they don't know what sustainability means, but it sounds good. I've seen things on restaurant menus that strike me the same way. I took these two parts of a definition from a UNESCO document: '... every generation should leave water, air and soil resources as pure and unpolluted as when it came on earth'. Alternatively, it was suggested that 'each generation should leave undiminished all the species of animals it found existing on earth'. I suppose that sounds good, as it was meant to be. But I believe that kind of thought is fundamentally the wrong way to go in thinking about this issue. I must also say that there are some much more carefully thought out definitions and discussions, say by the UN Environment Programme and the World Conservation Union. They all turn out to be vague; in a way, the message I want to leave with you today is that sustainability is an essentially vague concept, that it would be wrong to think of it as being precise, or even capable of being made precise. It is therefore probably not in any clear way an exact guide to policy. Nevertheless, it is not at all useless.

Pretty clearly the notion of sustainability is about our obligation to the future. It says

something about a moral obligation that we are supposed to have for future generations. I think it is very important to keep in mind – I'm talking like a philosopher for the next few sentences and I don't really know how to do that – that you can't be morally obligated to do something that is not feasible. Could I be morally be obligated to be like Peter Pan and flap my wings and fly around the room? If I fail to carry out a moral obligation, you must be entitled to blame me. You could probably say unkind things about me. But you couldn't possibly say unkind things about me for not flying around the room like Peter Pan because you know, as well as I do, that I can't do it.

If you define sustainability as an obligation to leave the world as we found it in detail, I think that's glib but essentially unfeasible. It is, when you think about it, not even desirable. To carry out literally the injunction of UNESCO would mean to make no use of mineral resources; it would mean to do no permanent construction or semi-permanent construction; build no roads; build no dams; build no piers. A mooring would be all right but not a pier. Apart from being essentially an injunction to do something that is not feasible, it asks us to do something that is not, on reflection, desirable. I doubt that I would feel myself better off if I had found the world exactly as the Iroquois left it. It is not clear that one would really want to do that.

To make something reasonable and useful out of the idea of sustainability, I think you have to try a different kind of definition. The best thing I could think of is to say that it is an obligation to conduct ourselves so that we leave to the future the option or the capacity to be as well off as we are. It is not clear to me that one can be more precise than that. Sustainability is an injunction not to satisfy ourselves by impoverishing our successors. That sounds good too, but I want you to realise how problematic it is – how hard is it to make anything precise or checkable out of that thought. If we try to look far ahead, as presumably we ought to if we are trying to obey the injunction to sustainability, we realise that the tastes, the preferences, of future generations are something that we don't know about. Nor do we know anything very much about the technology that will be available to people 100 years from now. Put yourself in the position of someone in 1880 trying to imagine what life would be like in 1980 and you will see how wrong you would be. I think all we can do in this respect is to imagine people in the future being much like ourselves and attributing to them, imputing to them, whatever technology we can 'reasonably' extrapolate – whatever that means. I am trying to emphasise the vagueness but not the meaningless of that concept. It is not meaningless, it is just inevitably vague.

We are entitled to please ourselves, according to this definition, so long as it is not at the expense (in the sense that I stated) of future well-being. You have to take into account, in thinking about sustainability, the resources that we use up and the resources that we leave behind, but also the sort of environment we leave behind including the built environment, including productive capacity (plant and equipment) and including technology. *To talk about sustainability in that way is not at all empty.* It attracts your attention, first, to what history tells us is an important fact, namely that goods and services can be substituted for one another. If you don't eat one species of fish, you can eat another species of fish. Resources are, to use a favourite word of economists, fungible in a certain sense. They can take the place of each other. That is extremely important because it suggests that we

do not owe to the future any particular thing. There is no specific object that the goal of sustainability, the obligation of sustainability requires us to leave untouched.

What about nature? What about wilderness or unspoiled nature? I think that we ought, in our policy choices, to embody our desire for unspoiled nature as a component of well-being. But we have to recognise that different amenities really are, to some extent, substitutable for one another, and we should be as inclusive as possible in our calculations. It is perfectly okay, it is perfectly logical and rational, to argue for the preservation of a particular species or the preservation of a particular landscape. But that has to be done on its own, for its own sake, because this landscape is intrinsically what we want or this species is intrinsically important to preserve, not under the heading of sustainability. Sustainability doesn't require that any *particular* species of owl or any *particular* species of fish or any *particular* tract of forest be preserved. Substitutability is also important on the production side. We know that one kind of input can be substituted for another in production. There is no reason for our society to feel guilty about using up aluminium as long as we leave behind a capacity to perform the same or analogous functions using other kinds of materials – plastics or other natural or artificial materials. In making policy decisions we can take advantage of the principle of substitutability, remembering that what we are obligated to leave behind is a generalised capacity to create well-being, not any particular thing or any particular natural resource.

If you approach the problem that way in trying to make plans and make policies, it is certain that there will be mistakes. We will impute to the future tastes that they don't have or we will impute to them technological capacities that they won't have or we will fail to impute to them tastes and technological capacities that they do have. The set of possible mistakes is usually pretty symmetric.

That suggests to me the importance of choosing robust policies whenever we can. We should choose policies that will be appropriate over as wide a range of possible circumstances as we can imagine. But it would be wrong for policy to be paralysed by the notion that one can make mistakes. Liability to error is the law of life. And, as most people around Woods Hole know, you choose policies to avoid potentially catastrophic errors, if you can. You insure whenever you can, but that's it.

The way I have put this, and I mean to do so, emphasises that sustainability is about distributional equity. It is about who gets what. It is about the sharing of well-being between present people and future people. I have also emphasised the need to keep in mind, in making plans, that we don't know what they will do, what they will like, what they will want. And, to be honest, it is none of our business.

It is often asked whether, at this level, the goal or obligation of sustainability can be left entirely to the market. It seems to me that there is no reason to believe in a doctrinaire way that it can. The future is not adequately represented in the market, at least not in the far future. If you remember that our societies live with real interest rates of the order of 5 or 6 per cent, you will realise that that means that the dollar a generation from now, is worth 25 cents today. That kind of discount seems to me to be much sharper than we would seriously propose in our public capacity, as citizens thinking about our obligation to the

future. It seems to me to be a stronger discount than most of us would like to make. It is fair to say that those people a few generations hence are not adequately represented in today's market. They don't participate in it, and therefore there is no doctrinaire reason for saying, 'Oh well, ordinary supply and demand, ordinary market behaviour, will take care of whatever obligation we have to the future'.

Now, in principle, government could serve as a trustee, as a representative for future interests. Policy actions, taxes, subsidies, regulations could, in principle, correct for the excessive present-mindedness of ordinary people like ourselves in our daily business. Of course, we are not sure that government will do a good job. It often seems that the rate at which governments discount the future is rather sharper than that at which the bond market does. So we can't be sure that public policy will do a good job. That is why we talk about it in a democracy. We are trying to think about collective decisions for the future, and discussions like this, not with just me talking, are the way in which policies of that kind ought to be thrashed out.

Just to give you some idea of how uncertain both private and public behaviour can be in an issue like this, let me ask you to think about the past, not about the future. You could make a good case that our ancestors, who were considerably poorer than we are, whose standard of living was considerably less than our own, were probably excessively generous in providing for us. They cut down a lot of trees, but they saved a lot and they built a lot of railroad rights-of-way. Both private and publicly they probably did better by us than a sort of fair-minded judge in thinking about the equity (whether they got their share and we got our share or whether we profited at their expense) would have required. It would have been okay for them to save a little less, to enjoy a little more and given us a little less of a start than our generation has had. I don't think there is any simple generalisation that will serve to guide policy about these issues. There is every reason to discuss economic policy and social policy from this point of view, and anything else is likely to be ideology rather than analysis.

Once you take the point of view that I have been urging on you in thinking about sustainability as a matter of distributional equity between the present and the future, you can see that it becomes a problem about saving and investment. It becomes a problem about the choice between current consumption and providing for the future.

There is a sort of dual connection – a connection that need not be intrinsic but is there – between environmental issues and sustainability issues. The environment needs protection by public policy because each of us knows that by burdening the environment, by damaging it, we can profit and have some of the cost, perhaps most of the cost, borne by others. Sustainability is a problem because each of us knows or realises that we can profit at the expense of the future rather than at the expense of our contemporaries and the environment. We free-ride on each other and we free-ride on the future.

Environmental policy is important for both reasons. One of the ways we free-ride on the future is by burdening the environment. And so current environmental protection – this is what I mean by a dual connection – will almost certainly contribute quite a lot to sustainability. Although, I want to warn you, not automatically. Current environmental

protection contributes to sustainability if it comes at the expense of current consumption. Not if it comes at the expense of investment, of additions to future capacity. So, there are no absolutes. There is nothing precise about this notion but there are perhaps approximate guides to public policy that come out of this way of reasoning about the idea of sustainability. A correct principle, a correct general guide is that when we use up something – and by that I mean our society, our country, our civilisation, however broadly you want to think – when we use up something that is irreplaceable, whether it is minerals or a fish species, or an environmental amenity, then we should be thinking about providing a substitute of equal value, and the vagueness comes in the notion of value. The something that we provide in exchange could be knowledge, could be technology. It needn't even be a physical object.

Let me give you an excellent example from the recent past of a case of good thought along these lines and also a case of bad thought along these lines. Commercially useable volumes of oil were discovered in the North Sea some years ago. The two main beneficiaries were the United Kingdom and Norway. It is only right to say that the United Kingdom dissipated North Sea oil, wasted it, used it up in consumption and on employment. If I meet Mrs. Thatcher in heaven, since that is where I intend to go, the biggest thing I will tax her with is that she blew North Sea oil. Here was an asset that by happenstance the UK acquired. If the sort of general approach to sustainability that I have been suggesting to you had been taken by the Thatcher government, someone would have said, 'It's okay we are going to use up the oil, that's what it is there for, but we will make sure that we provide something in exchange, that we guide those resources, at least in large part, into investment in capacity in the future'. That did not happen. As I said, if you ask where (and by the way the curve of production from the North Sea fields is already down; that asset is on its way to exhaustion) it went, it went into maintaining consumption in the United Kingdom and, at the same time, into unemployment.

Norway on the other hand, went about it in the typical sober way you expect of good Scandinavians. The Norwegians said, here is a wasting asset. Here is an asset that we are going to use up. Scandinavians are also slightly masochistic, as you know. They said the one thing we must avoid is blowing this; the one thing we must avoid is a binge. They tried very hard to convert a large fraction of the revenues, of the rentals, of the royalties from North Sea oil into investment. I confess I don't know how well they succeeded but I am willing to bet that they did a better job of it than the United Kingdom.

This brings me to the one piece of technical economics that I want to mention. There is a near analytical result in economics (mainly done by John Hartwick of Queen's University in Canada) which studies an economy that takes what we call the rentals, the pure return to a non-renewable resource, and invests those rentals[3]. That is, it uses up a natural asset like the North Sea oil field, but makes a point of investing whatever revenues intrinsically inhere to the oil itself. That policy can be shown to have neat sustainability properties. In a simple sort of economy, it will guarantee a perpetually constant capacity to consume. By the way, it is a very simple rule, and it is really true only for simple economies; but it has the advantage, first of all, of sounding right, of sounding like justice, and secondly, of being practical. It is a calculation that could be made. It is a calculation that we don't

make and I am going to suggest in a minute that we should be making it. You might want to do better. You might feel so good about your great-grandchildren that you would like to do better than invest the rents on the non-renewable resources that you use up. But in any case, it is, at a minimum, a policy that one could pursue for the sake of sustainability. I want to remind you again that most environmental protection can be regarded as an act of investment. If we were to think that our obligation to the future is in principle discharged by seeing that the return to non-renewable resources is funnelled into capital formation, any kind of capital formation – plant and equipment, research and development, physical oceanography, economics or environmental investment – we could have some feeling that we were about on the right track.

Now I want to mention what strikes me as sort of a paradox – as a difficulty with a concept of sustainability. I said, I kind of insisted, that you should think about it as a matter of equity, as a matter of distributional equity, as a matter of choice of how productive capacity should be shared between us and them, them being the future. Once you think about it in that way you are almost forced logically to think about equity not between periods of time but equity right now. There is something inconsistent about people who profess to be terribly concerned about the welfare of future generations but do not seem to be terribly concerned about the welfare of the poor people today. You will see in a way why this comes to be a paradox. The only reason for thinking that sustainability is a problem is that you think that some people are likely to be short-changed, namely in the future. Then I think you are really obligated to ask, 'Well, is anybody being short-changed right now?'

The paradox arises because if you are concerned about people who are currently poor, it will turn out that your concern for them will translate into an increase in current consumption, not into an increase in investment. The logic of sustainability says, 'You ought to be thinking about poor people today, and thinking about poor people today will be disadvantageous from the point of sustainability.' Intellectually, there is no difficulty in resolving that paradox, but practically there is every difficulty in the world in resolving that paradox. And I don't have the vaguest notion of how it can be done in practice.

The most dramatic way in which I can remind you of the nature of that paradox is to think about what it will mean for, say, CO_2 discharge when the Chinese start to burn their coal in a very large way; and, then, while you are interested in moral obligation, I think you should invent for yourself how you are going to explain to the Chinese that they shouldn't burn the coal, even living at their standard of living they shouldn't burn the coal, because the CO_2 might conceivably damage somebody in 50 or 100 years.

Actually the record of the USA is not very good on either the intergenerational equity of the intra-generational equity front. We tolerate, for a rich society, quite a lot of poverty, and at the same time we don't save or invest a lot. I've just spent some time in West Germany, and there is considerably less apparent poverty in the former Federal Republic than is here; and at the same time they are investing a larger fraction of their GNP than we are by a large margin.

It would not be very hard for us to do better. One thing we might do, for starters, is to make

a comprehensive accounting of rents on non-renewable resources. It is something that we do not do. There is nothing in the national accounts of the USA which will tell you what fraction of the national income is the return to the using up of non-renewable resources. If we were to make that accounting, then we would have a better idea than we have now as to whether we are at least meeting that minimal obligation to channel those rents into saving and investment. And I also suggested that careful attention to current environmental protection is another way that is very likely to slip in some advantage in the way of sustainability, provided it is at the expense of current consumption and not at the expense of other forms of investment.

I have left out of this talk, as some of you may have noticed until now, any mention of population growth; and I did that on purpose, although it might be the natural first order concern if you are thinking about sustainability issues. Control of population growth would probably be the best available policy on behalf of sustainability. You know that, I know that, and I have no particular competence to discuss it any further; so I won't, except to remind you that rapid population growth is fundamentally a Third World phenomenon, not a developed-country phenomenon. So once again, you are up against the paradox that people in poor countries have children as insurance policies for their old age. It is very hard to preach to them not to do that. On the other hand, if they continue to do that, then you have probably the largest, single danger to sustainability of the world economy.

All that remains for me is to summarise. What I have been trying to say goes roughly as follows. Sustainability as a moral obligation is a general obligation not a specific one. It is not an obligation to preserve this or preserve that. It is an obligation, if you want to make sense out of it, to preserve the capacity to be well off, to be as well off as we are. That does not preclude preserving specific resources, if they have an independent value and no good substitutes. But we shouldn't kid ourselves, that is part of the value of specific resources. It is not a consequence of any interest in sustainability. Secondly, an interest in sustainability speaks for investment generally. I mentioned that directing the rents on non-renewable resources into investment is a good rule of thumb, a reasonable and dependable starting point. But what sustainability speaks for is investment, investment of any kind. In particular, environmental investment seems to me to correlate well with concerns about sustainability and so, of course, does reliance on renewable resources as a substitute for non-renewable ones. Third, there is something faintly phoney about the deep concern for the future combined with callousness about the state of the world today. The catch is that today's poor want consumption not investment. So the conflict is pretty deep and there is unlikely to be any easy way to resolve it. Fourth, research is a good thing. Knowledge on the whole is an environmentally neutral asset that we can contribute to the future. I said that in thinking about sustainability you want to be as inclusive as you can. Investment in the broader sense and investment in knowledge, especially technological and scientific, is as environmentally clean an asset as we know. And the last thing I want to say is, don't forget that sustainability is a vague concept. It is intrinsically inexact. It is not something that can be measured out in coffee spoons. It is not something that you could be numerically accurate about. It is, at best, a general guide to policies that have to do with investment, conservation and resource use. And we shouldn't pretend that is anything other than that.

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Notes

1 Reprinted with permission from *National Geographic Research and Exploration*, **8**: 10–21 (1992).

2 This paper was presented as the Eighteenth J. Seward Johnson Lecture to the Marine Policy Centre, Woods Hole Oceanographic Institution, at Woods Hole, Massachusetts, on June 14 1991.

3 John M. Hartwick, 'Substitution among exhaustible resources and intergenerational equity,' *Review of Economic Studies* **45**(2); 347–543 (June 1978).

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Chapter 9

Environmental valuation methods in SIDS

Introduction

Clear and accurate valuation is fundamental to the design of economically efficient environmental policy. Around the world, environmental valuation is mainly used for:

- The preliminary investigation of environmental problems – getting a rough picture of policy options that might be worth exploring further.
- Cost-benefit analysis – detailed assessment of the benefits and costs of a particular policy option.
- Cost-efficiency analysis – finding the most efficient method for reaching a set target such as reducing flood risk or eliminating pesticide poisoning.
- Ex-post appraisal – examining whether, in retrospect the right decision was made and the correct values were estimated for costs and benefits.

In the last twenty years or so, economic valuation of the environment has become a small industry in its own right with a large number of associated texts and manuals. Bateman et al. (2002) offers an overview of stated preference methods in valuation, while van Breukering et al. (2007) shows how the methods can be applied in SIDS.

In this chapter we provide a brief overview of valuation techniques, provide case studies and examine some particular issues of concern to SIDS. Most of the basic principles of valuation apply to most economies, but there are three features that are especially pertinent for SIDS and we shall return to them in what follows:

1. Economic risk tends to be higher in SIDS compared to other kinds of economies.
2. Beneficiaries – for many SIDS tourists are an important source of income, but also important potential beneficiaries from environmental improvement.
3. Ecological risk, which as for economic risk is often higher in SIDS, compared to non-island states.

Certain kinds of environmental problems emerge more frequently on small islands. Compared to many larger countries, air quality tends to be less of a problem because of atmospheric mixing and prevailing winds. On the other hand, water quality may be particularly problematic, and, because island economies are often heavily dependent on the sea for livelihoods, the quality of surrounding water is important. Many low-lying SIDS are also at high risk from sea-level rise that is predicted to accompany global warming. Finally, the smallness of habitats may make the maintenance of biodiversity particularly difficult.

The special features of SIDS

There are some typical features of SIDS that are unusual in the context of valuation. These concern: the stakeholders, the economic risk and the ecological risk.

The Stakeholders

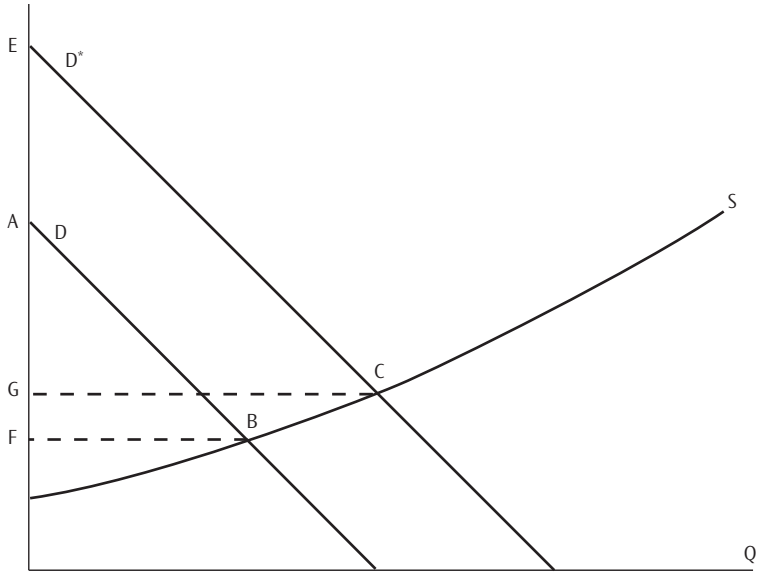
In a standard cost-benefit problem all the costs and benefits accumulate within one community. So the set of potential beneficiaries and the set of people who must bear the cost of a project are the same. With tourism projects the situation is slightly different. In Figure 9.1 we show the typical picture in SIDS, where the set of beneficiaries from a tourism-related project is not the same as the set of people who bear the costs (the citizens), although the sets overlap.

Figure 9.1. Beneficiaries and citizens

For example, the major beneficiaries of better coral reefs might well be visitors rather than citizens. If one was doing cost-benefit analysis from a global view point then the benefits to visitors would be included in the calculation of the project's viability. But typically that is not the case. Because cost-benefit analysis (CBA) is done from the perspective of the host nation, it is a local CBA. In these circumstances, benefits to visitors only count to the extent that these are captured by citizens. So, if the hotel facing the improved coral reef can raise its occupancy rate or increase room rates, then these benefits will accrue to the home nation and should be counted in. Additionally, some projects may generate non-use values for people who have no intention of visiting. Non-use values are derived from the pleasure individuals obtain simply by knowing something exists, even if they have no interest in visiting or experiencing it. There is plenty of evidence of non-use values both within and without countries. Citizens of the USA are apparently willing to pay to improve visibility around the Grand Canyon even if they will never visit it. It is conceivable that for rare and charismatic species, exotic habitats or unique environments many individuals around the world would be willing to pay something, but unless these payments can be collected by the state then they are irrelevant for the local CBA.

Figure 9.2 illustrates the situation where an improvement in environmental quality raises demand for visits to an island from D to D^*. We suppose that accommodation is supplied competitively and that S represents the appropriate supply curve. The total benefits from the improvement are ABCE, but only the increased profits to local suppliers – the area FBCG – can be included in a local CBA. This is potentially much smaller than ABCE.

Figure 9.2. Cost-benefit analysis with non-resident beneficiaries



It is worth adding an important point. Sometimes cost-benefit analysis is done as part of a case for development aid. In this situation it is appropriate to calculate the benefits to visitors and non-nationals that are not captured locally as these external benefits may be relevant to the funding agency. A topical example is that of Clean Development Mechanism (CDM) under the Kyoto protocol, which offers the opportunity for one of the richer countries that have signed up to the protocol to reduce their emissions by replacing carbon emissions in another country. Many SIDS are highly dependent on fossil fuels for their electricity generation and so projects of this kind represent opportunities for greater diversity in fuel sourcing as well as producing reductions in greenhouse gases. Table 9.1 illustrates this.

The final point concerns the dangers of double counting. Suppose we ask visitors their willingness to pay for improvements to water supply for an island where drinking water is sometimes risky or unreliable. We also find the extra profits local businesses would make from visitors if the supply improved. It is tempting to add these two sets of numbers, but some of the extra profits would come from the visitors' payments. Adding them would be counting the same benefits twice. There are a number of ways of dealing with the problem. The simplest is to subtract from the total the increased profits made.

Table 9.1. Inclusion of benefits in a SIDS valuation exercise

	Benefits to local citizens	Benefits to visitors	Non-user benefits for non-citizens
For Local CBA	Yes	The fraction that is captured locally	No
For development aid or global CBA	Yes	Yes	Yes

Note: Double counting needs to be avoided.

Economic risk

Although there is an extensive theoretical literature on cost-benefit analysis within a risky environment, in practice most valuation exercises concentrate on expected benefits and costs. The underlying justification for this approach is that projects are typically small compared to the size of the economy and their failure or success will not make a major dent in overall GDP. Yet, we noted in the introduction that the second potentially distinctive feature of SIDS is that their smallness often implies a lack of both ecological and economic robustness in the face of shocks. Markets may be thin; the economy may be overly reliable on a single crop or trade and its trade may be concentrated on only a few partners (Briguglio, 1995). In these circumstances, when a project is large compared to the size of the economy it can be appropriate to consider the consequences of failure (or indeed, success).

Failure may arise through two different sources:

- The anticipated benefits may fail to arise. For instance improvements to coastal water quality may fail to attract new tourist business if there is an economic downturn in key markets.
- Costs may be higher than anticipated, if, for instance, the project is financed through loans on the world market and global interest rates rise. If the project is financed through taxation, a drop in agricultural production (and associated taxes) may make the opportunity cost of funds higher.

Against this, the benefits may be higher than anticipated and the costs may be lower. This potential variability in outcomes represents economic risk[1].

Risk can be incorporated into a valuation in two stages. In the descriptive part of the enterprise, the possible outcomes can be identified and the benefits and costs in each outcome assessed. Incorporating risk into the actual valuation is more problematic. Van Breukering et al., 2007, note that 'The main approach to dealing with risk in a decision framework is to consider the expected value of alternative options'. But this can be inappropriate when the risk is high. The traditional alternative is to raise the discount rate used for the project appraisal. In this way future benefits are discounted more heavily, because they are less than certain to occur and the reasonable assumption is made that individuals are averse to risk. One problem with this method is that it also discounts future costs more heavily, when their riskiness means that we may wish to attach a greater weight to them. An alternative approach is to use explicitly a utility function for the assessment of benefits and costs that reflects aversion to risk. For instance in the Stern Report (2007) on climate change, the authors use the following function:

$$U = \frac{c^{1-\eta}}{1-\eta}$$

In this expression, U is utility, c is per capita consumption and η (the Greek letter, 'eta') is a measure of aversion to risk. Larger values of η represent greater aversion to risk. When $\eta = 1$, we have a special case in which $U = \ln(c)$, where ln is the natural log. The Stern report argues that $\eta = 1$ is in fact a reasonable value.

Ecological risk

Ecological risk matters for valuation because variance and uncertainty in the performance of the environment can affect the economy and the well-being of citizens. As with economic risk, ecological risk tends to be higher in small islands primarily because of their size, which can make the various habitats less resilient in the face of shocks. Also, there is a high proportion of endemism – species found only in one location. According to the FAO See: http://www.fao.org/forestry/sids/4786/en/, in Mauritius, Haiti, and Jamaica over 30 per cent of higher plant species are endemic, while over 25 per cent of mammals are endemic in the Solomon Islands, Fiji and Mauritius. Ecological sites are also likely to be linked, so that for instance poor solid waste management may damage river courses and onshore fisheries and reefs. The small size of islands also means that they face risks from being overrun by invasive species.

When there is ecological or economic risk to which individuals are averse, then they will be willing to sacrifice some resources in order to reduce such risk. For instance, suppose on an island subject to the risk of hurricanes, mangroves are removed in order to establish prawn farms and beach amenities. There is a 50 per cent chance of a storm year. In a storm-free year the value of these activities is US$1m, but damage and disruption means that in a storm year the benefits are only $0.4m. It is proposed to rebuild the mangroves and also provide coastal forests to reduce the damage from storms. Some inshore fisheries are then more productive and the forest will yield crops. Overall, the forest and mangroves reduce storm damage but also eliminate the benefits of storm-free year, so that the benefits are always $0.7m per year. If one just considers the expected outcome of the two options, they are the same: $0.7m, but the afforestation and re-establishment of the mangrove involves lower risk, so a risk-averse person will be willing to pay something to achieve it.

To sum up, risk reduction projects can be important in SIDS, so it is equally important to treat risk and changes in risk in any economic valuation. Using expected values is common but it can ignore a significant rationale for a project that is being considered.

Valuation methods in practice

Valuation methods in practice include the following:

1. Pricing methods
2. Revealed preference methods
3. Stated preference methods

Pricing methods

The primary advantages of pricing methods are that they:

i. often are more comprehensible to policy-makers, compared to stated preference;
ii. frequently use existing data; and
iii. they are possibly more robust than some valuation methods, if only because they are the result of actual choices, often made repeatedly by experienced consumers.

The major disadvantages are that:

i typically, they provide only incomplete measures of value;
ii more specifically, they typically underestimate values; and
iii they are poor at estimating the benefits of innovations and of completely new goods or programmes.

The main pricing methods are as follows.

- **Opportunity costs**

In the opportunity cost approach we examine what value would have to be foregone in order to, say, create or enhance a particular environmental asset.

- **Costs of alternatives**

One evaluation strategy is to calculate the cost of using some alternative resource. For instance, Costanza et al., (1989) undertake an assessment of the economic use value of a coastal wetland in Louisiana (see Table 9.2). To do this, they first identify the flow of ecological services from the wetland. For some of these services, such as commercial fishing, there is information available on the value-added of the existing industry. For storm protection, there is no such market information, so they consider instead the costs of building an equally effective man-made defence system. They argue that this underestimates the true value of storm protection, though it is the nature of the cost-of-alternatives approach that in practice a man-made barrier might well be an overestimate of the value. As can be seen from Table 9.2, storm protection is the largest contributor to the value of the wetland.

Table 9.2. Economic use values for the functions of a Louisiana wetland

Source of value	Valuation ($/acre)
Commercial fishery	400
Fur trapping	190
Recreation	57
Storm protection	2,400
Total	3,047

Source: Costanza et al. (1989)

- **Mitigation costs**

Mitigation costs are the prices which individuals pay in order to avoid or reduce environmental impacts. A family might buy bottled water or use a purifier when tap water is potentially harmful due to contamination. It is well known that the value to the family of safe water is less than the cost of mitigation (if it were not, then they would not be buying the bottled water or the purifier). We do not know what they would be willing to pay. So as with the costs of alternatives we can take it that the mitigation costs underestimate values. When mitigation is partial – for instance double glazing that lowers noise from a nearby airfield, but does not eliminate the nuisance – then we can conclude that the marginal value of the mitigation is equal to its marginal cost, but we still do not know the total value of the amenity.

- **Shadow project costs**

Another 'pricing' option is to look at the costs of providing an equal alternative environmental good elsewhere. For instance, suppose a new airport access road and runway extension destroys a wetland. One way to price the lost resource is to calculate the costs of building a new wetland elsewhere. This is often difficult to do because mangroves take years to grow and so the ecological value of the new site will not be realised for some time.

- **The Dose-response method**

The dose-response or production-function method is popular for evaluating health impacts of poor quality air and water and for assessing the benefits of policies to improve public health. In its most common form there are two parts to the method:

a linking differing levels of pollution (the 'dose') to differing levels of damage (the 'response'); and
b giving a monetary evaluation by multiplying this damage by the market price per unit.

For example, consider a study of the benefits of improving air quality in several large Brazilian cities conducted by Seroa da Motta and Mendes (1993). The study begins with an econometric analysis of the relationship between air pollution and mortality rates in Sao Paulo. In the first stage of the analysis, regression analyses were conducted relating death rates from respiratory diseases to air quality, social and economic, and meteorological variables. The relationship is then used in an analysis of the health care costs associated with air pollution in Sao Paulo and in two other major Brazilian cities (Rio de Janeiro and Cubatao). Five pollutants are included in the analysis: inhalable particulate matter (PM_{10}), carbon monoxide (CO), Ozone (O^3), Sulphur dioxide (SO^2), and nitrogen dioxide (NO^2). The main results suggest:

- an increase of 10 $\mu g/m^3$ of inhalable particulate matter implies an average increase in the mortality rate from respiratory diseases of 1.6 per cent;
- a drop in the PM_{10} concentration from 89 $\mu g/m^3$ to the primary standard of 50 $\mu g/m^3$ would reduce the mortality rate from respiratory disease by about 6 per cent; and
- mortality rates from respiratory diseases were related to concentrations of carbon monoxide, ozone and nitrogen and dioxide.

In the second part of the analysis, values were estimated for deaths and illnesses associated with poor quality air. The authors used health costs as a measure of costs. As with the other pricing methods, the assumption is that this is an underestimate – that these costs were incurred because the anticipated benefits were as least as large. Table 9.3 summarises some of the estimates.

Table 9.3. Hospital costs per death and total hospital costs due to air pollution, by city

City (year)	Deaths associated with air pollution	Hospital costs per death	Total
Sao Paulo (1989)	139	5,647	785,000
Rio de Janeiro (1984)	40	3,775	151,000
Cubatao (1988)	139	4,896	142,000

Source: Seroa and Mendes. (1993)

A key problem with this approach is that values that are elicited can be highly sensitive to the pricing measure. Moreover, these prices can be highly inaccurate. Suppose for instance that sufferers from air pollution died quickly without receiving much medical care. Then the method would suggest that costs of pollution are low.

In most studies involving health risks, different types of measures are used. A common approach is the human capital approach which estimates the earnings lost as a consequence of poor health. By the standards of the human capital measure, medical costs are usually a poor measure of the value of life. Krupnick, (1991), for instance, shows that the human capital cost of chronic bronchitis is around 40 times the estimated medical cost. In passing, it is also worth noting that the human capital approach is often criticised. For instance, it places a zero price on the life of someone who is retired. More generally, it fails to include all the benefits from health that are not picked up through higher earnings and for many individuals these benefits are significant. Many societies therefore use contingent valuation to estimate the benefits from reductions in health risk.

Usefulness of revealed preference methods

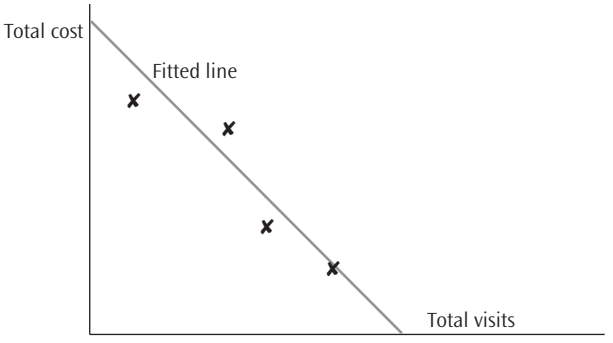
Revealed preference methods value environmental assets by observing purchases of market-priced goods, which are necessary to enjoy the environmental good in question.

- **Travel cost**

Individuals can reveal the value they place upon a good by the amount of time and other resources they are willing to devote to its consumption. For instance, Susie takes a trip to Mauritius. If the cost of her flight is £1,000 then we know she is willing to pay at least that amount to see Mauritius. This is the basis of the travel cost method. Suppose there were four equal-sized countries that supply tourists. The total cost for someone visiting from country i would be the monetary costs of the visit (m_i) plus the time costs (expressed in £) or, $m_i + t_i w$

where t_i is the time spent travelling from the ith country and w represents the opportunity cost of time. Let us imagine that for the four countries, the percentage of the population and total costs visiting Mauritius are (0.1, 1000), (0.06, 1500), (0.04, 2000) and (0.02, 3000). Note that as the costs rise, the number of visitors dwindle. Essentially, these are observations on a demand curve and we can plot them then use regression to discover a line of best fit (see Figure 9.3 where the crosses represent observations).

Figure 9.3. Estimating demand from travel cost data



If country sizes differ then adjustments must be made and we would also want to gather data on the age, sex, and income of all visitors to control for these variables in the estimation procedure. In the absence of individual-level data we might have to use country-level data, though that would limit the information that is obtained from the regression.

The method yields an estimate of consumer surplus, but it omits non-use benefits. For instance, many people might have no intention of visiting Mauritius, but they might place some value on the existence of high quality coral reefs. A second major problem with the travel cost method is that we need to have an estimate of the opportunity cost of time. We might argue that most visitors are on annual holiday so that the time spent in travelling would not normally be used for work. In this case we would still need to have some estimate of the value of the leisure time lost by sitting for many hours in a plane.

A third problem is that typically individuals travel for more than one reason. For some, the coral reefs are the only reason for their visit. For others who like sun, but not the sea, the quality of sea water may play only a small part in their decision. So, the analysis has to apportion the benefits of the trip between its different purposes, only some of which will be relevant to the project or problem being valued. For instance, in a study by Cesar et al. (2002) of the value of reefs around Hawaii, the authors obtain travel cost data for visitors coming from mainland USA. By using economy-class air ticket prices they estimate the basic travel costs for each group. To get an estimate of the total travel costs they assume that the opportunity cost of time equals 1/3 of the wage rate for visitors. To get a feel for the importance of the reefs to the visitors they include a question about its relative importance compared to the other reasons for visiting and attribute costs on that basis.

- **Hedonic pricing**

Rooms with a sea view cost more per night than those without; detached bungalows cost more than semi-detached or hotel rooms; and rooms with a balcony fetch a higher price than those without. In each case, the value placed on the amenity (a sea view, no shared walls, a balcony) is revealed by supply and demand. The method can sometimes be extended to deal with environmental amenities such as noise and air pollution. Rooms in hotels neighbouring an airport generally rent at a discount to identical buildings away from the flight path. The value that people place on quiet can be revealed by the choices they make. Hedonic pricing can therefore be used to value resources and features appreciated by visitors. By using house prices or house rents, it can also be used to value environmental features appreciated by the local population.

The problem with the hedonic pricing method is that other factors affect land prices, including many that are not environmental. Disentangling factors like this is difficult when the sample size is small in comparison to the number of factors, and in particular when factors are correlated across the sample[2]. For instance houses close to the shore face a higher risk of flood damage, but at the same time often benefit from a better view compared to houses inland. Hedonic pricing may be used in this instance to place a value on living close to the sea, but not its separate components, higher flood risk and a better view.

Applications of stated preference approaches

As we have just stressed, with many amenities it is not possible to use revealed preference methods. Instead, we have to rely on individuals answering hypothetical questions designed to reveal the value they would place on the good if it was marketed. In environmental economics in particular, this *contingent valuation* (CV) technique, though controversial, is widely employed. Similar methods are employed to evaluate safety improvements and in healthcare. There are a variety of difficulties with the CV technique, which call for caution in using its results. Nevertheless, its use is spreading and manuals for its use by government officials are now widely available (e.g. Bateman et al., 2002). One reason it is used is because non-use aspects of valuation cannot be estimated in any other way. Because there is no behaviour associated with non-use value, its level cannot be estimated using revealed preference methods. Often charismatic species or famous world monuments have this feature, so stated preference can be particularly important for rare or precious environmental features such as coral reefs or, for example, the Easter Island statues.

With stated preference methods, individuals may often have incentives to misrepresent their preferences for collective goods. Someone who is asked: 'what are you willing to pay for cleaner beaches?', but who is then told that they would not actually have to pay anything would have an incentive to overstate their valuation. Similarly, if asked the same question, but told that they would have to pay, then there would be an incentive to free-ride on other people. The problem is known as *strategic bias*.

The most commonly used method of eliciting values is an alternative technique known as *dichotomous choice*. Respondents are simply asked 'are you willing to pay x?', with x varied over the sample, and a bid curve[3] is estimated. The procedure is similar to that employed in the travel cost method, though the demand curve estimated is compensated rather than Marshallian.

While the dichotomous choice technique overcomes the problems of strategic bias in CV responses, a number of other problems remain, two of which we will consider here. The first is the tendency for individuals to give similar willingness to pay (WTP) figures for a large project (e.g. 'save endangered species') and its component parts (e.g. 'save the whale'). Known as part–whole bias or the embedding problem, its presence in a survey may require careful interpretation:

- It may be that the marginal utility of the amenity declines rapidly, so that it truly is the case that the value of the larger project is only slightly higher than that for its components.
- It may be that the survey does not actually elicit the values of the parts and the whole. Instead, the people doing the survey treat it as a hypothetical exercise where they are given the opportunity to advertise their altruism. They may then feel a 'warm glow' from saying 'yes' to the key questions. Since answering 'yes' to any bid value would yield the same 'glow', then the aggregate results suggest that the component and the whole are valued more or less equally.
- It may be that individuals truly do not have coherent preferences for the good in question and are guided by the suggestions of value embedded in the questionnaire.

It is important to be able to distinguish between these answers. Good surveys test subjects' understanding of the problem and probe their ability to formulate realistic answers. Some surveys therefore include 'cheap talk' reminders to participants of the possibility of 'warm glow' answers. It is also common to ask the same individual to value both the smaller good and the larger good and it is also common to split the sample so that the order in which the two are presented varies randomly. In this way, we can see both if the values for the part and whole differ for each individual, but also we can check to see if it is the first bid value that determines subjects' answers.

The possibility that the first bid value determines subsequent figures is known as 'starting point bias' – an example of *anchoring*, where subjects with uncertain values for the good respond to the numbers given to them. Anchoring has been demonstrated in a variety of circumstances, many of them quite unrelated to valuation. The many settings where anchoring has been found include guessing solutions to multiplication problems and the estimation of the number of African countries in the United Nations. In these tasks, subjects have to say whether the correct answer is above or below a value suggested by the experimenter. A classic example is provided Ariely et al., (2003), who asked students for the last two digits of their US social security number and discovered that it was correlated with their reservation prices for a number of unfamiliar goods. In other words, the higher the person's social security number, the bigger the value they tended to attached to the goods. When anchoring occurs in valuation, it calls into question the validity of the whole contingent valuation exercise because it suggests that individuals do not have well-formulated preferences. Instead, it suggests that they construct values and valuations based on the information they encounter – even if that information is actually irrelevant.

So, as with part–whole bias, it is important for researchers to test for anchoring in the data. And, if the data does show evidence of anchoring, then it must be viewed as less reliable for potential decision-makers.

Recently, economists have realised the value of having more structural data about preferences including, for example, whether people are willing to pay for better waste management. Methods from marketing and consumer psychology have been adopted resulting in what are known as *choice experiments*. In a choice experiment the attributes of the good are varied. Consider, for instance, possible improvement to a town's waste management scheme. Perhaps currently there is a problem with run off from a land fill site into a river after heavy rains and problems of flies and vermin during hot weather and smell when the wind is in a certain direction. We can assume different levels of investment into reducing the problem and different ways of tackling the issue. We can also assume that people in the town may have different priorities for the different aspects of the scheme. Subjects would face a series of questions like the one shown in Table 9.4, which just happens to have three alternatives. The values of the attributes would change between questions and a discrete choice model used to estimate the utility function for participants.

As an example, Beharry and Scarpa (2007) used a choice experiment to examine preferences for coastal management amongst visitors in Tobago. Among the attributes included

Table 9.4. A choice of experiment question

	Option A (no change)	Option B	Option C
Local tax, per month per household	No change	$1 more	$2 more
Days of run off into local river, per year	30	20	20
Days of flies per year	25	20	25
Days of smell per year	50	50	25
Choose one	☐	☐	☐

in the design were: visibility, probability of gaining infection during swimming, numbers of fish and the establishment of a marine park. They found that visitors were willing to pay a small sum (around US$1) towards the establishment of a park that restricted fishing rights, but twice this amount for improvements to water visibility and $6 per visitor for reductions in the probability of an ear infection.

To sum up, choice experiments therefore provide more information about the shape of the utility function. As such, compared to traditional contingent valuation techniques, the decision-maker can evaluate more options at once using the same survey. However, it can be easy to overwhelm subjects with information. Moreover, issues of part–whole bias and anchoring do not disappear when choice experiments are used. Though these new methods have been tested much less than traditional methods of estimating benefits, there is no particular reason why they should not have many of the same defects.

Conclusion

Fundamentally, economic valuation of the environment in SIDS involves the same kinds of techniques are as used in other countries. However, risk is probably more important in SIDS than in many other countries. In addition, the high dependence of many SIDS on tourism means that the pool of beneficiaries from an environmental management initiative needs to be examined carefully before a valuation study is undertaken.

Further reading

Hanley and Spash (1993) is slightly old but is still a good introduction to valuation of the environment. For an up-to-date manual on stated preference techniques, Bateman et al. (2002) is recommended and widely used. Brander et al. (2007), applies many of the ideas to SIDS and has many interesting examples.

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Notes

1 In everyday life, risk usually means the risk of the downside, of failure or disaster. In economics, risk means variability. For instance consider the possibility of a volcanic eruption, like the one which devastated much of Montserrat in 1995. This is undoubtedly a negative event. As the probability of an eruption rises from zero, the expected impact rises. The riskiness of the event can be measured here by its variance, which rises until the probability equals 0.5 then falls again. When volcanic eruption is certain, there is no risk.

2 The market for land used for hotels and that used for other purposes will typically be closely linked. Thus a comprehensive hedonic price analysis of an environmental amenity in an area where there are many tourist developments can be potentially complex.

3 A bid curve shows the proportion of the population who state they are willing to pay x for different levels of y. The area under the bid curve is then the mean willingness to pay. See Hanley and Spash (1993) for more details.

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Chapter 10

Tax instruments for environmental management in tourist destinations

Introduction

The intent of this chapter is to discuss some of the theoretical and practical issues associated with tourism taxation and to consider in more detail an approach that relies on a tax instrument that is already used at the local level in most developed and developing countries – property taxation. We begin by briefly addressing the major issues associated with identifying and measuring the external costs associated with tourism. That is followed by a brief review of analyses of alternative revenue instruments designed to internalise those external costs. The possibility of using property taxation is then addressed followed by a short summary and conclusion.

Background

For many developing and developed countries, tourism constitutes a primary service-based industry. And where a substantial portion of tourists are foreign, the incomes generated can be considered equivalent to an export industry[1]. With growing personal incomes throughout the world, the income elasticity of demand for tourism and increased availability of information regarding tourism opportunities in 'foreign' lands has led to very large increases in international tourism activity over the past decades. Table 10.1 gives details on international tourist arrivals worldwide between 1995 and 2006.

International tourist arrivals market

Tourism can, however, be considered a 'double-edged sword'. Despite the direct and indirect benefits from tourism activity, massive numbers of those same spending units can create a variety of damages to the local (and global) environment. The United Nations Environment Programme (UNEP) has identified three main areas where tourism can have a detrimental effect on the 'local' environment. These include: depletion of natural resources such as water and land quality; pollution of the air, water, and the landscape (through littering), as well as additional noise; and, finally, negative physical impacts on flora and fauna including destruction of coral reefs. UNEP also recognises that the global environment can be adversely affected if tourism leads to the loss of biodiversity, depletion of the ozone layer, or climate change[2].

Table 10.1. International tourist arrivals worldwide between 1995 and 2006

	International tourist arrivals (millions)					% Market share	% Change		% Average annual growth
	1990	1995	2000	2005	2006	2006	05/04	06/05	00–06
World	**436.0**	**536.0**	**684.0**	**803.0**	**846.0**	**100.0**	**5.5**	**5.4**	**3.6**
Europe	**262.3**	**310.8**	**392.5**	**438.7**	**460.8**	**54.4**	**4.3**	**5.0**	**2.7**
Northern Europe	28.3	35.8	42.6	51.0	54.9	6.5	7.8	7.6	4.3
Western Europe	108.6	112.2	139.7	142.6	149.8	17.7	2.6	5.0	1.2
Central/Eastern Europe	31.5	60.0	69.4	87.8	91.2	10.8	2.2	3.9	4.7
Southern/Mediter. Europe	102.7	140.8	140.8	157.3	164.9	19.5	5.9	4.8	2.7
Asia and the Pacific	**56.2**	**82.5**	**110.6**	**155.3**	**167.2**	**19.8**	**7.8**	**7.7**	**7.1**
North-East Asia	26.4	41.3	58.3	87.5	94.0	11.1	10.3	7.4	8.3
South-East Asia	21.5	28.8	36.9	49.3	53.9	6.4	4.9	9.3	6.5
Oceania	5.2	8.1	9.2	10.5	10.5	1.2	3.7	0.4	2.2
South Asia	3.2	4.2	6.1	8.0	8.8	1.0	4.7	11.0	6.4
Americas	**92.8**	**109.8**	**128.2**	**133.2**	**135.9**	**16.1**	**5.9**	**2.0**	**1.0**
North America	71.7	80.7	91.5	89.9	90.7	10.7	4.7	0.9	-0.2
Caribbean	11.4	14.0	17.1	18.8	19.4	2.3	3.7	3.5	2.2
Central America	1.9	2.6	4.3	6.3	7.0	0.8	13.2	10.8	8.2
South America	7.7	11.7	15.3	18.2	18.8	2.2	11.9	3.0	3.5
Africa	**15.2**	**20.1**	**27.9**	**37.3**	**40.7**	**4.8**	**8.8**	**9.2**	**6.5**
North Africa	8.4	7.3	10.2	13.9	14.9	1.8	8.9	7.4	6.5
Subsaharan Africa	6.8	12.8	17.7	23.3	25.8	3.0	8.8	10.4	6.5
Middle East	**9.6**	**13.7**	**24.5**	**38.3**	**41.8**	**4.9**	**5.9**	**8.9**	**9.3**

Source: World Tourism Organisation (UNWTO)

Economists consider these potential adverse effects of tourism activity as *externalities* since the behaviours of tourists (and industries supporting tourists) are imposing costs on others (including present and future generations) without bearing any of the costs themselves. In such instances, economic theory calls for some sort of policy intervention which will result in tourists directly bearing the costs associated with their behaviour. One such policy instrument which is often recommended is taxation.

Ideally, the tax instrument imposes a burden on participants in the tourism market to encourage them to alter their behaviour in a manner that will lead to an outcome where the additional full costs of their activities will approximate the additional benefits they derive. Such taxes are termed *Pigouvian taxes*, named after the economist who first suggested this approach for internalising externalities (Pigou, 1947). While implementation of Pigouvian taxation poses administrative challenges, it provides an underlying rationale for the use of tax instruments to internalise the externalities associated with the tourist industry.

Tourism and the environment

Environmental impacts of tourist activity worldwide are considered to be substantial (Green et al., 1990). However, empirical evidence on environmental degradation due to international tourism in LDCs is scarce. It is known that a variety of activities associated with developing and enlarging the tourism industry can entail environmental and other, direct, costs.

Where land formerly devoted to agriculture and industry is converted for tourism purposes, that conversion and infrastructure construction can have significant environmental implications. The highest rates of soil erosion are witnessed in the construction phase because there is a large amount of exposed ground, and noticeable disturbance produced by vehicle movements and excavations. According to a study, rates of erosion associated with construction and urbanisation are much higher than those obtained in undisturbed areas (Vice, et al. 1969, taken from Gouldie, 1996).

The supply of coastal resources and other environmental goods cannot be adjusted instantaneously or even with a lag in response to rising tourist demand, which would, in fact, accelerate the rate of depletion and degrade the quality of natural capital. This suggests a need to regulate the growth of international tourist inflow to avoid any excessive use of these resources.

There are several ways of approaching the challenges of maintaining the quality of environment in the face of rapid tourist population growth, including directly regulating tourist inflow, imposing fees on visits or designing taxes. As suggested above, the strategy of encouraging growth in tourism has its own potential advantages. International tourism growth can lead to rising per capita incomes in the host country, which in turn would help these countries to spend more on maintaining the threatened environment. This is supported by the historical experiences of OECD countries. According to the World Bank (1992b), 'concentration of a number of atmospheric pollutants are increasing functions of GDP per head when GDP per head is low, and are decreasing functions when GDP per head is high'. This relationship is better known as the environmental 'Kuznets' curve (Dasgupta and Mäler, 1995).

This approach, however, does not take into account the fact that environmental issues present themselves differently to different situations. Even though most of the environment may be renewable natural resource, the rate of resource depletion may exceed the rate of regeneration and this may reduce net gains. Technologies on the regeneration of natural capital are less known, though greater attempts are being made in this direction. Therefore, to maintain the rate of growth of net gains from international tourism, it would be necessary to regulate the growth of such tourists. In this framework, there is no place for subsidising international tourism (Jenkins, 1982; Tisdell, 1983; Piga, 2003). Thus, between regulation of tourist inflow and taxation of tourists, we argue for taxation both for the preservation of the environment, and as a source of revenue for the host country to meet the cost of environmental management. In other words, a greater emphasis is placed on restructuring the existing system of taxation of the tourism sector. This approach is in line with the World Bank (2000) study of the Caribbean region which

proposes several ways to capture economic rents from visitors with a view to enhancing the sustainable use of environmental resources.

Most environmental accounting systems, including the system of integrated environmental and economic accounts, suggest that degradation should be measured by obtaining estimates of restoration costs, rather than by attempting to quantify the effects of degradation (Harrison, 1993). Estimating restoration costs is, however, not simple. While governments do undertake efforts to prevent degradation or restore the environment, using these expenditures as an estimate of actual restoration costs is unlikely to be satisfactory given the budget constraints faced by developing countries. Nevertheless, the fact that a government undertakes preventative or restorative activities does at least indicate the government's judgment that benefits exceed the costs. One of the important preconditions for successful implementation of environmental protection projects, however, would be the adequate social cost recovery. What is crucial is that tourists' willingness to pay for tourist private goods should also include willingness to pay for a related public good, i.e. environmental protection. In this way, we avoid measuring the social cost of international tourism but instead calculate the revenue that would be generated if tourists were to be taxed for the social cost they produce.

Tourism and taxation

According to WTO (1998), the tourism sector represents about 10 per cent of GDP and investment worldwide and is expected to grow at the rate of about 4–5 per cent per year in the next 50 years. This international trend carries implications for the economy and the environment, and thus requires government intervention through fiscal policy. Tourism generates a fairly large share of national income for destinations. It is not uncommon for 'tourist countries' to get 10–25 per cent of their fiscal revenues from this sector. In some small, highly specialised countries, such as The Bahamas, over 50 per cent of government revenue is derived from tourism. However, generally, the net revenue gain from tourist activity may sometimes be much smaller. It has been estimated that perhaps only 10 per cent of gross receipts go to the governments of the Caribbean countries (Bryden, 1973) compared to 20 per cent reported in a number of other countries, such as Tunisia and Kenya (de Kadt, 1979). In the WTO Report (1998), a list of about 40 to 45 different types of taxes is presented, which fall on the tourism business and tourists directly or indirectly.

Whereas short-period international tourist stays are very common and such tourists do pay different types of taxes and fees imposed by destination governments, analysis of taxes on international tourists has not attracted many researchers. Tisdell (1983) and Bird (1992) are among the first researchers to offer a comprehensive account of taxes on international tourists, tax administration issues and public finance implications. Other researchers such as Combs and Elledge (1979) and Fujii, et al. (1986) discuss mainly the incidence of taxes on tourist accommodation in terms of who pays the tax and if taxes can be exported to tourists through higher accommodation cost.

Some recent studies link international tourist taxes with preservation of environment.

Cremer and Thisse (1999) have shown that international tourists may be willing to pay more to buy an environmentally friendly products in imperfectly competitive markets. Nath (1993, 2001) emphasises the role of local business property tax as a Pigouvian tax on tourist accommodation in financing visitor destination improvement projects in small island economies highly dependent on international tourists such as Mauritius. Piga (2003) using a game theoretic approach, derives results that link local government taxes and land management for tourism industry. The author shows that in equilibrium, a private monopoly would develop land more rapidly than a public monopoly. This development, however, is at the cost of faster exploitation of natural resources. In this context, the author advocates a development tax on land as a Pigouvian tax depending on environmental damages. In recent papers, Gooroochurn and Milner (2005) and Gooroochurn and Sinclaire (2005) developed a computable general equilibrium model to explore the efficiency and equity of changing sales tax rates on tourism and non-tourism related sectors. They examined various trade-offs and complexities associated with taxation of the tourism sector. Their models show that most tourism sectors are currently under-taxed and that raising taxes on these sectors is socially efficient and welfare improving.

However, computating the tax burden that international tourists should carry is not straightforward. The bulk of the burden of certain taxes and fees can often be directly attributed to international tourists and international business travellers. Among these are airport landing and parking fees and departure taxes, license fees and permits granted to tourist-oriented businesses, and taxes on casinos. Often, the preponderance of taxes is levied on up-scale hotels and restaurants[3]. Other taxes are borne by tourists and local residents alike. For example, value-added taxes applied to services consumed by both residents and non-residents will be borne by both groups and the extent of the burden on tourists will depend on the tax rate structure and tourists' spending patterns.

There are four main components of international tourist spending – foreign travel, accommodation and food, inland tour services and facilities, and shopping. What makes the computation of tax burdens more difficult is the fact that these shares are not necessarily constant. For example, there were significant changes in the pattern of tourist expenditure in Mauritius during 1980–86 (EIU, 1991). The share of meals and drinks increased from 8 to 18 per cent, while spending on local transport fell from 16 to 8 per cent and shopping and gaming rose from 13 to 20 per cent. Finally, spending on accommodation, the most important expenditure category after travel costs, declined from 60 to 52 per cent of total in-country tourist expenditures.

Finally, a full consideration of the taxes associated with international tourism should include taxes falling on incomes generated by international tourists in the host country. These may or may not be ultimately borne by tourists. Direct taxes imposed on the incomes of labourers employed in the tourist sector are probably borne directly by those labourers. It is harder to determine whether taxes on the incremental profits of businesses attributed to the additional economic activity associated with tourism are shifted onto the tourists or borne by in-country owners of those businesses and their suppliers of factors of production.

Ultimately, whether tourists pay a higher proportion of total tax collected than residents depends on tax policy. What is important here is to ascertain whether government in design-

ing tax rates is influenced by the interest of the resident population or puts a higher rate on international tourists, keeping in view the damages due to international tourism. A rough estimate of this can be obtained by looking at the relative size of the tourist population compared to the total population during a period of time, a day or a month. For example, in Mauritius, the proportion of international tourists within the total population is no more than 10–12 per cent in the peak months (EIU, 1991). Thus, international tourists do not constitute a significant proportion of consumers that would have generated any tax bias against or in favour of them in general consumption and miscellaneous taxes. According to one estimate (GOM, 1992, Table 2.15), Rupees 118 million was collected in the form of import duties, Rs 20.5 million as excise duties, and Rs 47 million as sales tax on goods and services consumed by international tourists in 1991. It is clear that a good part of these taxes becomes payable by international tourists in their capacity as a paying guest or as a temporary resident but not as a charge for the social cost of tourism enjoyment.

Linking tourist taxes to environmental costs of tourism

As discussed above, ideally tax policy will impose a tax on tourism that can capture the social cost of increased tourist travel. Tax rates should correspond to the social costs imposed by international tourists; the greater the social cost, the higher should be tax rates. Tax policy may be designed in the light of the fact that international tourists travel to enjoy a diffused 'product' at a specific place (destination), where it is produced. Some of these combinations cannot be replicated in other destinations, which indeed may confer on the host country a monopoly power to treat the visitors as more than a paying guest for charging purposes. Nevertheless, the availability of alternative tourist destinations may produce semi-competitive conditions in the tourist accommodation sector.

In principle, higher demand for accommodation by tourists will generate greater demand for environmental resources, both as enjoyment of amenities and inputs in the production and consumption of tourism services. As the supply of the environmental resource increases, its marginal product decreases because environmental quality goes down. While on the consumption side accommodation and environmental resources are complementary, they will be substituted in the production of such goods and services. Substitution possibilities between the environment and accommodation can be enormous because the latter involves conversion of land devoted to agriculture and industry for tourism purposes on a considerable scale, Both conversion and construction could have significant effects on the ecological balance of a site and pose environmental complications. Thus, both consumption and production activities would entail loss of environmental quality. This would indicate that a rise in the market value of accommodation generated by demand and supply forces in the tourism sector would be at the cost of environmental quality. Thus, the higher the value of accommodation, the lower will be the environmental quality. This relationship suggests that the market value of accommodation will constitute a reasonable base of any Pigouvian tax on international tourists since the market value of tourist accommodation and tax liability will be positively related.

The value of tourist accommodation is also justified as the base of a Pigouvian tax in terms of optimal tax theory. It is argued in the literature that, in the absence of 'tax handles' to

tap leisure, it may be superior to tax consumption items that are complementary to leisure (Hardy, 1993). Tourism is largely a leisure activity; about 90 per cent of tourists can be grouped under 'leisure as a purpose of visit' in Mauritius (EIU, 1991). And, as was noted above, about 60 per cent of total tourist expenditure is accounted for by accommodation.

Direct taxes on accommodation can be realised through additional ad valorem 'tourist taxes' imposed on hotel room tariffs. In fact, this is very common throughout the world, particularly in sites catering to tourists (international or domestic). Furthermore, differential rates might be imposed depending on the nature of the accommodation (e.g. two-star hotels would require a lower tax paid by tenants than a four-star hotel) or the residence status of the tenant[4]. A potential disadvantage of such taxes imposed in an attempt to internalise the externalities of international tourists is that hoteliers may collude with hotel guests to impose lower room charges, resulting in tax revenues that fall short of the external costs associated with tourism activities.

Using business property taxation to capture the environmental costs of tourism

The use of property taxes on international tourist accommodation is feasible and can have the benefit of capturing the environmental costs of that tourism. It does, however, face certain administrative challenges that are described below.

For a given trend in tourist arrivals, the market value of a tourist business property would rise due to the capitalisation of tourism growth trends in land value and property value. Thus, the trends in market value would broadly capture the increased tourist travel and associated social cost. Symbolically,

> Tourist Business Property Tax (TBPT) liability = (C*+ m)t* where C* is market value of accommodation; and t* is TBPT (Pigouvian tax) rate on tourist accommodation.

Under an ad valorem room tax, different amounts of taxes are payable for the same amount of accommodation used even though the same amount of accommodation is assumed to create the same social cost. Under a Pigouvian tourist business property tax, higher taxes will be associated with higher amounts of accommodation used. As such it will capture tourists' willingness to pay for the social cost produced. The merit of a tax on the tourist business property value is that when the social cost of increased tourist travel rises, which is manifested in the increased market use of accommodation, tax liability would also rise.

Conditions for effective tourist business property tax administration

Although the administrative details associated with a tourist business property tax will differ depending on the country in which it is used, the imposition of any property tax requires a number of specific administrative steps. These may include:

1. specification of which level of government has the right to impose and collect a property-based tax;
2. identification of taxable property;

3 valuation of that property;
4 imposition of a levy against the valuation; and
5 collection of the taxes due.

Property taxes are most commonly assigned to local governments, since such taxes have theoretical and practical advantages as local revenues relative to other taxes. However, where the tax is intended to correct for market failures due to the externalities associated with tourism, it is probably most reasonable for the tax to be imposed by a national or at least a regional taxing authority. This is because the external costs of at least some of the activities of tourists fall on all residents of the country; as such, internalising the externalities should be carried out on a basis beyond the immediate locality[5]. In some countries such as Mauritius, this could require the creation of new taxing districts (discussed in more detail below). At present in the country, hotels, guesthouses, bungalows, huts, restaurants and shops located outside a municipal jurisdiction are not liable to pay (local) property taxes. Given the island's topography, all the municipal areas are located at its centre, but most of the tourist accommodation is found very close to beaches. These properties, which do not fall under municipal councils, are not assessed for municipal rates. The proposed tourist business property tax is based on the logic that the business component of local property tax should be applicable to all properties devoted to business and entertainment irrespective of their location.

In areas where property taxation is already in place, identification of taxable tourist business properties has already occurred. While identification of small properties, e.g., residential houses in large cities, can be challenging, identification of large tourist-oriented hotels should be easily identified even if they are not on the current property tax rolls[6]. Furthermore, it is easy to observe construction of new tourist accommodation.

A determination (assessment) of the taxable value of a parcel is generally the most difficult administrative task associated with property taxation. Interestingly, different countries utilise different definitions of what constitutes taxable value. One approach – the capital valuation method – requires an estimate of the market (capital) value of the property, i.e. at what price a willing buyer and seller would be willing to purchase/sell the property. A second approach – annual rental valuation method – attempts to estimate the annual rent that the owner of the property could fetch from willing tenants. For instance in Mauritius, the tax base is the rateable (rental) value of property, which is determined by the central assessment authority. Hotels and other accommodations are assessed on the basis of room rents adjusted for occupancy.

Unfortunately, due to administrative problems of assessment processes, assessed valuations of properties under either the capital or annual rental value approach generally lag behind the true value[7]. Moreover, market transactions in hotels/motels are quite infrequent, which makes the availability of the data on the market value of tourist business properties quite difficult.

An alternative and better way to deal with the problem of continuous assessment, which heavily relies on market value of properties, is to use the standardised rates with a provision to make it grow in response to rise in demand. Standardisation proposals in the literature

have taken several different forms. One approach is area-based standardisation of tax payment: ORG (1979) and Ramakrishna (1980) have suggested moving away from rental value and relating property tax to the plinth area. Surcharges or 'extras' may be added according to location, type of construction, nature of use and age of building. Each of these would be divided into a few categories and a tax value would be attached to each category. In the second approach, rental or market value per unit of area is fixed.

The fourth step in any property tax system is determination of the tax rates. Generally tax rates are determined (if not otherwise constrained by legislative upper or lower bounds) on the basis of the desired level of projected revenues and the assessed tax base (the 'tax value'). Tourist business property tax (TBPT) rates can be fixed per sq. ft of covered area under a property. The location and quality of property would automatically result in different standard rates.

One desirable attribute of any tax system is that revenues grow with a corresponding rise in the demand for services and in the costs of those services due to changes in prices. It is, obviously, necessary to generate enough revenue to meet government expenditure on tourism-related maintenance. In order to impact growth or elasticity in TBPT revenue, either the base or the rates must be adjusted annually to reflect the effects of those factors.

It would be quite useful to develop a tourism growth index combining relevant factors for indexing proposes. Revenue requirements can be made to depend upon the growth rates of total tourist arrival (g_1), total tourist expenditure in the host country (g_2) and general government expenditure (g_3). g_1 captures the effects of larger tax-paying populations, g_2 measures tax payers' capacity to pay, and g_3 is indicative of increasing requirements for government expenditures to maintain tourism projects. An average of these rates (g) would give a measure of the rising cost of environmental protection, which can be used for indexing purposes. TBPT payable by a tourist business property can now be calculated in either of the following ways:

- **Alternative 1**
  $TBPT = AAO [t_0 (1 + g)]$
- **Alternative 2**
  $TBPT = t [(AAO) MV (1 + g)$

  where,
  - AAO : Area under property adjusted for occupancy
  - MV : standardised market value per unit of property
  - t_0 : standardised tax rate per square feet covered area
  - t_a : tax rate per square feet covered area
  - g : growth rate of total tourist arrival

Alternative 1 proposes indexing the standard tax rates as against indexing the standardised market value in alternative 2. Standardised rates can be worked out in view of revenue needs, which can be fixed in terms of the estimated government expenditure on maintaining the environment for conducting tourism business. Benchmark estimates of the maintenance costs of projects and informed qualitative judgements can also be used as a guide.

These tax methods are an attempt to acquire economic rents bestowed on the private sector in an administratively feasible way but they may not be equal to Pigouvian taxes. Lump sum taxes are not Pigouvian since they do not affect the marginal conditions to create incentives and disincentives. In fact, these taxes once paid to cover pollution cost would encourage the taxpayer to pollute as much as possible so as to maximise benefit from the payment[8]. If the idea is to regulate the demand in Pigouvian terms, then it is imperative to specify different pricing methods to those derived from marginal conditions. Indexing these rates in line with tourism growth will not influence the short-run marginal costs, but presumably will affect in the long run to the extent that they are included in the long-run marginal cost. This long-run effect is crucial in the present tax design. The willingness to pay for environmental damages through TBPT would have implications for the demand for accommodation depending on who bears the burden of the tax.

The TBPT burden

Who pays TBPT is a central issue for tax design and reform. Even though it is statutorily payable by the owners of property, there may be situations when the tax may be shared between the owner of property and tourists, or it may fall separately on owners or tourists. Ideally, the TBPT will be shifted to tourists who are the principal reason there is environmental degradation. Furthermore, if the tax is exported it will not generate adverse effects on resource allocation in the tourism sector, e.g. will not be shifted on to labour. There have been studies in the USA (Combs and Elledge, 1979 and Fujii, et al., 1985) which show that a substantial portion of such taxes are shifted to tourists.

There are two distinct views on the incidence of the residential property tax- traditional and modern[9]. Since the value of accommodation consists of the land value and the value of any structures on the land, the theoretical approaches differ as regards their treatment. A tourist tax would tend to be shifted if capital is mobile, supply of land is elastic and the demand for accommodation is price-inelastic. Where, as in the case of Mauritius, there is an excess supply of tourist accommodation, tax-shifting outcomes will largely depend on demand conditions in the accommodation market. As long as international tourists are price takers, market conditions will be favourable to tax shifting. Data on tourist preferences and cost differences in alternative destinations are not available. Nevertheless, the recent trends in international tourism in Mauritius and many similar countries can help form some opinion about tax shifting.

It is important to note that the upward trend in tourist arrivals in Mauritius has continued unabated despite the fact that the rents and prices in the domestic markets have increased. However, continuous depreciation of the Mauritian Rupee would have minimised the effect of these cost increases. Thus, small increases in the cost of tourism due to BPT, which is considerably neutralised by the currency depreciation would have little adverse impact on the tourist demand. In other words, BPT is more likely to be borne by international tourists. Even under the conditions of relatively stable exchange rates, such taxes will be borne by international tourists because of the up-market profile of tourists to most developing countries.

Administration of TBPT

In most countries, a final political question must be addressed – namely, what government entity should be given the responsibility for designing, imposing and administering the TBPT. Several alternatives exist including the central government as part of its overall revenue raising – public spending responsibilities; local governments; or the creation of a new, special purpose district.

Local governments, which traditionally have exclusive rights to property taxation in many countries, may argue that since the TBPT is a property-based tax, the revenues should accrue to them. An advantage is that such governments probably already have property tax administrative apparatus in place so that the transition costs would be lower with this arrangement. A disadvantage is that the funds collected under a TBPT may be diverted to uses other than environmental protection. Furthermore, there is always the risk that, in an attempt to attract additional private tourism investments, e.g. hotels to the locality, a local government may keep TBPT rates as low as possible. (This, by the way, is a potential issue associated with 'environmental federalism'.)

Finally, it needs to be recognised that some developing countries with strong international tourist sectors do not have property taxes imposed on tourist areas either because such areas lie outside municipal boundaries, e.g. Mauritius, or there are no municipal level property taxes in place. Thus, creation of a tourist business district may be in order. The economic argument for creating a tourist business district is based on the idea of the geographic area over which the tourist businesses are distributed. An idea of the incidence of such businesses can be ascertained by looking at the location of hotels, motels and huts. The geographical area over which they are scattered may cut across several district and village councils so a single taxing district can be more efficient than one that is segmented. This authority should be vested with independent expenditure and revenue functions. TBPT can be an important source of revenue for this business district authority. This authority should be the sole body to undertake civic functions in this area with a view to improving visitor destinations. This authority thus can be modelled as an autonomous single purpose parastatal body. However, this arrangement also has a disadvantage. As a parastatal, the authority may not be as accountable to the citizenry as are directly elected, representative municipal or urban districts.

Summary and conclusion

Taxation of international tourists has generally been attempted through the taxation of tourist expenditure, which is dominated by the cost of accommodation in the host country. Implementation of tourist expenditure taxation in the large informal tourism sector is a difficult task, which provides ample opportunities for free-riding. For the same amount of tourism enjoyment, a tourist can choose, in collusion with private providers of services, to pay a lower or insignificant amount of taxes. Therefore, even though such taxes are most suitable on administrative grounds, there seems to be a need for some other tax measure.

A proposal is made to employ tourist business property tax on the market value of tourist accommodation 'within' the existing framework of local property taxation. This tax is

based on the Pigouvian principles of taxing negative externality created by international tourism. It is important to note that such a tax does exist in all countries; however, its value as a Pigouvian tax is not recognised particularly in tourist destination countries. Economic trends and tourist public goods externalities are capitalised in the market value of accommodation. Thus, as the social cost of increased tourist travel rises, which is manifested in the higher demand for accommodation, tax liability also increases. A properly designed tourist business property tax would also capture informal accommodations, which are mostly used by low-spending tourists.

VAT may be retained on revenue grounds with suitably designed tax rates. There is a case for lower VAT rates as the consequences of a VAT would be economy-wide as against a more localised incidence of tourist business property tax. Even though VAT is popular on revenue grounds, there is a trend towards a reduction in VAT rates on tourist-related goods and services in the European Union.

To avoid any conflict with existing property taxes, it would become necessary to work out a mechanism of inter-governmental fiscal co-ordination between the central government and local level authorities, namely, municipalities and rural district councils. In the interest of the tourist sector, however, tax and expenditure sharing devices should have a bias towards improving visitor destinations. A better fiscal co-ordination can be visualised by assigning this job to a new organisation, namely, a tourist business district authority.

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Notes

1 It is, however, recognised that, particularly for many developing countries, the incomes generated from international tourists do not necessarily remain in country. Many of the revenues from airline tickets, four- and five-star hotels, cruise lines, etc. are, in fact, derived by multi-national firms.
2 For a fuller discussion of these see the UNEP, Production and Consumption Branch – Tourism website: http://www.uneptie.org/pc/tourism/home.htm
3 These generalisations are, however, more relevant for small developing countries than for larger or higher income countries where tourism by residents constitute a substantial proportion of all tourists. For example, it was estimated that of 44 million visitors to New York City in 2006, 37 million were residents of the United States with 7 million international visitors. (Reuters News Agency, December 27, 2006).
4 It is, for example, common to find higher room rates are imposed on hotel guests holding a foreign passport than on local residents.

5 It is also the case that if the property tax on hotels was made a local levy, local governments might find it to their economic advantage to under-tax hotels in order to entice additional hotel investment in the locality. This is comparable to the disadvantages mentioned above regarding the inefficiencies of using subsidies for attracting tourism-based businesses.
6 This constitutes another weakness of a hotel room tax. Informal accommodations can more easily avoid this levy than where all structures are on property tax rolls.
7 For a good description of these problems, see Bahl and Linn, 1992.
8 Obviously, for any pollution tax to be effective, the rate at the margin must equal or exceed the cost of the pollution.
9 For references on both theoretical and empirical literature, see Harberger, 1962; Bird and Slack, 1978; Nath, 1987; Nath and Sen, 1989; Bahl and Linn, 1992.

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Chapter 11

Road transport, motorisation and pollution

Introduction

In everyday life, people and goods have to be transported, often over long distances. Children have to go to school, the employed need to go to work, stock at shops has to be replenished, and businesses have to be looked after. All these activities require transportation and transportation requires roads and vehicles, especially in the absence of other modes of transport such as rail, air or waterways.

Whereas the benefits of the use of roads and vehicles cannot be denied, the fact is that such uses also impact upon the environment. Many of the negative impacts of road transport on the environment have been experienced in the urban areas of the highly developed countries. A 2005 World Bank publication stated that:

> 'Urban air pollution from road transport is a growing concern in a large number of developing country cities. With rising income, the use of motorized transport is expected to continue to increase in the coming years, potentially worsening air quality. Poor air quality in turn has been shown to have seriously adverse effects on public health. The World Health Organization estimated that 650,000 people died prematurely from urban air pollution in developing countries in 2000.'

Small Island Developing States (SIDS) may not be immune to these negative impacts. However, they may learn from the experiences of the developed as well as developing world to mitigate the impact and adapt to the risks.

This chapter begins with a discussion on the links between road transport density and vehicular expansion. The next section analyses the trend in motorisation and pollution, and considers some of the environmental impacts of road transport with particular reference to air quality. The fourth section examines some public policy responses to pollution from road transport. The final section offers some conclusions.

Road density and vehicular expansion

Rodrigue (2006) argues that the transport sector is an important component of the economy, impacting on development and the welfare of populations. When transport systems are efficient, they provide economic and social opportunities and benefits that result in positive multiplier effects such as better accessibility to markets and additional investments. When transport systems are deficient in terms of capacity or reliability, they can have an economic cost such as reduced or missed opportunities. Transport also carries an

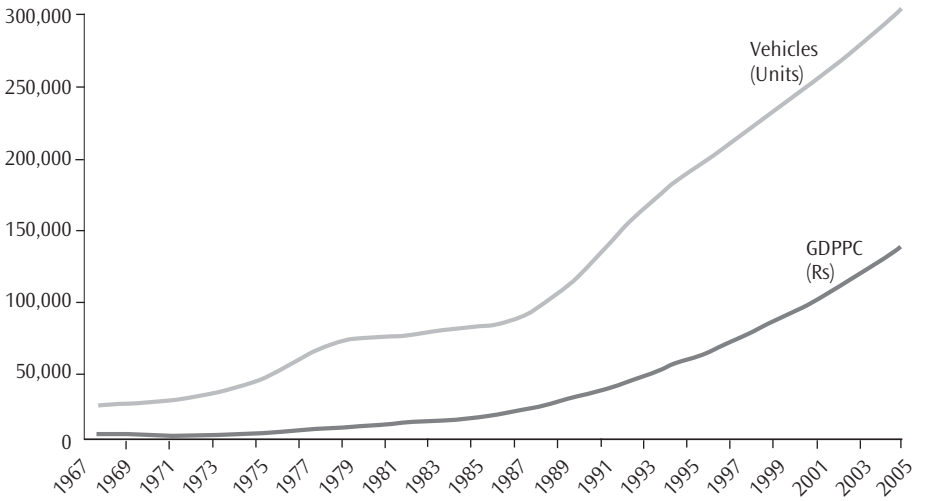
important social and environmental load, which cannot be neglected. It has commonly been the role of the government to promote and re-distribute wealth and, to that end, possessing the means of transport is a fundamental requirement that facilitates, intensifies and contributes to international trade. The necessity of international trade for economic development to take place has been illustrated by Barro and Sala-I-Martin (1992), and Collier and Gunning (1999), amongst others.

While it is established that higher growth levels are generally associated with greater availability of road infrastructure, there is considerable variation with significant outliers in both dimensions. Table 11.1 shows the road density in km of road/square km of land area and the GDP per capita in SIDS in 2008. Singapore, which is the most developed of the SIDS with a GDP per capita of US$52,000, has a road density of 4.72 km of road/square km of land area, followed by Bahrain at US$37,200 per capita/to 5.26; The Bahamas and Cyprus, both at US$28,600 per capita, against 0.27 and 1.58 respectively. Malta, with a GDP per capita of US$24,200, has the highest road density at 7.05 km of road/square km of land area.

The case of The Bahamas is striking. Among the SIDS with a road density of less than 1 km of road per square km of land area, it assumes the median position in terms of road density but the highest position in terms of GDP per capita and the third highest position overall along with Cyprus. With about the same road density (1.01 km of road per square km of land area against 1.00), the GDP per capita of Seychelles is 40 per cent higher than that of Mauritius.

Vehicular expansion in Mauritius has been significant. Figure 11.1 plots the rise in the number of vehicles registered since 1979 as well as GDP per capita. The relation between increase in GDP per capita and increase in the number of vehicles is clearly demonstrated. In fact, the rate of change in the number of vehicles is greater than the rate of change in GDP per capita as from 1987. The rapid economic growth (termed the Economic Miracle due to FDI-led light industrialisation) witnessed since 1983 was also manifested in transportation growth, thereby causing accelerated vehicular expansion.

Figure 11.1. Vehicles registered in Mauritius and GDPPC (1979–2005)



Source: Adapted by the authors using data from the National Transport Authority, Mauritius

Table 11.1. Road density and gross domestic product per capita (2009)

Small island state	Road density km/square km	GDPPC (US$) Estimates 2008
Antigua and Barbuda	2.64	19,000
The Bahamas	0.27	28,600
Bahrain	5.26	37,200
Barbados	3.71	19,300
Belize	0.13	8,600
Cape Verde	0.33	3,800
Comoros	0.41	1,000
Cook Islands	1.36	9,100 (2005)
Cuba	0.55	9,500
Cyprus	1.58	28,600
Dominica	1.03	9,900
Dominican Republic	0.41	8,100
Fiji	0.19	3,900
Grenada	3.28	13,400
Guinea-Bissau	0.12	600
Guyana	0.04	3,900
Haiti	0.15	1,300
Jamaica	1.99	7,400
Kiribati	0.83	3,200
Maldives	0.29	5,000
Malta	7.05	24,200
Marshall Islands	0.36	2,500
Mauritius	1.00	12,100
Micronesia, Federated States of	0.34	2,200
Nauru	1.14	5,000 (2005)
Palau	0.13	8,100
Papua New Guinea	0.04	2,200
Saint Kitts and Nevis	1.23	19,700
Saint Lucia	2.00	11,300
Saint Vincent and the Grenadines	2.13	10,500
Sao Tome and Principe	0.32	1,300
Seychelles	1.01	17,000
Singapore	4.78	52,000
Solomon Islands	0.05	1,900
Suriname	0.03	8,900
Trinidad and Tobago	1.62	18,600
Tuvalu	0.31	1,600 (2002)
Vanuatu	0.09	4,600

Source: The CIA World Factbook 2009: Central Intelligence Agency

Trends in motorisation and pollution

Mauritius is not endowed with mineral resources. Its sugar industry, light-machine-based garment industry, international tourism, financial and information technology services are its major economic activities. The growth of these sectors has been facilitated by the expansion of infrastructure of which road transport is an important segment. While all economic and human activities are sources of pollution, Mauritius's sugar industry, international tourism and road transport accompanied by motorisation can be identified as the principal pollution-generating activities. In this section, the focus is on trends in vehicular growth and motorisation-induced pollution. Pollution due to motorisation and traffic congestion in peak hours is the concern.

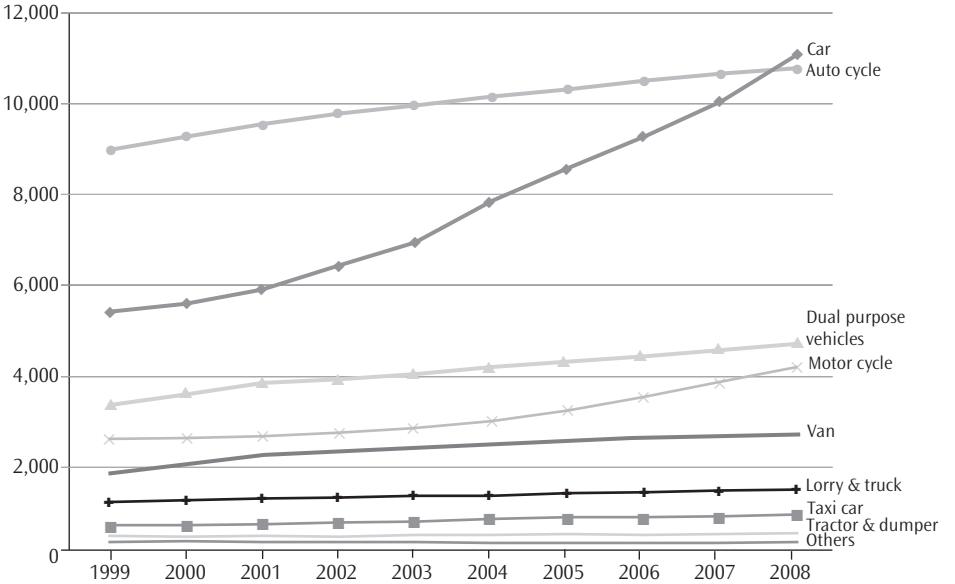
The urban and rural areas in Mauritius are well interconnected and every part of the island is accessible through tarred roads. The principal north–south link is through the capital city with, at present, no effective by-pass, giving rise to a serious problem of traffic congestion and air pollution. Traffic congestion in Mauritius has been a subject of concern for some time. The construction of a ring road in the central-government-cum-business district of Port Louis has been on the agenda since 1975. However, the proposed Terre Rouge – Verdun – Trianon Link Road, which will connect Terre Rouge and Rose Hill, will not greatly ameliorate the situation since it will bypass Port Louis by some distance.

Mauritius uses a system of evaluation of northbound and southbound vehicular movements, at strategic points along the highway (M1) to measure the level of traffic congestion having implications for air pollution. However, information regarding a measure of the air quality at different points on the highway or elsewhere was not accessible. It is now commonly observed that at peak times in 2009 the congestion on the M1, the principal main road from south to north in Mauritius extended over some 8 kilometres in three lanes to Port Louis and over 7 kilometres in two lanes from Phoenix towards Port Louis. The situation on lateral roads leading to the M1 is similar; journey times on the 17 m-long M1 can be one hour or more.

Several proposals to alleviate traffic congestion in Mauritius are under consideration. The 2007/08 budget *inter alia* provides for the Terre Rouge – Verdun – Trianon Link Road. The theory of induced traffic suggests that new roads bring their own users, and that an increase in vehicular traffic brings in its wake traffic congestion, which in turn gives rise to a number of environmental problems, such as oil spills on the roads washed onto adjacent land, thereby damaging the ecological system, litter from used tyres and spare parts, and air pollution. Thus new roads may not solve the problems of traffic congestion and related environmental issues in the country and it may make them worse. Further, SIDS that rely heavily on the tourist sector, such as Mauritius, would have a high proportion of their coastal areas serviced by roads. This will generate all the negative impacts that the use of these roads by vehicular traffic produces.

The number of private cars in Mauritius increased from 47,987 in 1999 to 102,556 in 2008, registering an average annual increase of 11.37 per cent. The trend of the number of vehicles registered according to vehicle categories over the past twenty years is shown in Figure 11.2.

Figure 11.2. Trend of the number of vehicles registered in Mauritius according to vehicle categories

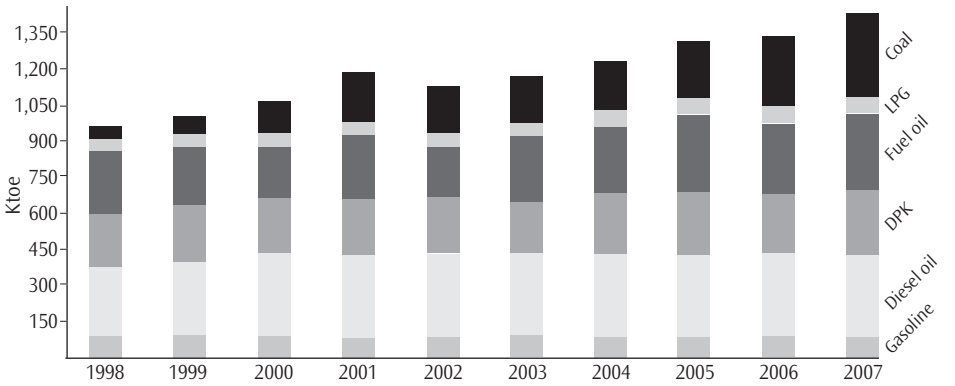


Source: Drawn from data obtained from National Transport Authority Mauritius, 2009

The average annual increase in mass transit vehicles was 1.78 per cent for buses and 4.15 per cent for taxi cars. This shows that the growth of vehicles using petrol (now unleaded) and liquefied petroleum gas (LPG) is faster than the growth of diesel-driven buses and taxis. This trend in motorisation would have a positive effect on pollution abatement. This is also a sign of a shift to cleaner technologies as a relatively high level of economic development is attained. This is a classic indication of Environmental Kuznets Curve (EKC), with levels of pollution declining with rapid economic growth.

There is another interesting part of this story. The volume of petroleum products, in thousand tonnes of oil equivalent (ktoe), imported into Mauritius over the period 1998–2007 is reported in Figure 11.3. It could be seen that there is no striking change in the quantity of

Figure 11.3. Imports of energy resources, 1997–2006



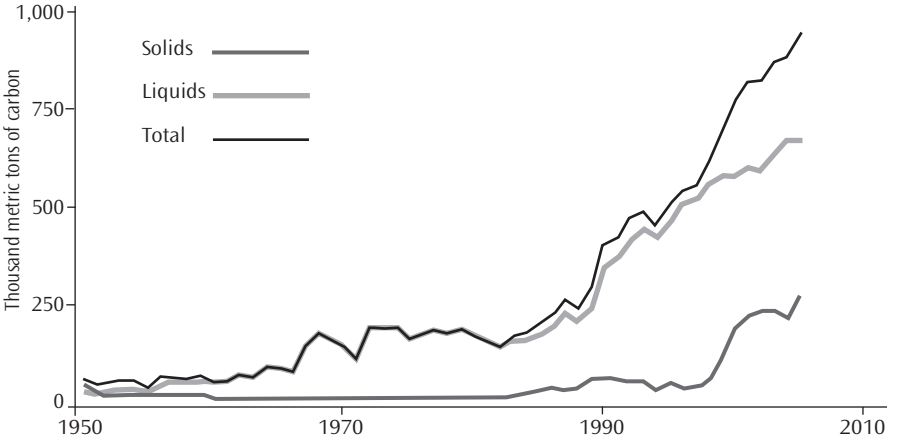
Source: Central Statistics Office, Mauritius, 2007

gasoline, diesel and LPG imported over the past ten years despite the remarkable increase in the number of road vehicles registered over the years. Indications are that the modern GLI (injection fired) vehicles consume 20 per cent less gasoline than GL (engine fitted with carburettor) vehicles for the same distance covered. With VVTI (variable valve timing injection) engines, the fuel consumption is still less. The fact is that most of the vehicles that are now being imported are injection-fired. This offers more evidence of an EKC.

However, there is a need to distinguish between emissions per vehicle – which are less nowadays with improved technology in engineering designs – and total emissions which may be more with the increase in the number of vehicles. Also, growing congestion increases emissions per vehicle as well as total emissions, as it increases fuel consumption per kilometre travelled. Generally, small islands states do not have the logistics for detailed studies on emissions. The California-based Carbon Dioxide Information Analysis Center (CDIAC) notes that the volume of CO_2 emissions has substantially increased over the past fifty years and the increase is likely to be as great in the next decade as it had been over the past two decades. The situation for Mauritius, as reported by CDIAC, is given in Figure 11.4. CO_2 emissions in the form of gases, flaring and cement are too small to be evident on the graph.

It is instructive, however, to analyse the problem dimension of these developments. The environmental benefits from the emergence of technologically more sophisticated vehicles, particularly private vehicles, can be negated by increased pollution caused by traffic congestion. It should also be added that most private vehicles are large sized vehicles, and therefore their contribution to congestion and pollution cannot be overlooked. Further, in the absence of a goods train system (abolished in 1960s), roads are extensively used to transport sugarcane from fields to sugar factories and such carriers are one of the major sources of vehicular congestion and pollution during the sugarcane harvesting season. Under the New Sugar Action Plan, attempts have been made to centralise the sugar crushing operations to reduce per unit cost of sugar production. While this arrangement is economically efficient, its environmental efficiency has not been assessed. Centralised sugar industry operations require the movement of sugar cane over long distances to reach the designated sugar mills, thereby contributing to traffic congestion in some areas.

Figure 11.4. CO_2 emissions from Mauritius



Source: Carbon Dioxide Information Analysis Center, http://cdiac.ornl.gov/

The problem of air quality has given rise to major concerns in the most advanced countries. Karim (1997) reports that studies done in Dhaka, Bangladesh indicate that motor vehicles are also a major or primary source of other toxic air pollutants, apart from carbon monoxide, hydrocarbons, photochemical oxidants, nitrogen oxides, particulate matter and lead, including benzene and a number of carcinogens, associated with particulate matter.

Onursal and Gautam (1997) relate the experiences from seven Latin American urban centres where air pollution caused by motor vehicles is a major environmental problem. If appropriate measures are not taken soon, vehicular air pollution in the region is likely to worsen, posing a great threat to human health and welfare. The authors analyse pollutants emitted by motor vehicles, their effects, pollutant-control measures targeted at vehicles, fuels, and transport management. Case studies for Mexico City, Mexico, Santiago, Chile, São Paulo, Brazil, Belo Horizonte, Brazil, Buenos Aires, Argentina, Rio de Janeiro, Brazil, and Santafé de Bogotá, Colombia, illustrate the impact of these measures in the region and how they can be strengthened.

The Executive Summary of the Latin America Regional GEF Sustainable Transport Project, World Bank Project ID: GE-P096017 (2006) reports that the transportation sector is currently responsible for more than one-third of the carbon dioxide (CO_2) emissions in Latin America, and is the fastest growing sector. The International Energy Agency projects that CO_2 emissions from vehicles will increase by a factor of 2.4 (or 140 per cent); from about 4.6 gigatonnes in 2000 to 11.2 in 2050. The vast majority of this increase will take place in developing regions, especially Latin America and Asia, as a result of increased motorisation and vehicle use.

Air pollution from vehicular emissions has not been of major concern in SIDS, partly due to the notion that SIDS benefit from favourable winds that ventilate the air and disperse the pollutants arising out of road transport. However, those SIDS that are closer to larger countries in the area can be affected by pollutants including acid rain blown away from these countries. Singapore, for example, is greatly affected by trans-boundary pollution from wild fires from mainland Asia. Air quality is being increasingly recognised as a key component in human and environmental protection and as a natural resource of value commercially, especially for island tourism. Without government intervention, unfettered market forces may result in this common resource being depleted. In Singapore and Mauritius, there has been a recognised need for government intervention to control the level of pollution especially due to vehicular emissions.

Public policy response

Policy measures to minimise the adverse effects of vehicular pollution are increasingly being adopted in many countries. Soon after the passage of the US National Environmental Policy Act of 1969, the US Environment Protection Agency (EPA) began working to reduce lead emissions, issuing the first reduction standards in 1973, which called for a gradual phase-down of lead to one tenth of a gram per gallon by 1986. The average lead content in gasoline in 1973 was 2–3 grams per gallon or about 200,000 tons of lead a year. From 1975, passenger cars and light trucks were manufactured with

a more sophisticated emission control system which included a catalytic converter that required lead-free fuel. In 1995, leaded fuel accounted for only 0.6 per cent of total gasoline sales and less than 2,000 tons of lead per year. Effective January 1, 1996, the Clean Air Act banned the sale of the small amount of leaded fuel that was still available in some parts of the country for use in on-road vehicles. EPA allowed fuel containing lead to be sold for off-road uses, including aircraft, racing cars, farm equipment, and marine engines.

In the case of SIDS, Singapore has been taking corrective measures since 1991 starting with Light-Duty Highway Vehicles. The Ministry of the Environment issued the first Singapore Green Plan (SGP) in May 1992 followed by a second Plan in August 2002 that sets targets for 2012. The SIDS have made good progress towards meeting the SGP 2012 targets. Examples include ambient air quality as measured by PSI (particles per square inch) that was in the 'good' range for at least 85 per cent of the days in each of the years between 2003 and 2007 and the annual average PM (particulate material) 2.5 level fell from 21μg/Nm^3 in 2005 to 19μg/Nm^3 in 2007.

In Mauritius, both economic incentives and command and control measures exist in different forms. By mid 1980, government started offering duty-free incentives to certain categories of economic operators for the purchase of new vehicles. Certain classes of government employees started benefiting from the scheme from 1987. It was such policies that permitted the replacement of older, high emission vehicles with fuel efficient and environmentally safer vehicles. This measure however carried with it another series of negative externalities in that it shifted a good number of public officials away from mass transit and car-pooling to private means of transport, adding to the problem of road congestion.

The control of vehicular emissions through regulatory measures in Mauritius is of most recent origin, however. The Road Traffic (Control of Vehicular Emissions) Regulations was promulgated in 2002 (Box 11.1).

Box 11.1. Mauritius: The Road Traffic (Control of Vehicular Emissions) Regulations 2002

Prior to registration:

- Every motor vehicle will have to be constructed and maintained in such a manner that smokes and noise emitted from it does not exceed the prescribed limits.
- Only petrol driven motor vehicles that shall be capable of running on unleaded petrol shall be registered as from 1st January 2003.
- No new diesel driven motor vehicle shall be registered unless it complies with a capacity limit of 40 per cent and the prescribed standard of exhaust emission as from 1st September 2003 and 1st January 2004 respectively.

Prior to the delivery of a new or used imported vehicle to its owner, a dealer will have to issue a certificate testifying that the motor vehicle meets the prescribed standards relating to both exhaust and noise emissions.

Consequently, carbon monoxide (CO) and Hydro Carbons (HC) emissions standards for motorcycles and auto cycles have now been introduced. Finally, maximum noise emission

standards for all types of motor vehicles and two-wheelers range from 79 to 92 decibel (dBA), depending on the type of vehicle. It is important to note that in 1995 leaded fuel accounted for only 0.6 per cent of total gasoline sales and less than 2,000 tons of lead per year.

Other policy measures regarding road transport include user charges and parking fees. In addition to helping to diminish the propensity of drivers to use the roads, user fees offer a source of funding for maintaining roads in good condition and compensate for the negative externalities arising out of road use. Whereas user fees are quite common in other countries, their introduction in Mauritius has not made any significant progress. SIDS may be well advised to introduce user fees where new roads are constructed especially in the coastal areas.

Parking fees are another instrument that may be used. In Mauritius, the Paid Parking Scheme introduced in 1993 was aimed at reducing parking in towns. The scheme could have been a deterrent to congestion on roads leading to town if the parking fee rates were appropriately designed and fixed. Unfortunately, the parking fee is set at a nominal level so that it has not reduced road congestion. In 2002, the parking fee rate was increased by 400 per cent, almost 7 times more than the increase that could be attributed to cumulative inflation rate of 68 per cent. However, the rate is still pegged below a deterrent value. Further revisions have not been politically feasible.

Insofar as the destruction of natural habitat is concerned, the intervention of the Mauritius government to halt a road designed to aid travel for tourists presents an illustration of a new willingness to protect the environment for the longer term advantage of the community and the environment. The aim of the road was to provide a quicker access to tourists from the airport in the South East to the hotels on the eastern coast of the island. Environmentalists opposed the project arguing that Ferney Valley, one of the country's few remaining indigenous forests, was vital for the survival of threatened flora and fauna and was home to six species of critically endangered trees, including the *Eugenia Bojeri*, *Pandanus Macrostigma* and *Pandanus Iceryi* – trees assumed extinct until their discovery in 2008. The forest is also home to half the world's population of Mauritius kestrels, once the world's rarest birds. From near extinction in the 1970s, its population had grown to almost 1,000 as a result of a captive breeding programme in Ferney Valley.

Achim Steiner, former Director-General of the World Conservation Union, argued that given the small amount of good quality tropical forest remaining on Mauritius, this development could only be viewed as 'catastrophic' to native biodiversity. The South-eastern highway was intended to run over 25 kilometres through the Ferney Valley. In response to this opposition, the government called for a re-design of the road. The Highway is now in two parts: the first part connects Plaine Magnien, near the airport, to Ferney and the second part connects Kewal Nagar to Bel Air. The earlier proposal of connecting Ferney to Kewal Nagar was shelved, thus saving the Ferney Valley. The Ferney Valley is now a protected area and a site for eco-tourism which is being encouraged in Mauritius. The environmental value of Ferney Valley can be assessed by using methods such as travel costs and contingent valuation methods. But it is also important to note that the conservation of such natural gifts would help tourism development and promote the ecological balance of the island.

Concluding remarks

The small island state of Mauritius provides an illuminating example of the challenges faced by small island states as they strive to promote economic development whilst embracing environmental and social values. Road transport has been an area in which government has sought to adjust for market failure, and to curb the effects of air pollution due to vehicular emissions. There have been some efforts at reducing air pollution on the roads but traffic congestion remains, undermining policy objectives and adding substantially to travel time for workers and school children. The challenge of further policy intervention remains. Mauritius, as a result, suffers from the tragedy of the commons. Road pricing has yet to be used to correct for the flaws in the market for road space. Plans for new by-passes, a bridge over the seaport of the capital and decentralisation of government and business premises are under review. If implemented, these measures may provide remedies for the problem of congestion. The government has converted the forested Ferney Valley, which would have been affected by a planned highway project, into an ecological protected area, safe from any further intrusion of road development. This is an example of a major policy intervention for environmental management.

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Chapter 12

An illustration of the tragedy of the commons: The demise of the Aral Sea

Introduction

The source of many environmental and natural resource problems lies in ill-defined property rights. In this chapter, we explain how the tragedy of the commons can result from existing types of ownership/property rights regimes and examine the consequences. The implications for policy-making are also briefly discussed. The dire consequences of the tragedy are illustrated by the case of the Aral Sea.

Defining core concepts

The tragedy of the commons is a type of social trap, often economic, that involves a conflict over finite resources between individual interests and the common good. The tragedy results when a group of people is responsible for the management of a resource for which no one holds exclusive rights. Thus, the resource can be exploited on a first-come, first-serve basis. The tragedy affects common pool resources (CPR). In economics, the tragedy of the commons is used as an example of the prisoner's dilemma where players gain if they co-operate to use the resources in a sustainable manner and lose if they do not. The dominant outcome of this game is that the players choose not to co-operate and all end up losing.

Box 12.1. Defining some core concepts

A **common pool resource** is a resource that multiple people can use and that is subject to rivalry (i.e. an agent's consumption reduces the benefits available to other users). It may be private property, government property, common property, or open access.

A **common property resource** is a resource owned as common property by some group of appropriators – and not exclusively by one agent or source. Examples are groundwater, fisheries and communal forests.

The characteristic of an **open access** resource is that no one has the right to exclude others from using this resource. Examples include the ocean, open-sea fisheries and atmospheric air.

Subtractability implies that an agent's consumption of a resource reduces the amount available to others.

Source: Ciriacy-Wantrup and Bishop (1975), Ostrom (1990)

Hardin's contribution

Ecologist Garrett Hardin (1968) popularised the concept 'tragedy of the commons' to explain problems of overuse and degradation of natural resources. He used the hypothetical example of a commonly owned pasture to illustrate such a problem. Herders typically wish to maximise yield by increasing the size of their herd. The addition of each animal to the herd has both positive and negative consequences. On the positive side, the herder receives more proceeds due to each additional animal. However, each animal will also contribute to some extent to degradation of the pasture land. While the herder alone gains from adding each animal to the herd, the cost of overgrazing is an externality shared by all the herders. As a rational actor, each herder would like to add to her flock. Therein lies the tragedy:

> Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own interest in a society that believes in the freedom of the commons (Hardin, 1968).

If all herders follow this pattern, the commons will ultimately be destroyed. Hardin recognised that this concept could be applied in a broader sense to many environmental problems including acid precipitation, ocean dumping, atmospheric carbon dioxide discharges, firewood crises in less-developed countries and over-fishing. The tragedy arises where individual rational behaviour (i.e. acting without restraint to maximise personal short-term gain) can cause long-range harm to the environment, others, and, ultimately, oneself.

The common's dilemma is analogous to the prisoner's dilemma derived from non-cooperative game theory where participants are trapped in a process leading them to take sub-optimal decisions (see illustrative example in Box 12.2). In this context, external authorities are presumably needed to impose external rules and regulations on users since the latter cannot come up with effective agreements to preserve the commons in a sustainable manner. From Box 12.2, a community would have difficulty in self-managing the commons due to incentives to cheat on agreements.

Box 12.2. CPR Management: An example of the prisoner's dilemma

		Agent A	
		Co-operate	Do not co-operate
Agent B	Co-operate	20 20	30 0
	Do not co-operate	0 30	3 3

Agents A and B are faced with two possible courses of action: 'co-operate' to manage the commons in a sustainable manner or 'do not co-operate'. Each agent is assumed to

behave independently and to take decisions on the optimum strategy to follow contingent upon expectations that he/she has about the other agent's behaviour.

The pay-off matrix shows changes in the welfare of agents A and B in the event that they select a particular strategy. It is clear from the above that the highest welfare gain to society would occur where both agents decide to co-operate (agent A gains 20 and agent B gains 20). If both decide not to co-operate, each would gain only 3 due to degradation of the commons.

As a rational decision-maker, agent A forms two types of expectations about agent B: agent B can co-operate and abide by the rules of sustainable CPR or agent B can decide not to co-operate or cheat on the agreement. If agent A believes that agent B will co-operate, agent A would gain 20 by co-operating but would gain a higher amount (30) by not co-operating. Thus, the optimum strategy would be 'not co-operate' if agent B co-operates. However, if agent A assumes that Agent B would not co-operate, agent A would have zero benefits by co-operating and would gain 3 units by not co-operating. Here again the optimum strategy is not to co-operate.

'Not co-operate' is a dominant strategy selected by each of the players irrespective of the expectations that they form about each other's behaviour. This situation contributes to the tragedy of the commons where players have an incentive to cheat on agreements to manage CPRs in a sustainable manner.

Is the tragedy of the commons unavoidable?

Not all CPRs will necessarily lead to the tragedy. Hardin's predictions apply mainly to open access resources rather than common pool resources (Ciriacy-Wantrup and Bishop, 1995; Bromley, 1991, 1992). Under open access any individual can use the resource, while under common property access is restricted to a group of appropriators. In the economics literature, the difference between the two can be described in terms of lost rents. Open access is a key condition for total rent dissipation associated with the tragedy of the commons (Gordon, 1954). In the absence of exclusivity, profit-maximising agents are not motivated to use the CPR in a sustainable manner benefiting themselves in the future or coming generations. They perceive that if they do not use the resource now, others will do so. Each agent therefore operates in a static framework and extracts resources from the common pool till the point where their short-run profits are maximised. Entry in the industry occurs as long as abnormal profits exist. At equilibrium, all rents are exhausted at the cost of high levels of harvest of the CPR. Under common property ownership, not all the rents are dissipated and the tragedy can be avoided. This result is obtained when there are few appropriators with heterogeneous costs (Cheung, 1970) and access rules can be enforced (Ostrom, 1990).

Managing the commons

The tragedy of the commons, while not inevitable, is more likely to occur in the presence of **subtractability** and unrestrained open access. Subtractability describes the nature of

the resource and cannot be changed. The key to preserving the commons therefore implies restraining access and consumption. Over time researchers have debated the effectiveness of various management solutions to this class of problem. Hardin (1968) advocates policy measures that would directly impact human behaviour or values of morality. According to him, no technical solution to this tragedy exists where

> A technical solution may be defined as one that requires a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or ideas of morality (Hardin, 1968).

Three possible ways suggested by Hardin (1968) and others to avert the tragedy are: 'coercion', 'privatisation' and 'polluters pay'.

- **Coercion**

Coercion is generally administered by external agents. In an extreme formulation, this prescription involves total centralised authoritarian control of the resource, for instance, direct management by a government body or state ownership. However, the implementation of this approach has been largely unsuccessful. Centralised solutions involving coercion fail to recognize the general human tendency to resist compulsion (De Young and Kaplan, 1988). Resource users, for instance, can pressure the government so as to undermine the enactment or enforcement of laws if they do not believe in the severity of environmental costs (Ostrom, 1992). Failures of nationalised CPRs have been documented in several developing countries in the case of forests, inshore fisheries and large-scale irrigation systems (see Ostrom, 1999 and Grafton, 2000 for an excellent review of the literature).

- **Privatisation**

Privatisation is a strategy whereby both benefits and costs of resource use accrue to individuals owning the resource. This contrasts with common pool arrangements where external costs due to resource degradation are shared by all the users. Privatisation would result in a socially optimal outcome by internalising that externality. This prescription to the commons problem requires government intervention to define and safeguard property rights. Privatisation, however, does not necessarily ensure sustainability. Private profit maximising CPR owners would be tempted to overexploit their resources if growth of proceeds from using the CPR exceeds resource growth. Moreover, this measure may not be feasible. The fluidity of some resources such as large bodies of water and air makes it difficult to divide them into parcels with distinct bundles of property rights (McCay, 1995).

- **Polluters pay principle**

The polluters pay principle can be applied to curtail incentives to overuse CPRs. An external regulatory agency can manage the commons by fees, taxes or penalties at the request of the majority of the people affected. The implementation of this class of instruments would depend crucially upon factors such as the financial and administrative capabilities of the country or state as well as political will. Scarcity of funds and the lack of necessary administrative skills can emerge as real constraints especially in the case of developing countries. Political economy factors encompass actions by conflicting interest groups having effects on the enforcement of rules (Oates and Portney, 2001).

Self-organised management institutions

A large, growing body of literature shows that, contrary to Hardin's predictions, with proper institutional design and social norms, a socially self-managed commons can be sustainable over long periods of time without the need for external agents or centralised management. Ostrom (1990, 1992) compiled a set of institutional rules and conditions that would effectively result in lower levels of environmental degradation (Box 12.3). These include the ability to have clear enforceable rules that will restrict access to the CPR and conditions for resource governance and use.

Box 12.3. Conditions exhibited by durable CPR institutions

1. **Clearly defined boundaries:** Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself.
2. **Congruence between rules and local conditions:** Rules restricting time, place, technology, and/or quantity of resource units are related to local conditions. There should be a small set of simple rules related to the access and resource use patterns agreed upon by the appropriators, rules easy to learn, remember, use and transmit.
3. **Collective-choice arrangements:** Most individuals affected by the operational rules can participate in modifying these operational rules. There is a need to remain adaptable, to be able to modify the rules with regard to membership, access to and use of the CPR and to remain responsive to rapid exogenous changes.
4. **Monitoring:** Monitors, who actively audit CPR conditions and appropriator behaviours, are accountable to the appropriators or are the appropriators. The enforcement of the rules is shared by all appropriators sometimes assisted by 'official' observers and enforcers.
5. **Graduated sanctions:** Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offence) by other appropriators, by officials accountable to these appropriators, or by both.
6. **Conflict-resolution mechanisms:** Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials. There is also the need to adapt the rules to changing conditions and apply different rules to different problems and scales of problems.
7. **Minimal recognition of rights to organise:** The rights of appropriators to devise their own institutions are not challenged by external governmental authorities. Appropriators must be able to legally sustain their ownership of the CPR. Furthermore, their organisation must be perceived as legitimate by the larger set of organisations in which it is nested.
8. **Nested enterprises:** For CPRs that are part of a larger system, the appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organised in multiple layers of nested enterprises.

Source: Based on Ostrom (1990, 1992)

As noted by Grafton (2000), the potential weakness of any property regime – by state, private or community – is the inability to adapt to changes in the resource or institutional environment. For collective rights to be successful, they have to adapt quickly enough to

shocks to the resource, technology and encroachment by outsiders. In the case of the latter, the state may play an important role in maintaining exclusivity by restricting access to the CPR from people outside the community. Social norms of the community can be more effective at controlling opportunistic behaviour of individuals within the community.

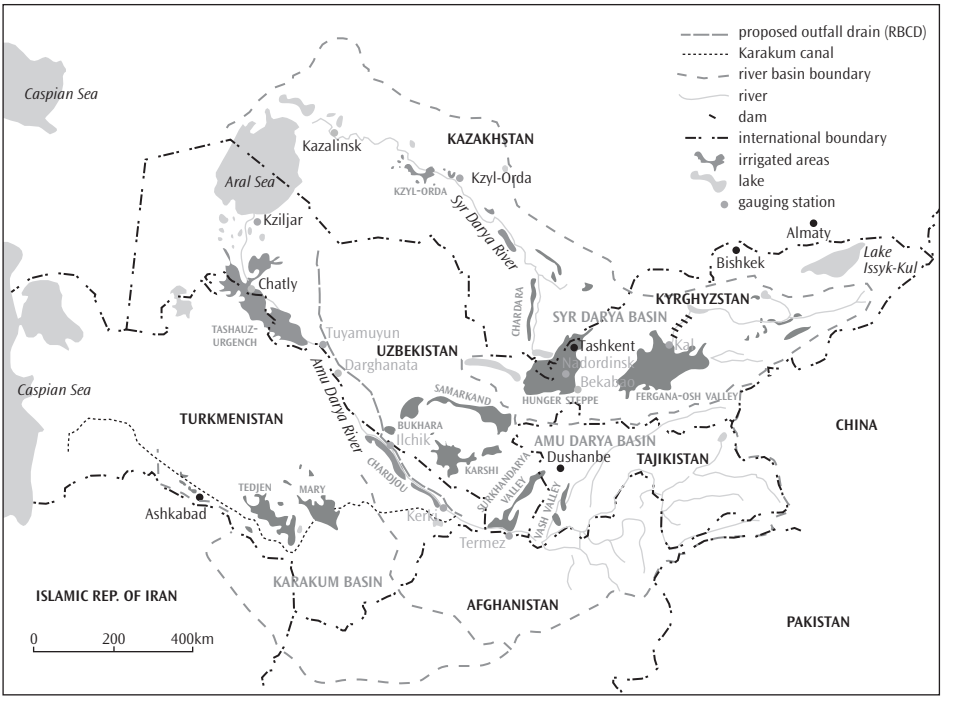
The demise of the Aral Sea: A case study

The demise of the Aral Sea is cited as a modern example of the tragedy of the commons. The sea, which was once the fourth largest inland sea on the globe, is today on its way to extinction as a mighty sea. Described as the 'most staggering human disaster in the twentieth century' by the United Nations Development Programme (UNDP), the Aral Sea basin intersects five Central Asian Republics – Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan – which lie in a 690,000 km^2 landlocked zone (Figure 12.1).

Situation before the 1960s

Before the 1960s, the Aral Sea had a surface area of 64,000 km^2, a water volume of 1,020 km^3 and an average depth of 20–25 km. The mineralisation of the sea, which was freshwater, did not exceed nine grams per litre. The sea supported a thriving fishery with 160 tons of fish being pulled daily from its waters.

Figure 12.1. Map of the region: Aral Sea



Key events leading to human-induced catastrophe

In 1918, the Soviet Union decided that the two rivers that fed the Aral Sea, namely the Amu Darya in the south and the Syr Darya in the northeast, would be diverted to try to irrigate the desert, in order to grow rice, melons, cereal, and cotton. This was part of the Soviet plan for cotton, or 'white gold' to become a major export. Irrigation canals were built on a large scale in the 1940s. These canals were dug speedily without any type of clay or concrete lining leading to massive water loss due to evaporation and filtration. It is estimated that the canals lost up to 40 per cent of the water before it reached its destination (Glantz and Zonn, 2005). However, at the time the influx of money from cotton blinded the Soviet officials to the inevitable results of their actions.

Situation post 1960s: An environmental crisis

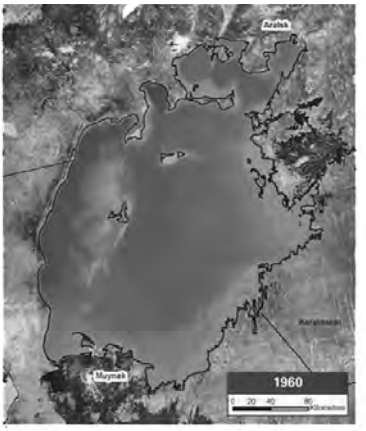
- **The sea on its way to extinction:** Excessive water diversion for irrigation has caused a loss of more than 75 per cent of the lake's water. The lake shrunk from over 65,000 km^2 to less than half that size, exposing large areas of the lake bed covered with salt deposits and contaminated with toxic residues made of agricultural chemicals.
- **Economic impacts**
  Fisheries: The lake's salt concentration increased from 10 per cent to more than 23 per cent, contributing to the devastation of a once-thriving fishery.
  Agriculture: Crop yields have diminished due to added salinity – even in some of the same fields irrigated with the diverted water.
  Employment: About 3.5 million people who depend upon fisheries and agriculture in the area have seen their livelihoods severely affected.
- **Pollution:** Dust storms and toxic dust have blown away up to 75,000 tons of exposed soil annually, dispersing its salt particles and pesticide residues even up to the Himalayas.
- **Health:** Widespread air pollution has led to serious nutritional and respiratory ailments in countries bordering the Aral Sea. High infant and maternal mortality rates have been recorded (Grabish, 1999).
- **Climate change:** Due to the shrinking of the sea, the local climate in the region has reportedly shifted, with hotter, drier summers and colder, longer winters.

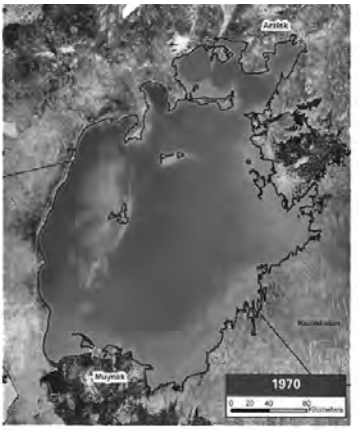
The time frame of this environmental catastrophe is depicted starkly in Figure 12.2.

Within a short span of about 30 years (1960 to 1990), continued shrinking reduced the sea into two basins: the Small Aral Sea in the north and the Large Aral Sea in the south. In 2003, the Large Aral shrunk further and got subdivided into eastern and western basins (Glantz and Zonn, 2005). In 2007, the salinity of the South Aral is recorded to have increased to 100 g/l (grams per litre) while salinity of normal seawater is typically around 35 g/l (Micklin and Aladin, 2008). The fast disappearance of this sea with associated environmental and socio-economic impacts is an issue of tremendous concern at the international level.

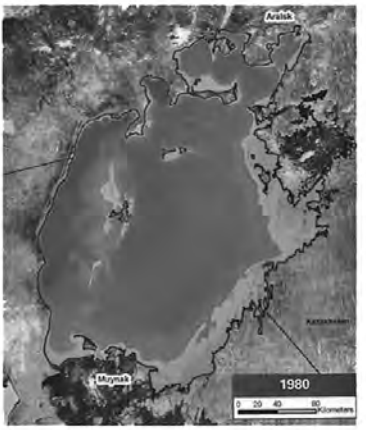
Figure 12.2. Evolution of the Aral Sea

1960–1970

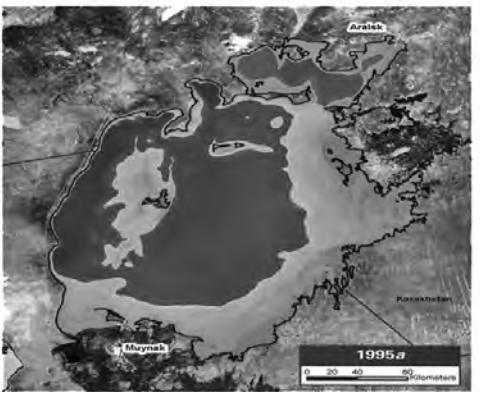


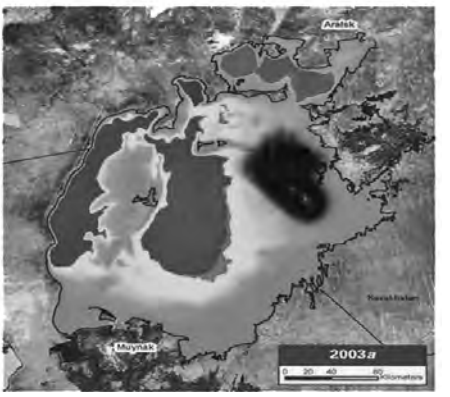


1980–1990



1995–2003





Source: Glantz and Zonn (2005)

International agreements to save the Aral Sea and their effectiveness

- The intensive internal problems of the Aral Sea became internationalised with the break-up of the Soviet Union in 1991.
- In 1992, the five newly independent Central Asian republics – Kazakhstan,

Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan – negotiated an agreement to coordinate policies on their transboundary waters and solve the Aral Sea crisis.

- An Interstate Coordination Water Commission (ICWC) was formed to prepare annual plans for water allocation and use, and define water use limits for each riparian state.
- This agreement also established a coordinating body, the Interstate Council for the Aral Sea (ICAS), primarily responsible for 'formulating policies and preparing and implementing programmes for addressing the crisis'. To mobilise and co-ordinate funding for the Council's activities, the International Fund for the Aral Sea was created in 1993.
- Subsequent agreements in the 1990s and in 2002 have updated policies and reorganised transboundary water management institutions.
- The years 1994 and 1995 saw some major developments. Allocation of water for preservation of the Aral Sea became recognised as a legitimate water use for the first time. In January 1994, the five nations signed a deal to pledge 1 per cent of their budgets to help the sea recover (Micklin and Aladin, 2008).
- The Nukus Declaration was ratified by head of states of the basin nations in 1995 and indicated the need for a 'unified multi-sectoral approach and the development of co-operation amongst the states and with the international community' (McKinney, 1996).
- Despite these forward moves, concerns were raised about the effectiveness of these plans and institutions. Critical issues include funding problems and some legal complications inherent in such agreements.
- In 1998, the Interstate Council for the Aral Sea (ICAS) and the International Fund for the Aral Sea were merged into the International Fund for the Aral Sea (IFAS).
- Since its formation, the IFAS has been under severe constraints and has had difficulties with its credibility and dealing with multi-sectoral issues. The organisation was not very successful with its mandate at developing regional water management strategies (McKinney, 2004). Because of this, the Board of IFAS did not meet until 2002.
- In 2002, the Central Asian Cooperation Organization (CACO) was established with a broad mandate to promote co-operation among member states on water, energy, and the environment. As of early 2004, a secretariat still had not been established, but one is being planned.
- Short-term programmes to stabilise the environment of the Aral Sea are supported and supplemented by a variety of governmental and non-governmental agencies, including the European Union, the World Bank, UNEP, and UNDP.

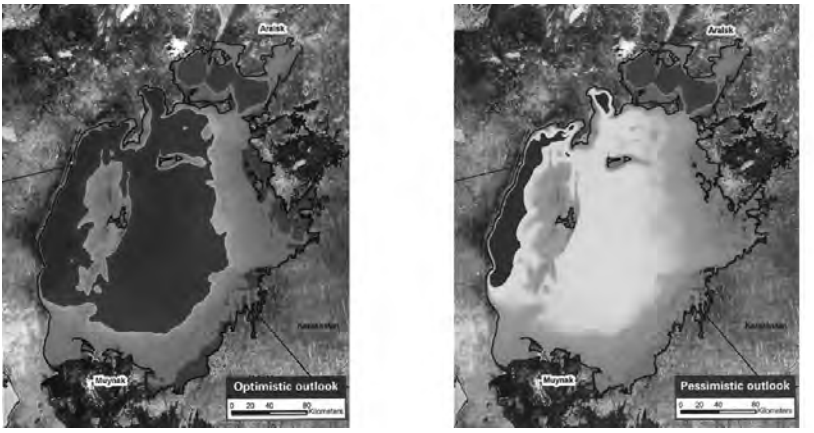
Strategies at the local/country level

The economies of Central Asia are trying to diversify agriculture. This move is, however, mostly motivated by factors such as the high cost of fertilisers and pesticides, lower yields of cotton fields due to salinised soils and the difficulty in competing price-wise and quality-wise in international markets. It does not seem that there is an urge to save the Aral Sea (Glantz and Zonn, 2005).

Is there hope?

Despite commitments to save the Aral Sea, few attempts have been made to restore it to its previous levels or even much of what remains. One major constraint relates to the importance of the Aral waters to countries benefiting from them. To restore the Aral Sea, large volumes of water would have to reach the sea, crippling local and national economies. Political leaders with short-term agendas dictated by electoral rules may favour policies that do not effectively ensure the sustainable use of this common pool resource despite pressure at the international level. The fate of the South Aral, in particular, spells concern. The larger part of this sea lies in poorer Uzbekistan, which has the highest water withdrawal rate recorded as compared to the other four Central Asian Republics (UNEP/GRID-Adrenal Maps and Graphics Library, 2005).

Figure 12.3. Optimistic outlook v. pessimistic outlook



Source: Glantz and Zonn (2005)

The key to managing this trans-boundary water resource lies in some common arrangement such as international co-operation among all the users of the rivers.

- **A strong regional economic entity can provide support when issues arise between basin states.** The Central Asian Economic Community, now Central Asian Cooperation Organization, played a key role in mediating between the Aral Sea Basin states when difficulties within the IFAS arose. Even though regional economic entities have their own limitations, they can provide a stability that basin states may otherwise not have.
- **Lack of trust and credibility can hinder the process of co-operation.** This became apparent during the years of 'dormancy' of the IFAS when issues of trust and credibility were found to hamper the functioning of the organisation.

To promote co-operation, we need a game-like policy move by which credible threats and repeated games can generate incentives not to cheat upon agreements. Non-co-operative behaviour is more likely in the case of poorer economies highly dependent on agriculture. A reduction in water withdrawal for irrigation may imply sacrificing short-term economic growth to earn benefits in the long-run. Because of the trans-boundary nature of this

resource, a potentially hard-hit country may choose to free-ride if others are abiding by the agreements to avert this tragedy of the commons. While the costs of extraction would be shared by all bordering countries, the benefits of any binding agreement would go to the defaulter as well. To be successful, any commitment to save the Aral Sea must be backed by some adequate compensatory mechanisms from the international community. Good governance both at local and regional levels, and institutional frameworks quickly adapting to changing political, technological and social parameters, would contribute to the success of these measures. To conclude, Figure 12.3 provides both a hopeful and a pessimistic picture of the future of the Aral Sea contingent upon the success of international efforts. This also shows the irreversibility of certain environmental changes beyond a particular threshold.

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Climate change and SIDS

Introduction

Rising concentrations of carbon dioxide, methane and other greenhouse gases are changing the world's climate. According to the Intergovernmental Panel on Climate Change (IPCC)[1], 11 out of the 12 years prior to 2006 rank in the 12 warmest years on the planet since records began in 1850 (IPCC, 2007). Gradual temperature increases are occurring around the world, but are highest in the more extreme latitudes and are greater on land than in the ocean regions. Meanwhile, ocean temperatures have increased up to a depth of 3,000 metres (IPCC, 2007). The greatest temperature rises have been found in the Arctic, where annual mean temperatures have increased at twice the rate of the world average.

Most of the evidence assembled by the IPCC suggests that human activity is responsible for the largest part of the increase in emissions of greenhouse gases. Anthropogenic carbon dioxide emissions have risen by 80 per cent between 1970 and 2004 (IPCC, 2007), while atmospheric concentrations of methane have more than doubled since the pre-industrial era, principally through agricultural and industrial activity. Atmospheric levels of nitrous oxide have also increased significantly over the same period and almost all the halocarbons in the atmosphere are the result of human activity. Although some individual countries have begun abating or controlling emissions, global emissions continue to rise, fuelled by population growth and economic activity.

Although there is still great uncertainty about the details of future climate trends, many SIDS appear to be extremely vulnerable to the effects of climate change. In this chapter we cover some of the main effects of climate change and their consequences for SIDS.

Climate change: Implications for SIDS

Small islands are scattered across the globe and their weather patterns vary. As a result the impact of climate change will not be felt in the same way by all SIDS. For instance, Caribbean islands typically have distinct wet and dry seasons, with rainfall usually much lower during the months of the northern winter. Mediterranean islands also tend to see distinct variation of precipitation across the year, but here it is the winter months that are wettest. The climate of these islands is heavily influenced by that of the neighbouring countries. For central Pacific islands, weather is shaped by trade winds and semi-permanent sub-tropical high pressure belts. In this region there is also considerable year-to-year

variation in weather caused by the El Niño Southern Oscillation or ENSO. Normally, there is high pressure over the Pacific Ocean with lower pressure further to the west over northern Australia and Indonesia. Winds move from the Americas towards the west, bringing rainstorms to the western edges of the Pacific. Meanwhile, along the South American coast, cold water wells up to the surface. When El Niño occurs, air pressure patterns are reversed, reducing the easterly winds and cutting off the upwelling of cold water off Peru and Ecuador. Fish stocks fall and rainfall increases along the South American coast. In contrast to the west, in Australasia there can be lower temperatures, reduced rainfall and drought. In the Indian Ocean, the Asian monsoon is the major factor in seasonal variation and is linked with the ENSO (Mimura et al., 2007).

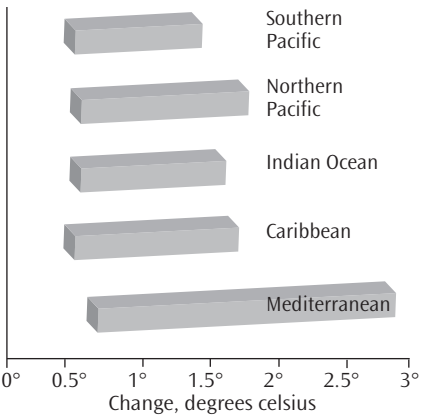
Much of the forecasting of the effects of higher greenhouse gas levels has been done at the regional or global level and has concentrated on:

- mean temperature rises;
- changes in average precipitation;
- changes in variability; and
- extreme events (cyclones or hurricanes).

One problem with accurately forecasting the impact of climate changes on SIDS is that the calculations required to estimate weather trends for small areas such as islands can be very imprecise. With their computer models, climate change scientists generally offer a range of estimates for the future, to emphasise current uncertainties. Some of these uncertainties are particularly apparent with SIDS, as the figures below make clear. Figure 13.1 shows the range of possible outcomes for mean annual temperatures for the next 30 years based on current understanding of emission trends and climate. For all the regions some rise in temperatures is anticipated, but in the Mediterranean the rise could be as high as 2.8 degrees or as low as 0.7 degrees.

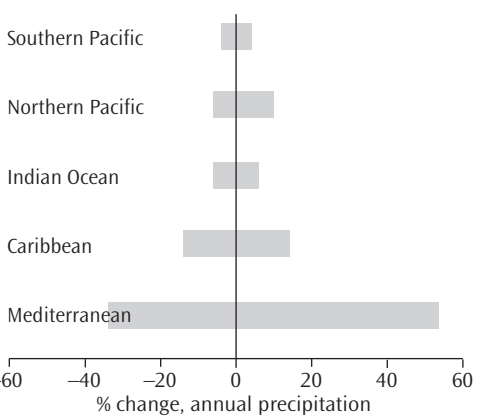
Figure 13.2 shows some summary predictions for rainfall over the same period. In all cases there is a possibility of a rise or a fall (or of course no significant change). For some regions the range of uncertainty is still large.

Figure 13.1. Projected increase in mean air temperature, 2010–2039



Source: Mimura et al., 2007, Table 16.1

Figure 13.2. Projected percentage change in annual precipitation, 2010–2039



Source: Mimura et al., 2007, Table 16.2

Temperature and rainfall changes beyond this time frame are even more unpredictable but all regions are expected to see some rise in mean temperature as long as the behaviour of the world's economies maintains its current trend (Mimura et al., 2007). The range of average temperature rises predicted for the Caribbean region is 0.94 to 4.18 for the years 2070–2099, while predictions of average precipitation run from -49.3 per cent to 28.9 per cent for the same period. Some of the uncertainties are due to human behaviour. A forecast of temperature many years in the future requires strong assumptions about economic activity and the size and date of emissions. In making its estimates, the IPCC panel considers a number of different futures for the world, including a 'business as usual' case, low and high growth, and rapid and slow changes in emissions intensities. IPCC forecasts for the next 20 or so years are not sensitive to the assumptions it makes about the economy and technology but with deeper movement into the future, forecasts become less certain and more dependent on the assumptions built into the model.

These charts omit predictions of the variance. For many countries, estimates of the variability are as important as predictions of the mean. Consider, for example, a country that faces no change in annual mean rainfall but because of climate change has no rainfall in 3 out of 6 years, and double the current rainfall in the other 3 years. The problems of adaptation faced by this country would be very different to those confronting a country with a small but predictable rise or fall in rainfall. Crop choices may vary, water storage facilities will need to be expanded and water conservation and flood protection measures enhanced. The consensus of the IPCC is that Mediterranean countries, including Cyprus and Malta, are very likely to face more episodes of drought in the future. More episodes of low rainfall are likely in the Caribbean. Conversely, the intensity of rainfall in the Indian Ocean monsoon is expected to rise, bringing with it the prospect of greater floods and disease.

We have already mentioned the key role played by ENSO in the weather of the Pacific and Indian Oceans. According to UNESCAP, each El Niño event has resulted in water shortages and drought in Papua New Guinea, Marshall Islands, Federated States of Micronesia, American Samoa, Samoa, Tonga, Kiribati and Fiji. More frequent El Niño events also bring an increased risk of tropical cyclones, particularly for Tuvalu, Samoa, Tonga, Cook Islands and French Polynesia[2]. What is not clear at the moment is whether climate change will alter the frequency or intensity of El Nino events. The IPCC offers no consensus on this important issue and current computer models of climate change do not give a consistent picture.

Many tropical SIDS face a regular annual threat of cyclones or hurricanes, and tropical storms at levels 4 or 5 (the most intense) have increased in frequency since the 1970s. As Table 13.1 illustrates for Grenada, these extreme events can have major and lasting economic impacts on island economies.

Some forecasts for the future have been made for this kind of extreme weather event. In its 2007 report, the IPCC states that is 'likely' that the intensity of tropical storms will increase over time, as measured both by maximum wind speeds and by precipitation rates, but it is less certain about the frequency of storms. There is some link between the ENSO and the location and strength of tropical storms in the Pacific and Indian Oceans (Landsea, 2000). Uncertainty over the future pattern of ENSOs therefore makes it harder to predict the frequency and intensity of cyclones.

Table 13.1. The cost of a hurricane: Ivan in Grenada in 2004 (Direct and indirect damages in millions of US dollars)

	Direct	Indirect	Total
Agriculture	20	17	37
Manufacturing	7	2	8
Tourism	113	37	150
Utilities (electricity, water/sewage, telecommunications and cable)	60	33	93
Education	72	1	73
Housing	508	3	511
Other (transport, wholesale industries and healthcare)	7	4	12
Total	**787**	**97**	**884**

Source: OECS, 2004

Sea-level rise

Climate change is very likely to raise sea levels worldwide through two main mechanisms. First, at normal sea temperatures a rise in temperatures leads to expansion of the water. Secondly, higher temperatures lead glaciers and other forms of ice to melt. If that ice is on land, then its melting eventually adds to the volume of water in the oceans, raising sea-levels. Though there is currently great uncertainty over how much land-based ice will melt in the future, it is relatively easy to estimate thermal expansion and the consequences of ice melting. What we can say, however, is that if, for example, all the ice in Greenland were to melt, sea levels would rise by around 7 metres (Gregory et al., 2004). Actual predictions for sea-level rise over the next 50 years are much more modest than this alarming figure. Over the period 1961–2003, sea levels rose at an average rate of 1.8 millimetres per year (IPCC, 2007). The IPCC's expectation is that rates of sea-level rise for the rest of the century will exceed this. Woodworth (2005) has suggested a figure of 0.5 metres as a sensible mid-level estimate for islands such as the Maldives. The range of figures for 2090–2099 is 0.19 to 0.58 metres (Mimura et al., 2007), but because of imperfect mixing and variable thermal expansion sea-level rises will vary across the globe.

A rise in sea levels associated with climate change can have devastating effects on low-lying areas. The most damaging outcomes are inundation, flooding, beach erosion and saltwater intrusion. The economic and human impacts of these changes could be considerable. In many SIDS a large proportion of the population lives close to the sea, often in low-lying areas threatened with flooding. Recent migration trends have raised the number of people living close to the shore, particularly in the Pacific Islands.

Some islands are more threatened than others by sea-level rise. Atoll islands built on coral reefs such as Tuvalu are extremely low lying and are exposed to wash-over during strong storms. Water is often supplied from rainfall or from shallow groundwater cappings which are at risk from salinisation. Islands that are on raised reefs and hardened limestone rock

are generally less exposed to inundation, but still the majority of the population lives close to the shoreline. Even in the larger SIDS, the largest settlements and other social and economic infrastructure is on the coast.

Coral reef changes

Many of the world's most precious coral reefs can be found around tropical islands. Coral reefs provide a wide variety of economic and ecological functions including storm protection, biodiversity, and fisheries. Reefs provide a habitat for perhaps one quarter of all marine species and are therefore amongst the most diverse of all ecosystems (Pandolfi et al., 2003). Their diversity and beauty brings in tourists for snorkelling and scuba diving. Carleton and Lawrence (2005), estimate annual benefits to the Turks and Caicos Islands of US$47.3 million per year. Out of this total, tourism and diving accounted for $18.2m, coastal protection was worth $16.9m, fisheries contributed approximately $3.7m and biodiversity accounted for the remaining $4.7m.

Many reefs are potentially threatened by climate change. In theory, acidification (caused by higher CO_2 levels in the atmosphere) could damage coral, but there is presently no clear field data on this issue. An increase in the incidence or intensity of storms could also damage reef growth, but perhaps the greatest threat is from bleaching through higher temperatures. This effect is well-documented and a source of worry. If sub-sea temperatures consistently exceed 2°C above the average seasonal maxima, corals die. As shown in Figure 13.1, a 2°C rise is at the upper end of predicted changes in mean air temperatures over the next 30 years. However, a lower mean rise can bring with it extended periods of higher temperatures and it is this risk that threatens coral reefs in the short and medium term. With the death of coral, storm protection is reduced considerably, fish production falls and biodiversity collapses. As a consequence the associated tourism demand will fall.

The Kyoto Protocol

The current international agreement concerning greenhouse gas emissions is the Kyoto Protocol, first agreed in December, 1997. It focuses on abatement by the richer nations ('Annex 1') of the world by setting binding emissions targets for developed nations. For the EU this means that 2012 emission levels should be 8 per cent below the 1990 figures. The corresponding targets for the USA and Japan were 7 per cent and 6 per cent respectively while Russia was set a 'no change target' and Australia was allowed to increase its emissions by 10%. A variety of mechanisms were allowed, including activities that absorb carbon such as tree planting and emissions trading schemes. Countries with emissions targets can also get credit towards their targets through project-based emissions reductions in other such countries. Through the Clean Development Mechanism (CDM), developed countries can use certified emissions reductions from projects in developing countries to contribute to their targets. To enter into force, the Protocol had to be ratified by at least 55 countries, accounting for at least 55 per cent of the total 1990 carbon dioxide emissions of developed countries. After further negotiations in Bonn and Marrakech, concessions were given to Russia and Canada. Russia eventually signed and the treaty came into force. Most recently (2007), Australia has also ratified the Protocol, but it is unlikely that the USA will ratify the

Protocol, leaving it amongst the 20 or so countries such as Somalia and Afghanistan that have not joined.

The Kyoto Protocol has been widely criticised. The cap on emissions for richer countries is too weak to have a major impact on climate change. In fact, the Protocol does not stabilise emissions, in part because it does not place any obligation on any developing countries. China, for instance, is now the biggest emitter of greenhouse gases and is above the world average on a per capita basis, yet nothing is required of it. Furthermore, the international mechanisms for obtaining credit are hard to police and open to abuse. Finally, the collapse in manufacturing in transition economies has created perverse incentives to raise emissions (e.g. Japan buying unused credits from East European countries).

Negotiations about a replacement for the Kyoto Protocol have gone on in fits and starts, but have been largely stymied by the differing perspectives of the major players and by the apparently large scale of the cuts required to first halt and then reverse the rise in CO_2. A summary of a recent Ministerial meeting in Bangkok, April 2008, sums this up:

Box 13.1. Summary of a recent ministerial meeting in Bangkok, April 2008

The EU proposed reducing Annex I emissions by 30 per cent by 2020 and 60-80 per cent by 2050. Brazil highlighted burden sharing and historical responsibility. India identified similar commitments by all developed countries, including non-Kyoto parties, as a precondition for developing country action. They called for equal distribution and convergence of emission rights. Saudi Arabia called for a bottom-up approach in defining a long-term goal. The US emphasized the need for differentiation among parties, depending on changing social and economic conditions, as well as current emissions and emission trends. The African Group emphasized equal treatment of adaptation and mitigation, and the special needs of Africa, small island developing states (SIDS) and the LDCs. Bangladesh, Ghana, Egypt and others supported developing an adaptation protocol.

Source: http://www.iisd.ca/vol12/enb12362e.html

With slow progress at the global level, some countries have acted independently to set targets. The European Union, for instance, has set itself a 20 per cent reduction of greenhouse gas emissions (compared to 1990) for 2020 and some individual member states have gone further, setting targets for reductions of up to 50 per cent by 2050.

Adaptation and mitigation

Adaptation refers to policies that take climate change as a fact, but seek to adjust human behaviour. Mitigation refers to policies that reduce emissions of greenhouse gases. The size of SIDS means that their effective contribution to the climate change is minimal, so that while they can be expected to contribute to any global reduction in CO_2 emissions, this cannot have much of a positive impact on world emissions and global climate change.

Abating greenhouse gases is a global public good in that the benefits are non-rival and non-excludable. As such there is an incentive for countries to free-ride. This is one of the main reasons why international agreements are hard to sustain. On top of this, there is

intergenerational conflict: most of the costs of dealing with carbon emissions must be met by older generations, but the benefits will largely accrue to the young and unborn. As a result, there is a persistent temptation to postpone action and leave the problem to the next generation.

Unlike mitigation, most of the benefits of adaptation are local public goods. At a national level, countries can undertake adaptation without having to worry too much about the external consequences of their actions.

Box 13.2. The Mauritius Declaration

The Declaration was agreed in Mauritius by SIDS nations meeting under the auspices of the United Nations in January 2005. The participants agreed that climate change represents a significant risk to SIDS and called on all nations of the world to stabilise carbon emissions at a level which stops major changes to the world's climate.

To deal with climate change, it advocates a number of measures, including:

- greater energy efficiency and development of renewable energy sources;
- dissemination of new technologies and ideas to SIDS;
- raising the scientific capacities of SIDS with the support of the IPCC; and
- greater investment in monitoring of global and local climate changes.

To deal with flooding and inundation, a number of policies can be tried, and these can be broadly grouped into retreat, accommodation and protection (Tompkins et al., 2005). With retreat, development is prevented near low-lying coastlines, subsidies for coastal development are withdrawn and infrastructure development, such as roads, is confined to higher ground. The sea is allowed to claim land as humans move to higher ground. Retreat is feasible when land is plentiful and there is little coastal development, but for some SIDS like Tuvalu and Tonga, retreat would mean abandoning large portions of available land. The highest point of Tuvalu is only 4.5m, while in Tongatapu (the largest island in Tonga) for instance, a 1m rise in the sea level would threaten 10.3km^2 of land. With storm surges of 1.5m, 37.3km^2 would face flooding – about 14 per cent of all the available area of the island (Mimura, 1999).

The most extreme form of retreat is island abandonment. The governments of some threatened countries, notably Tuvalu and the Maldives, have raised the possibility of mass evacuation in the face of sea-level rise.

Accommodation may come in many forms. If housing regularly faces the risk of flooding, then it may be wise to add storeys, so that citizens can move to higher floors during inundation. Concrete rather than wood can be used for construction; homes can be strengthened to withstand higher winds and electrical circuits moved away from ground level. Roads and storage facilities can also be raised and key aspects of infrastructure such as power sub-stations and water treatment works can be moved or given flood protection. Salt resistant crop varieties can be planted on low-level fields, or land close to the sea can be converted to grazing.

Protection is at the other end of the adaptation spectrum. It involves hard structures such

as sea walls and flood barriers to protect against flooding. For some urban settlements, particularly in richer island countries, this is feasible and probably cost effective. However, hard structures at one point on a coastline can lead to faster erosion elsewhere. For this reason, sea walls are no panacea. Moreover, it is hard to protect against salinisation.

Some adaptation may be natural. According to the IPCC, some types of coral may be able to withstand higher temperatures while many types of coral can grow vertically, adapting to sea level rises. In a similar vein, the mangrove forests that provide storm protection and fisheries in many tropical and sub-tropical countries may move inland if their freedom to adapt is not constrained by buildings, sea defences and other hard structures (IPCC, 2007).

Adapting to other dimensions of climate change can also take many forms. In agriculture, adaptation may involve switching crop varieties, e.g. to drought-resistant types, or changing patterns of land use. At the same time, investment in water storage, irrigation systems and more efficient water management can provide a buffer against water shortages or erratic supply. The feasibility of internal population movement towards cooler areas and away from the shoreline may be limited because of the small size of many SIDS, but it may still ameliorate some of the most extreme impacts of climate change.

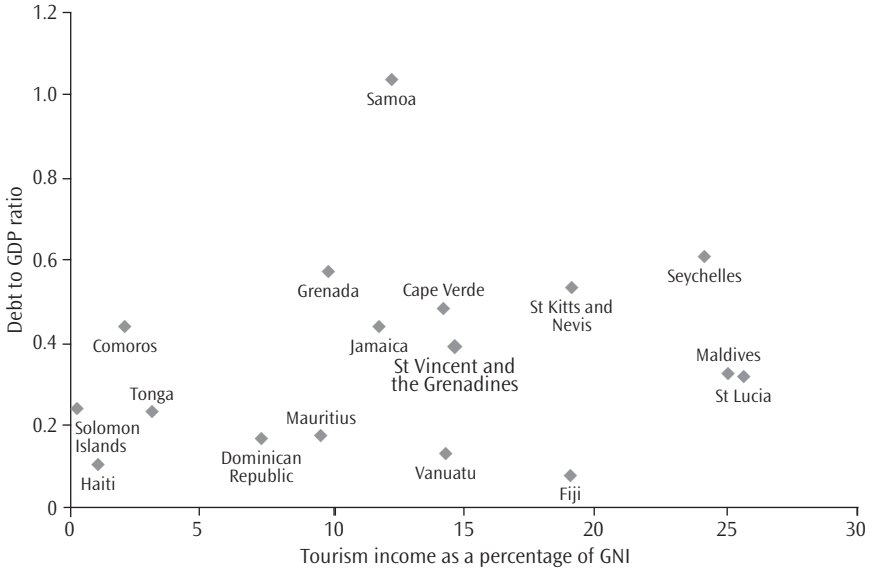
Higher temperatures may result in changes in biodiversity, particularly at higher latitudes, where some invasive species may become viable. Further, patterns of disease may change. Mimura, (2007), points to a higher risk of dengue fever, malaria and other tropical diseases, particularly in temperate countries. Here, adaptation may involve greater public health measures and stricter quarantine measures. Diseases such as dengue fever and other health risks can also rise in the wake of tropical storms. Thus one crucial part of adaptation may involve having a greater capacity to deal with health risks in the event of major disasters.

One economic instrument that has been discussed as a method of promoting adaptation is insurance. Insurance cannot solve a problem that occurs constantly, but it can provide an effective method of risk management for storm damage and other intermittent problems. When risks are priced by insurance markets, individuals and organisations have incentives to reduce such risks by changing behaviour (e.g. moving away from coastal zones), and also can smooth consumption in the face of shocks such as drought, floods and tropical cyclones. The isolation of SIDS often means that internal risk markets are poorly developed. In any event, such institutions would provide little cover for disasters that affect a whole island. Regional insurance markets (e.g. covering the islands of the Caribbean or the South Pacific), possibly supported by governments or international aid agencies, might be more feasible and have therefore been considered positively by some authors (e.g. Parry et al., 2005).

Tourism

As Figure 13.3 illustrates, using data for 2005, many island economies are heavily dependent on tourism as a source of income. In this important aspect of their economies SIDS face direct and indirect effects from climate change. The direct impact of climate

Figure 13.3. Economic vulnerability to tourism shocks



Source: World Bank and United Nations

change on tourism industries arises from the loss of amenities, such as coral reefs. Similarly, if temperature rises become too extreme or cyclone risk increases to an unacceptable level or freshwater availability is compromised, tourism demand may fall.

Many SIDS are long-haul destinations and this may make them vulnerable to the indirect effects of climate change. In particular, visitor numbers may be sensitive to the effects of mitigation policies taken by other countries. For instance, the EU has agreed to include aviation emissions in its cap and trade system for controlling carbon use. In the long run, this will raise the cost of fuel for airlines, raise ticket prices and reduce tourism demand. Efforts being made to change the psychology of consumption towards sustainable behaviour may also lead to a long- term trend away from long-haul holidays.

As Figure 13.3 suggests, the economic impact of climate change via tourism may vary considerably between SIDS. Tourism expenditure as a percentage of gross national income (GNI) is important but relatively low in some of the larger SIDS economies such as Mauritius or the Dominican Republic. Some of the countries in the figure also have relatively low debt to GDP ratios and are therefore better able to cope with adverse economic shocks. However, countries with high debt-to-GDP ratios and high tourism dependency ratios (e.g. the Seychelles) are less well placed to cope with a major downturn in tourism demand.

In the face of mitigating activities by other countries it is not clear what SIDS can or should do. One option is to make tourist activities 'greener' thus making them more attractive to eco-conscious travellers. For instance, many SIDS are heavily dependent on oil and gas to generate electricity. Switching to renewable sources of energy such as wind and solar power may have only a minimal impact on global mitigation of carbon emissions but it may help maintain tourism demand.

Conclusion

Many SIDS are highly exposed to the risks created by climate change. For low-lying atoll islands the risks from sea-level rise are particularly acute. At the same time, as small and often poor countries, SIDS are not in a position to exert much leverage over global policies towards the control of carbon emissions. They may also suffer from the consequences of the policy decisions taken by other countries, particularly if tourism demand weakens. As many countries around the world will discover, adapting to climate change takes time and considerable resources. The most economically efficient way of adapting may not involve hard structures or protecting existing infrastructure and lifestyles. Instead, retreat and accommodation may be more sensible (Mimura et al., 2007), particularly when population density is low or existing infrastructure is limited.

Further Reading

The most up-to-date consensus view on SIDS and climate change can be found in Mimura et al., 2007 which contains a wealth of detail. The manual by Tompkins et al., 2005, provides guidance to policy-makers on how to create an adaptation strategy.

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Notes

1 The IPCC is a body sponsored by the United Nations to come to a consensus view on the science of climate change. It brings together the work of many scientists from across the world and summarises the current state of knowledge every six years or so.

2 http://www.unescap.org/mced2000/pacific/background/climate.htm

John L Roberts

Chapter 14

Disaster risk reduction: Practical adaptive options

Introduction

This chapter puts the issue of disasters into the broader perspective of the management of natural resources for sustainable development.

In contrast to economic vulnerability, which is mainly inherent in small and island states, some aspects of environmental and human vulnerability to disasters can be prevented by local and by international action. This chapter argues that reducing vulnerability and increasing the resilience to environmental risks, however, should involve a comprehensive assessment of likely political and economic impacts: options in the use of scarce resources and the relative returns on investment, against other choices for improving welfare.

The relative impact of disasters is compared with other causes of death and environmental damage such as road traffic accidents, war and personal violence, with the issue of disasters set within the context of public policy choices. This chapter examines the strategic approaches being developed for assessing the vulnerability of countries in the Pacific and the Caribbean regions to common disaster risks, the work of the UN International Strategy for Disaster Reduction (UNISDR) and the UN-endorsed Hyogo framework for policy and action in this field.

The scope of disaster risk reduction

Risk is defined by ISDR[1] as the probability of damage or loss resulting from the effects of hazards on human life and the environment. Risk in a country may be expressed by the equation:

[2]Risk = Hazards × vulnerability/capacity for effective response

This equation defines risk in terms of the multiple of the hazards and vulnerability of a country to them, per unit capacity for effective response (other things being equal). Technically, this equation defines risk as the slope of the curve of the multiple of hazard and vulnerability – which might be termed effective exposure – to effective response capacity. Thus risk increases as the frequency and strength of hazards increase; as the vulnerability to them increases, and as the capacity for effective action diminishes. The management challenge is to reduce risk by cost-effective measures and by avoiding disproportionate responses. This task can be approached by:

- assessing a hazard;
- taking cost-effective action to reduce vulnerability; and
- increasing capacity for effective action to respond to the hazard.

Risk analysis provides an assessment, for a country or location, of the probability of the impact of hazards, having regard to vulnerability or exposure and adaptation to expected effects. Impact is the measure of those effects, that is, the actual loss resulting from the disaster. Risk assessment is subject to uncertainty and the limitations of information and knowledge, and may not accurately predict the impact of a disaster. Risk assessment is also subject to the variability of other factors, which are not included in the risk equation, but which may not comply with the assumption of remaining constant. Hence 'other things' may not remain 'equal'. For example, external to the risk equation is the population variable. The impact of risk may change as the size of the population exposed to it changes and as the environment changes in response to population change. In SIDS if the population on the sea coast increases, for example through tourism, then the adverse impact of the risk of a tsunami or sea surge is likely to be increased, although the defined risk of the event may remain constant.

The effect of the combination of increased sea-coast tourism and sea level rise, through Climate Change, for example in the Maldives, will have the combined effect of raising both the risk and the potential adverse impact on life, property and the natural environment on which tourism depends. Thus policy and management approaches to disaster risk reduction must take into account a wider range of factors than are evident from the simplified equation of risk above.

Disaster risk management

Using the risk equation, Table 14.1 shows a range of activities that disaster risk reduction can embrace:

- Reduce the frequency and strength of hazards
- Reduce vulnerability to such hazards
- Increase capacity for effective response

In exploring the relevant and most cost-effective action to take to reduce disaster risks, it is necessary to be more precise about the definition of these phenomena and the potential risk reduction measure (see Box 14.1).

Whilst for the factors giving rise to the economic vulnerability of small states and SIDS are inherent, not all their risks of environmental disasters arise from inherent vulnerabilities. Some disasters can be avoided entirely, whilst vulnerability to others can be substantially reduced. However, in all cases the strategic resilience of small and island states can be improved.

It is evident that natural hazards such as volcanoes and tsunamis that give rise to some natural disasters present potential risk to people and environments in their pathway. The vulnerability of countries to these hazards can be reduced, however, by not placing social and economic infrastructure in the path of such natural hazards and by designing and building structures that reduce, rather than augment, any adverse impacts.

Table 14.1. Activities for disaster risk reduction

Objectives	Activities
Reduce the frequency and strength of hazards	• Reduce emissions of greenhouse gases. • Reduce the power levels in electrical cables. • Regulate the number of locations of hazardous industrial premises and processes. • Reduce the use and number of military landmines.
Reduce vulnerability to hazards	• Provide protective barriers, danger signs and set-back controls against the hazards of sea surges, flooding and exposure to hazardous chemicals. • Provide protective clothing and safe procedures for workers and others exposed to hazards. • Develop fail-safe designs for hazardous processes (braking systems, ejector seats, parachutes and life jackets). • Provide early warning systems for evasive action to reduce the exposure to approaching hazards.
Increase capacity for effective response	• Increase capacity for rescue of the environment, property and people from the impact of hazards. • Improve emergency support and relief to mitigate effects of immediate impact. • Extend capacity for repair and rehabilitation of the environment, property and people after the impact of hazards. • Increase long-term rehabilitation, evaluation and reinforcement of capacity for resilience and risk reduction.

Box 14.1. Key terms in Disaster Risk Management

We may define the key terms in this field in the following way:

A **disaster** is an event or series of events causing significant impact on the natural environment, adversely affecting normal human activities, and causing sudden loss which may exceed the capacity of the local community resources to effectively respond in the rescue and rehabilitation of people and systems affected. Examples of disasters include the tsunami of 2004/5 in the Indian Ocean causing widespread loss of life and damage to many communities from Sri Lanka to the Maldives and the Seychelles; Hurricane Katrina which in 2005 devastated New Orleans in the USA and adjacent communities and territories; and forest fires in Greece in 2007 which caused death and injury to the resident population and widespread property damage. Disasters also include man-made events such as marine oil-spills, industrial fires, meltdown of nuclear reactors, shipwrecks and airplane crashes.

A **hazard** is an identified object, activity, process or event that could give rise to injury or damage to people or the environment. Hazards may arise from natural phenomena such as submerged rocks or icebergs at sea, volcanoes and avalanches, or from human activities, such as dangerous sports or industrial processes, from military activity such as the laying of explosive landmines, from built infrastructures such as high-power electrical pylons, and unguarded coal mines and quarries. Hazards may be classified in terms of their location, level of risk, strength, frequency and potential for causing loss and damage.

Disaster risk reduction is action taken to reduce the frequency and strength of hazards and to reduce the vulnerability of people and the environment to those hazards.

Disaster risk management is the process of policy development and decision-making to lessen the risks and impact on people and the environment of hazards of natural and other disasters. This may be based upon a conceptual framework of those elements considered most critical in producing adverse impacts of disasters and the most cost-effective measures for prevention, preparedness, adaptation and mitigation of the consequences.

Impact is the resulting loss from an event, such as a disaster, in terms of its adverse effect on people, property and the environment. The impact may be expressed in terms of physical effects (numbers of deaths, injuries, jobs lost, homes, workplaces and communities affected, buildings and roads destroyed or damaged); or it may be expressed in economic terms using monetary values of the losses incurred. In comparing economic losses from disasters in different countries, account should be taken of the inter-country differences in the values placed on losses of life, property and the environment, which may largely reflect differences in the wealth of countries, rather than the relative size of the physical impact of the disaster.

Resilience is the capacity to recover from shocks (from the Latin *to leap back*). It has been explored from an economic perspective with respect to small states[3] Briguglio and his colleagues defined economic resilience in three dimensions as the ability of an economy:

a to recover quickly;
b to withstand shocks; and
c to avoid shocks.

The concept of resilience, in this approach, is seen as a nurtured capacity, whilst vulnerability is considered inherent.

Environmental resilience is similarly the capacity to respond to ecological shocks. Professor Albert Binger, of the West Indies University department of environment and development '(WSSD 2002), has argued that SIDS are inherently vulnerable in so far as they depend upon the unsustainable use of non-renewable natural resources' and are exposed to natural disasters; their resilience depends upon developing alternative economic structures which reduce their capacity to exploit non-renewable natural resources and invest in environmental regeneration. Resilience includes the development of effective responses to disasters including search and rescue, rehabilitation and evaluation to provide improved risk assessment, education, skills training, early warning systems and preparedness.

Risk analysis is concerned with the assessment of the nature and extent of risk, the probability that an adverse event might occur, the factors that affect that chance and their environmental and human consequences. The function of risk analysis is to identify the nature of risks, their potential economic, social and environmental impact, people's perception of risk, how society can manage risk, and the role of analytical techniques, such as economics, in illuminating such questions. There are four components to risk assessment and its analysis: hazard identification; dose-response estimate; exposure assessment; and risk characterisation (which includes safe exposure levels, acceptable risk level, uncertainty, and data limitations). The process of risk analysis reviews the technical features of hazards (location, intensity, frequency and probability), the physical and social extent of vulnerability, and the capacity for prevention, mitigation, adaptive response and rehabilitation in relation to potential impact.

Vulnerability is the extent of exposure to attacks or harm. Briguglio et al. (2006), define economic vulnerability as '*exposure to external shocks arising from intrinsic features of the economy, measured by economic openness, export concentration, and dependence on strategic imports*'. The index developed from this approach has been used in conjunction with an index of **resilience** to map the responsiveness of countries to varying levels of intrinsic vulnerability. Briguglio's work on economic vulnerability arose from a 1995 UN call for the development of a vulnerability index as part of a programme of action in small states. In parallel, the UN called for the development of an index of ecological vulnerability, especially to track the impact of disasters, but this approach was frustrated by lack of adequate data from enough countries.

Social and environmental vulnerability is the condition of being exposed and susceptible to loss and damage from natural and other hazards. The level of exposure is affected by isolation and the location, frequency and extent of hazards. Vulnerability may be lowered by providing protection against known hazards or removing vulnerable environmental elements from their path. Risk can be further mitigated by adaptation and by building up capacities that can reduce the extent of loss and damage and achieve rapid response, rescue, and recovery.

Sea walls can protect coastlines, property and people from sea surges. But if they are not well designed they can cause unexpected environmental and human loss that might have been better avoided by set-backs. Concrete houses that are destroyed in an earthquake may cause more damage to people and the environment than the straw houses they replaced. In California and Japan, buildings have been designed to withstand the impact of certain defined levels of earthquakes; but if poorly built, they may give rise to a greater loss of life or property. Bridges are commonly designed to withstand excessive loads from heavy traffic and from wind and water pressure, but their performance may critically depend on standards of construction and maintenance[4]. Moreover certain types of environmental hazard can be caused or accentuated by human activity such as those arising from climate change, global warming, sea-level rise, desertification, land and air pollution. In addition to the human enhancement of the potential risk of natural hazard, disasters can be the result of entirely man-made hazards. These include, for example, nuclear accidents and marine oil spills.

Types of risk and responsiveness to them

Table 14.2 sets out a stylised classification of the state of countries in the face of the risks of certain disasters and their capacity for risk reduction. It can be seen from this that countries differ in their responsiveness to similar risks. Countries may be broadly classified in terms of their responsiveness to risk as in Tables 14.2 and 14.3. For example, Mauritius has a low risk from cyclones but this has been achieved not because of low levels of exposure but because it has achieved high resilience and protection from their impact. Exposure to hazards remains high but the capacity for effective response through prevention, mitigation and rehabilitation has been highly developed. Thus, the impact of cyclones in Mauritius is low by comparison with Madagascar. In the latter case, the risk ishigh, arising from both elevated levels of hazards and exposure to them and from the low level of response. In the hypothetical kamikaze case of 'Cona', the risk of flooding has been made worse by locating increasing numbers of people in the low-lying areas.

Table 14.2. Stylised risk analysis by disaster type and country capacity for resilience

Disaster type	Nature and extent of risk	Probability/ frequency	Physical/ social vulnerability	Capacity for prevention, mitigation, rehabilitation	Expected impact	Vulnerability/ Resilience type
Mauritius Cyclones	Low	Some every year	High	High	Low/ Medium	Self made
Madagascar Cyclones	High	Many every year	High	Low	High	Catastrophic
Mauritius Malaria	Low	Rare imported cases	High	High	Very low	Self made
Comoros Malaria	High	Endemic	High	Low	High	Catastrophic
Mauritius Volcanoes/ earthquakes	Low	Rare	Low	High	Very low	Best case
La Réunion Volcanoes	High	Every ten years	High	High	Low	Self made
Maldives Sea surges and sea-level rise	High	Frequent	High	Low	High	Catastrophic
"Cona" Flooding	High	High	High	Low	High	Kamikaze
Nuclear power plant accident in SIDS	None	Zero	High	Low	Zero	Not relevant
Marine oil spill accidents IOC islands	Low	Low	High	High	Low	Self made

Table 14.3. Vulnerability and capacity for resilience

Vulnerability	Resilience	
	Low resilience	*High resilience*
High vulnerability	Class 1	Class 3
	Catastrophic/worst case	Self made
Low vulnerability	Class 2	Class 4
	Kamikaze	Best case

Mauritius can thus be classified as a class 3 or 'self-made' state (see Table 14.3) with high vulnerability and high resilience. Madagascar can be classified as a 'catastrophic state' with high vulnerability and low resilience. The challenge of management is to steer Madagascar towards the 'self-made' state by increasing its capacity for effective response to hazards and lowering its vulnerability to them.

Table 14.2 also says that while the IOC islands[5] have a high vulnerability to marine oil-spills, they have developed an effective regional response which provides protection through prevention and rapid response measures.

The worst case scenario is stylised for the hypothetical island state of 'Cona', which is subject to the hazard of flooding and has made itself more vulnerable to this hazard by locating an increasing number of people in flood-risk areas and failing to provide protection for them.

Potential for risk reduction

Table 14.4 sets out examples of the potential for disaster risk reduction in the face of a range of recognised hazards. For some hazards certain interventions are not relevant. For example, cyclones, tsunamis and volcanoes are largely inescapable hazards; whereas the risks of malaria, desertification, marine oil spills, nuclear power accidents and some aspects of climate change are susceptible to hazard prevention or limitation.

In the face of desertification, search, rescue and emergency treatment are less relevant for risk reduction than hazard reduction and the building of strategic resilience. By contrast, sea surges may not be avoidable, but the repair and maintenance of sea walls and flood defences are vital to reduce exposure. Together with search and rescue they reduce the risk and the impact on people, property and the natural environment in the face of an inescapable hazard.

Table 14.4 shows that in the case of the risk of man-made disasters, such as accidents in nuclear power plants and marine oil spills, the full range of management responses is relevant from prevention, reduction of exposure, rescue, rehabilitation and the building of strategic resilience through education, skills development and infrastructure investment

Table 14.4. Potential for risk reduction

Disaster type	Potential for action on risk reduction					
	Reduce hazard	Early warning protective	Search and rescue	Emergency support and	Repair and rehabilitation	Strategic resilience reinforcement
Cyclones	✘	✔	✔	✔	✔	✔
Malaria	✔	✔	✔	✔	✘	✔
Desertification	✔	✘	✘	✘	✔	✔
Volcanoes	✘	✘	✔	✔	✔	✔
Tsunamis	✘	✔	✔	✔	✔	✔
Climate change	✔	✘	✘	✘	✔	✔
Sea surge flooding	✘	✔	✔	✔	✔	✔
Nuclear power plant accident	✔	✔	✔	✔	✔	✔
Marine oil spill	✔	✔	✔	✔	✔	✔

Impact of disasters

Economists approach disaster risk reduction by considering both the cost of resources required for intervention and the opportunity cost of using those resources for such intervention rather than for alternative uses. The concept of opportunity cost thus embraces the issue of the choice of investment in one type of action compared with another and the loss arising from not using resources for a more cost-effective intervention.

Disasters are characterised by their infrequency and their confined location, whereas other classes of events causing death, injury and environmental damage, like road traffic accidents, tend to be frequent and widely scattered. This paradoxically makes each road accident less newsworthy[6] and less the subject of sharply focused risk reduction measures. Thus the impact of each road accident tends not to give rise to review of public policy or programmes, despite the fact that the cumulative impact of road accidents results in more deaths than the impact of individual disasters.

Box 14.2, Table 14.5 and Figure 14.1 provide a perspective on the impact of a major tsunami in the Indian Ocean in 2004–5, a major hurricane that hit the southern states of the USA in 2005 and other significant disaster events in the past four decades.

Box 14.2. Disaster alert 2005

The impact of the tsunami of December 2004 in the Indian Ocean and hurricane Katrina in the western Atlantic went far beyond immediate catastrophic damage, which was immense in both cases. It raised fundamental questions about how far countries are adequately prepared for avoiding the worst impact of such major events.

Following the 2005 UN SIDS Mauritius conference, two substantial international reviews on disaster risk management were produced[7] which built on strategic work undertaken

through the UNISDR, whose aim is to reduce losses from disasters. A number of SIDS contributed national reports to the process of development of the Hyogo Framework for Action[8] which emerged from this work in 2005 and which is based on an integrated approach to hazard and risk assessment and capacity building for emergency preparedness, response and recovery.

Investment in safety normally progresses through statutory regulation and insurance requirements, which are usually re-formulated following notable disaster events. The standards adopted in both regulation and insurance cover transport, buildings and infrastructure standards and include regulations and licensing procedures for the design, manufacture and registration of aircraft, ships, trains and road vehicles, and safety standards for buildings covering robustness, safety protection, escape and rescue.

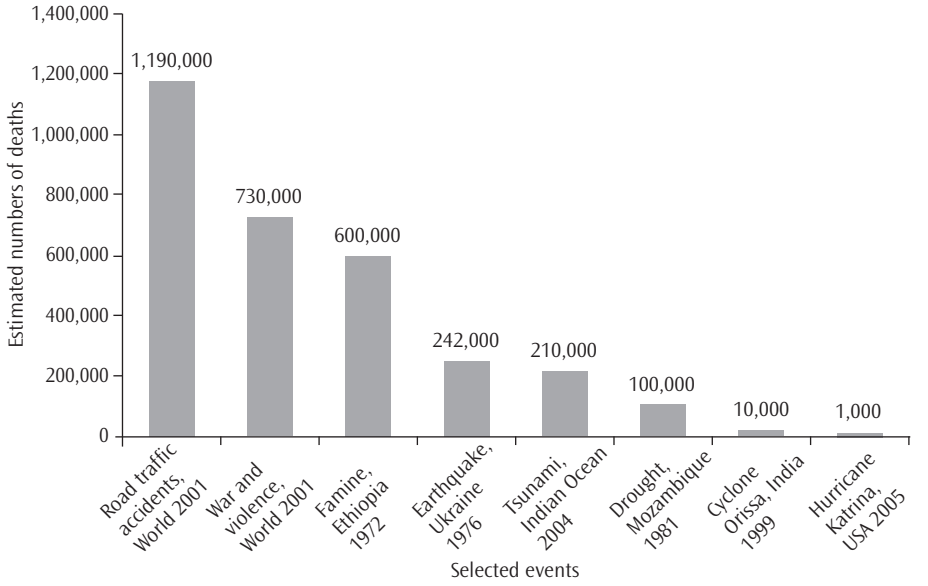
Against this background it is reasonable to ask: why is it that the preparedness and mitigation whichis now emerging as rational policy was not adequately incorporated into statutory regulations or insurance requirements before the tsunami and the hurricane disasters? Why were so many people vulnerable to the tsunami? Why were there no early warnings for bathers? Why were the hotels not set back from the sea? Why were the buildings not built to a standard to withstand the battering? What can now be done for rehabilitation and preparedness in case of another such event? In the case of hurricane Katrina, there was plenty of warning, both accurate and timely, but people are asking why were so many people vulnerable? Why were the levees (the flood barriers) not built to withstand the worst-case scenario? Why were so many people not evacuated by public transport? Why were emergency services not standing by to rush in water, food and security? Such questions are generally explored in post-hoc enquiries (see Table 14.5).

Table 14.5 provides a summary of the impact of the tsunami of December 2004 and what emerged from the impact of Katrina. The local inquiries following these events have set out the mitigating measures that could have reduced the damage and saved many lives and the means and the costs of implementing such measures in the future. The international strategic reviews re-examined the broader questions of intergovernmental preparedness and response. They built on the lessons evident from these two most recent case studies of how nature can overwhelm the coping capacity of even the richest of countries.

For the AIMS countries[9] the range of disaster hazards and risks are wide and varied. They include droughts, floods, wind storms, locusts, volcanoes, earthquakes, oil-spills, landslides and forest fires and the intense cross-boundary smoke clouds arising from them. Action taken by countries has been summarised in the 2004 AIMS Synthesis Report on progress with the Barbados Programme of Action[10], but further review is being undertaken to fill in the gaps in the information for region-wide learning from country experience.

Investing in risk reduction and better safety measures against inescapable natural events needs to be set within a broader framework of the relative costs and benefits of saving life, injury and damage to property and the environment, through risk management as a whole. Global figures of deaths from road accidents, armed conflict and inter-personal

Figure 14.1. Disasters, accidents and injury, deaths from selected events 1972–2005



Sources: UNISDR and WHO

Table 14.5. The costs of the 2004 tsunami, hurricane Katrina and future investment for disaster management

Impact and costs	2004[11] Indian Ocean Tsunami	2005 Hurricane Katrina Western Atlantic
Deaths	170,000–250,000	1000
Emergency relief and rehabilitation	US$3 billion[12]	US$200 billion[13]
Mitigating action against future events	• Early-warning systems and communications • Evacuation plan • Rapid rescue and emergency response • Building setback • Beach protection • New building standards	• More effective evacuation of poor, elderly and sick • Strengthening of flood protection • Rapid rescue and emergency response • New building standards and physical planning

violence outweigh the impact of natural disasters (see Figure 14.1). In this context, it is worth noting that WHO estimates that the introduction of seat belts in passenger cars in the USA cost US$1,406 per life saved, and that the US savings from the use of safety helmets by motorcyclists exceed the costs by US$23 million a year[14]. Such assessments of cost-effectiveness are becoming a standard issue in public policy, always bearing in mind the opportunity cost of not protecting life and property more cheaply in alternative fields of action.

Relative impact from disasters and from other fatal risk factors

Table 14.6 shows the relative impact at national and regional levels of disasters compared with other risk factors that give rise to fatal injuries, including road traffic accidents, inter-personal violence, fires and war. It can be seen that in each case the death toll from road traffic accidents and from inter-personal violence is greater per million of population in each of the regional strata of which the countries are part, than the national death toll from disasters. The hurricane Katrina disaster of 2005 killed about 1,000 people; the annual death toll from road traffic accidents in North America is about 50,000. Annual deaths from violence per million of population in the UK and the USA are respectively 24 and 50 times greater than deaths per million of population from disasters.

Social vulnerability and disaster risk reduction in SIDS

In assessing the impact of any adverse event, it is necessary to consider the social economic impact as well as the impact on the natural environment. Whilst road traffic accidents are frequent, with an immediate loss of life and injury and vehicle damage, much of this is subject to legally enforced insurance cover and rapid emergency response, treatment and repair. Special features of many natural disasters are their large-scale impact, logistical difficulties in rapid emergency response, gaps in insurance cover, and the long-run impact on social and economic activity and on the environment. This may include not only damage to property, to social and economic systems, but also adverse effects on water and sanitation systems, agriculture, woodlands, natural habitat, biodiversity and ecological systems. For SIDS, aspects of ecology linked to social and economic systems may be affected, including beaches, coral reefs, inshore fishing and aquaculture, and protected marine and coastal areas.

Table 14.6. Relative impact from disasters and other selected risk factors: Deaths per million population per year, national and regional figures

Country	Disasters[15]	Road traffic accidents[16]	Violence	War	Fires
Venezuela	67	178	274	18	9
Turkey	16	100	36	9	14
Vietnam	12	179	41	2	12
Tajikistan	4	100	36	9	14
USA	1	149	58	9	12
UK	0.2	114	10	2	7
Median values	8	131	38	9	13

Source: WHO (2008) World Health Report, Geneva

International policy on disaster risk reduction

Disaster risk-reduction policy has been a process of development through the UN and its agencies supporting and enhancing regional and national efforts. The 2002 World

Summit on Sustainable Development gave special attention to this field and the 2005 UN SIDS Conference, through the Mauritius Strategy, further promoted policy development and the improvement of risk programmes.

The WSSD policy called for countries and regional organisations to support SIDS in developing 'comprehensive hazard and risk management, disaster prevention, mitigation and preparedness, and help relieve the consequences of disasters, extreme weather events and other emergencies'[17]. This commitment followed on from the recognition promoted by the UN Disaster Relief Organisation in 1990 that the economic impact of disasters over the previous 20 years revealed that more than half the disaster-prone countries were SIDS. Further, the FAO had found that SIDS were prone to extremely damaging cyclones, storm surges, volcanic eruptions, earthquakes, forest fires, extended drought and extensive floods[18].

Immediately after the 2005 UN SIDS Mauritius Conference the UNISDR at Kobe agreed with member countries the Hyogo Framework for action on disaster reduction (see Box 14.3). These policies remain the theme for international development in this field, although there are significant gaps in evidence about best technical practices for dealing with each type of hazard in different locations and communities and the cost effectiveness of intervention. Recent work by the World Bank, the UNISDR – which has itself been

Box 14.3. Extract from the 2005 UN SIDS Mauritius Strategy

Natural and environmental disasters

19. Small Island Developing States (SIDS) are located in the most vulnerable regions in the world in relation to the intensity and frequency of natural and environmental disasters and their increasing impact, and face disproportionately high economic, social and environmental consequences. The tragic impacts of the 26 December 2004 Indian Ocean earthquake and tsunami and the recent hurricane/cyclone/typhoon season in the Caribbean and Pacific highlight their vulnerability. SIDS have undertaken to strengthen their respective national frameworks for more effective disaster management and are committed, with the necessary support of the international community, to:
    - **a** Strengthen the International Strategy for Disaster Reduction and related small island developing states regional mechanisms as facilities to improve national disaster mitigation, preparedness and early-warning capacity, increase public awareness about disaster reduction, stimulate interdisciplinary and intersectoral partnerships, and the mainstreaming of risk management into the national planning process.
    - **b** Use opportunities such as the 10-year review of the Yokohama Strategy on Natural Disaster Reduction, including the programme outcome for 2005–2015 of the World Conference on Disaster Reduction, to be held in Kobe, Japan, in January 2005, to consider the specific concerns of small island developing states, including issues relating to insurance and reinsurance arrangements for small island developing states.
    - **c** Augment the capacity of SIDS to predict and respond to emergency situations, including those affecting human settlements, stemming from natural and environmental disasters.

undergoing major reforms in its strategy and structures – and regional organisations, especially in the Pacific and Caribbean SIDS regions are throwing light on these issues[19].

Response systems in SIDS

In the Pacific islands, many of which are low lying and very isolated, a regional response system – The Comprehensive Hazard and Risk Management system (CHARM) – has been designed as a tool for integrated disaster risk reduction. The Pacific SIDS have fragile ecosystems with many populated coastal low-lying areas especially vulnerable to extreme weather conditions, and the potential of sea-level rise from climate change[20]. For these reasons, Pacific SIDS are committed to the implementation of development projects to reduce risks to people, property and the environment. They have strengthened their national and regional resilience to hazard impacts. The historical record of specific disaster-reduction initiatives also shows that Pacific island states have adopted positive approaches in both traditional and more contemporary ways to enable Pacific islanders to maintain a respect for their chosen cultural values.

In the Caribbean, the Caribbean Hazard Mitigation Capacity (CHAMP) has been developed. CHAMP provides a means for making assessments of the critical infrastructure facilities that may be vulnerable to extreme events. It provides hazard-specific maps covering a variety of critical facilities such as power generation, water and sanitation, waste management, public buildings, fire and emergency services, schools and hospitals. The assessments identify the value of probable maximum loss reflecting topography, design, building practice, materials and condition. The results of the assessments are used to prioritise investment in capacity building for resilience.

In the Maldives, community awareness of vulnerability is common. The islands were severely affected by the tsunami of 2004 losing over 70 lives, and suffering extensive flooding and loss of vital infrastructure facilities and damage to water and sanitation systems. It was estimated that the Maldives would need 10 years or more to recover from these adverse effects. To prevent hazards such as severe storms and waves from becoming future disasters, local communities and NGOs are working together planting trees on the beaches and constructing sea walls to prevent beach erosion. This has helped to reduce the impact of waves on the islands but proved insufficient to withstand the impact of the tsunami in 2004 (see UNISDR 2004 p.186)[21].

ISDR reports that there is considerable geographic variation in the occurrence and impact of natural hazards in the last decade. Asia was affected by approximately 43 per cent of all natural disasters and accounted for almost 70 per cent of all lives lost due to natural hazards. During the two El Niño periods of 1991–92 and 1997–98, floods in China alone affected over 200 million people in each period. Nevertheless, in relative terms, Africa is the most heavily affected region, per capita, especially when drought, epidemics and famine are considered. The special aspect of risk associated with SIDS is the limited area of refuge for escaping from the immediate effects of disaster. The largest island in the Maldives is smaller than Heathrow airport and the highest point is less than 2 metres above sea level.

Environmental sustainability and disaster risk reduction

The 10th Special Session of the Governing Council/Global Ministerial Environment Forum of the UN in Monaco in February 2008 reviewed progress on the environmental impact of disasters and progress with disaster risk reduction across the world. The Council acknowledged that the various strategic policy initiatives through the UN, including the:

- Millennium Declaration,[22]
- Millennium Ecosystem Assessment,[23] and
- Hyogo Framework for Action[24]

have different perspectives but that environmental degradation, poverty and disaster risk share common causal factors as well as common impacts on security and welfare. The Council accepted that better environmental services, management, and information offer opportunities to reduce risk, decrease poverty and achieve more sustainable development.

The Council asserted that '*healthy ecosystems provide natural defences, wetland ecosystems for example function as natural sponges that trap and slowly release surface water, while mangroves, dunes and reefs create physical barriers between communities and coastal hazards. Conversely, degraded ecosystems reduce the coping capacities of communities and social systems. Disaster recovery processes need to take the state of ecosystems and ecosystem services into account*'.

Conclusion

Disaster risk reduction is the focus of international, regional and national concern in sustainable development strategy and management. Policy frameworks in this field have been the focus of increasing UN commitment for decades and have been elaborated in relation to the special risks for SIDS, other small states and low-lying countries. This concern has been amplified following the growing threats of climate change and sea-level rise, to which many SIDS are seriously exposed. The 2004 tsunami in the Indian Ocean and the 2005 hurricane Katrina in the Caribbean and in the Southern USA promoted further international deployment of resources in the analysis of risk, the rehabilitation of people, property and the environment, and the call for better information, management and preparedness, including effective early-warning systems. This chapter has reviewed the evidence of the relative costs of disasters compared with other hazards to life, property and environment and has identified the need for greater attention to evidence-based policy, the better assessment of risk and more thorough evaluations of the cost effectiveness of intervention.

Further reading

Briguglio, L., G. Cordina and E.J. Kisanga (2006). *Building the Economic Resilience of Small States*. University of Malta and the Commonwealth Secretariat. http://publications.thecommonwealth.org/building-the-economic-resilience-of-small-states-416-p.aspx

IOC (2004). *AIMS Synthesis Report, progress on the Barbados Programme of Action*. IOC for the AIMS Group, pp. 43–45.

Khan, M.E. (2005). 'The death toll from natural disasters, the role of income, geography and institutions', *The Review of Economics and Statistics*, **87** (2) 271–284.
Living with Risk: A global review of disaster reduction initiatives 2004 version Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR) http://www.unisdr.org/eng/about_isdr/bd-lwr-2004-eng.htm
UNISDR (2004). *Living with Risk; a global review of disaster reduction initiatives*. UN
UN Millennium Assessment Reports: http://www.millenniumassessment.org/en/index.aspx
UN Millennium Declaration http://www.un.org/millennium/declaration/ares552e.pdf, Also known through the Millennium Development Goals (MDGs). See UN General Assembly Resolution 55/2, 8 September 2000:
WHO (2002). *Reducing the risks*. World Health Report. Table 2 Deaths by cause. Geneva: WHO, pp.190–191.
WSSD (2002). *Report of the World Summit on Sustainable Development, Johannesburg, 26 August – 4 September* UN/Conf.199/20, Annex Plan of Implementation paragraphs 58–61, page 41, UN New York., ISBN 92-1-104521-5
Strachan, J. et al. (2005). *The Plain Language Guide to the World Summit on Sustainable Development*. London: Earthscan, p. 91.

Useful website links

United Nations Strategy for Disaster Reduction: www.unisdr.org
The Hyogo Framework for action 2005–2010, www.unisdr.org/wcdr and Hyogo Framework for Action 2005–2015: Building the resilience of nations and communities to disasters: http://www.unisdr.org/eng/hfa/hfa.htm

Notes

1 See www.unisdr.org
2 See Box 14.1 for definition of key terms.
3 Briguglio et al. (2006)
4 See www.wbdg.org/design/resist-hazards and www.unisdr.org
5 The IOC islands are Comoros, Madagascar, Mauritius, La Réunion (a Department of France), and the Seychelles.
6 Dog bites man; not news; man bites dog; front page story!
7 One by UNESCO working with the Intergovernmental Oceanic Commission and other bodies. Another has been undertaken by the Commonwealth Secretariat with particular attention to the vulnerability of SIDS working with CARICOM (the Caribbean Community), PIFS (The Pacific Island Forum Secretariat) and the IOC (Indian Ocean Commission). www.unisdr.org. 2nd Pacific regional disaster risk management meeting for Pacific CEOs of finance/planning and disaster management; Caribbean Disaster Emergency Management Agency: http://www.cdera.org 3rd Caribbean Conference on Comprehensive Disaster Management December 2008; World Bank Disaster Risk Management Team: http://web.worldbank.org/; Global Facility for Disaster Reduction and Recovery: www.gfdrr.org. The Commonwealth's effort arose from commitments made at the January 2005 UN SIDS strategy meeting in Mauritius to follow up the 2004 tsunami and levels of technical preparedness in small island developing states.
8 The Hyogo Framework for action 2005–20010, was developed through the UNISDR (UN agency for International Strategy for Disaster Reduction) in Japan in 2005. Its stated outcome

is 'the substantial reduction of disaster losses in lives and in the social, economic and environmental assets of communities and countries; see www.unisdr.org/wcdr

9 AIMS countries are UN-recognised small island developing states and low-lying states in the Atlantic, Indian Ocean, Mediterranean, and South China Seas; namely: Bahrain, Cape Verde, Comoros, Cyprus, Guinea Bissau, Maldives, Malta, Mauritius, Sao Tome and Principe, Seychelles, Singapore.

10 IOC (2004) AIMS Synthesis Report, progress on the Barbados Programme of Action. IOC for the AIMS Group, pp. 43–45.

11 www.tsunami.civil.tohoku.ac.jp/sumatra2004/report for a research-based assessment of the impact; and http://en.wikipedia.org/wiki for a review based upon news coverage.

12 The comparatively low estimate of cost in the Asian and African countries affected, contrasts with the figure for the US event and the impact of buildings, infrastructure, business and property which in the US economy are more expensive to replace; both figures are based on local estimates of costs of local labour and building materials, etc.

13 Arising from extensive property and infrastructure damage and the evacuation and subsequent need for resettlement of over 750,000 people across a territory the size of the UK.

14 WHO (2002) *Reducing the Risks, Promoting Healthy Life*. The World Health Report, Geneva: WHO.

15 National figures from Khan, M.E. (2005). 'The death toll from natural disasters, the role of income, geography and institutions', *The Review of Economics and Statistics*, **87** (2) 271–284.

16 Other figures in this table are from the regional strata in which each of the countries is located in WHO (2002), pp. 190–191.

17 WSSD 2002 Plan of Implementation, paragraph 58 (h) UN 2002 op.cit.

18 Strachan J. et al. (2005) *The Plain Language Guide to the WSSD*. London: Commonwealth Secretariat, Earthscan. p. 91.

19 See www.unisdr.org; and http://www.worldbank.org/hazards

20 See www.unisdr.org for current summaries of policies, case studies and best practices in action in SIDS and elsewhere.

21 UNISDR (2004) *Living with Risk; a global review of disaster reduction initiatives*. UN.

22 UN Millennium Declaration http://www.un.org/millennium/declaration/ares552e.pdf, Also known through the Millennium Development Goals (MDGs). See UN General Assembly Resolution 55/2, 8 September 2000.

23 UN Millennium Assessment Reports: http://www.millenniumassessment.org/en/index.aspx

24 Hyogo Framework for Action 2005–2015: Building the resilience of nations and communities to disasters: http://www.unisdr.org/eng/hfa/hfa.htm

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Chapter 15

Coastal lagoon management in three Pacific island situations: Is scientific knowledge used effectively?

Introduction

The small islands of the South Pacific region, like many other parts of the world, are experiencing population growth and, more particularly, the movement of people into major urban centres. Most Pacific cities, especially the capitals of regional countries, are located in naturally protected coastal waterways. This is a historical situation, arising from the need to provide protected deep-water harbours for ships, the main form of international travel and trade. These waters are protected by offshore barrier reefs, by islands or by riverine deltas. However, these protective mechanisms also have the effect of limiting mixing of near-shore and open-ocean waters (Viles and Spencer, 1995). This provides an opportunity for problem materials, derived from human activities, to accumulate in the near-shore waters and the marine zone with which most people interact.

Urbanised coastal lagoons represent one of the most threatened global environments. These water bodies, as a result of their adjacent populations, are subjected to human impacts from habitat modifications, poor waste management, industrial discharges, storm-water runoff and shipping activities. In some cases, the lagoons are approaching ecological collapse. The ecological behaviour of these water bodies is difficult to determine as they are constantly undergoing change due to the effects of tides and river inputs. The management of coastal lagoons is often complicated by the multi-jurisdictional nature of the legislation that frequently applies to them.

It is a common saying that 'you cannot manage what you cannot measure'. There has therefore been a significant global effort to gather scientific information about coastal areas with the stated goal of ensuring that decision-making is based on a firm knowledge base. The knowledge base should focus on ecological conditions and processes in coastal water bodies and the potential impacts of humans on them. It is also important to emphasise that planning and management should be integrated and multi-dimensional in nature, and should accommodate the technical, social and economic components of such a complex undertaking. Despite this aspiration, a number of researchers have found that an integration of science, policy and management is lacking (e.g. Hoare, 2002; Kay and Alder, 2005; van Kerkhoff, 2005; Thompson, 2006). In this context, the Pacific islands have not received much attention.

The global effort to provide management regimes for coastal lagoons tends to involve three main phases, notwithstanding local variations, as follows:

Phase 1: Evaluation of ecological processes and community expectations to create a scientific understanding of the main factors controlling lagoons and the expectations and goals of the people using them.

Phase 2: Development of a cooperative management plan using information gathered in Phase 1. This needs to be flexible and adaptable as new information becomes available.

Phase 3: Implementation and monitoring to determine whether the plan is achieving its goals.

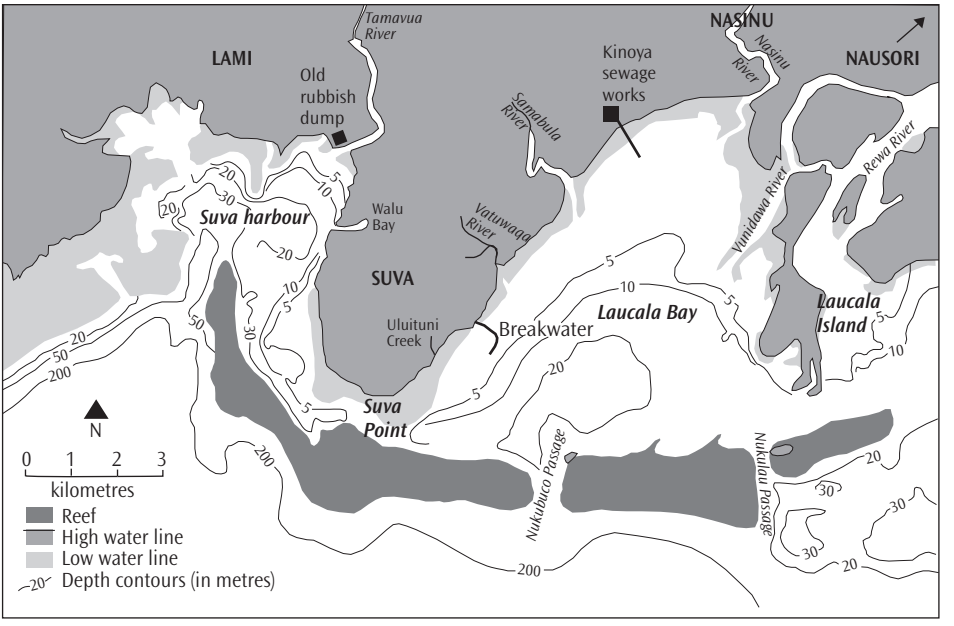
This chapter reviews the situation in three Pacific localities, Suva Lagoon in Fiji, Fanga'uta Lagoon in Tonga and Funafuti Lagoon in Tuvalu, by examining what is being done about the management of these areas, what scientific knowledge is available and how it is being utilised therein.

Suva Lagoon

Suva Lagoon, located in south-east Viti Levu, the largest island of the Fiji group, consists primarily of Laucala Bay and Suva Harbour (Figure 15.1).

The lagoon is one of the most commercially important water bodies in the South Pacific region. Since Suva (at 178°43'E and 18°15'S) was established as the capital of Fiji in 1882, this lagoon has been an intensive shipping centre, acting as both a national and regional hub for transport and trade. The development of Suva as a major commercial centre in the Pacific islands has also led to a rapid expansion of the local population (see

Figure 15.1. The Suva Lagoon System, Viti Levu, Fiji



Source: Tuvalu Map Server: http://map.tuvalu.tv

Table 15.1. Population census data for the Suva area

Date	Greater Suva*		Suva City	
1966	80,269	(17%)#	54,157	(11%)
1976	117, 827	(20%)	63,628	(11%)
1986	157,980	(22%)	69,665	(10%)
1996	214,628	(28%)	77,366	(10%)
2007	247,141	(30%)	75,225	(9%)

* Greater Suva = the Suva, Lami, Nasinu and Nausori local government areas (LGAs)

#The figures in parentheses are the % of the total population of Fiji

Source: Fiji Bureau of Statistics. http://www.statsfiji.gov.fj/

Table 15.1), with subsequent increases in construction, industry and related infrastructure. The local populace have also made extensive use of the resources within and around Suva Lagoon for food, shelter and recreation. All of these activities have had a dramatic impact on the local environment with some components (e.g. the old Lami rubbish dump) having significant immediate influence, while others (e.g. declining water quality) have had less obvious consequences (Morrison and Aalbersberg, 2006).

Given the importance of Suva Lagoon to Fiji and the region, and the rapidly expanding urban population (now over 200,000 in the surrounding catchment), it is surprising that the local authorities have not given higher priority to the systematic acquisition of environmental information on this water body, particularly on the pollution situation, which is regarded by one observer as being 'out of control' (reported in Morrison, 2006). While information has been collected since the 1970s, no systematic programme is in place to determine the sources, types and quantities of pollutants entering the Suva Lagoon system. An assessment of the potential contaminant sources (Morrison et al., 2006) indicates a range of problem materials – nutrients, metals, hydrocarbons, organo-chlorines, micro-organisms and other materials such as plastics, tyres, clothing and general rubbish.

A recent review of the ecological and other information on the Lagoon (Morrison, 2006) indicates that some 'true' knowledge gaps exist (e.g. bird life, invertebrate ecology, reef-seagrass-mangrove interactions, health impacts of poor Lagoon condition) while other information has been collected but not published (e.g. reef changes, physical oceanography, regional geology, algae, seagrasses and fish). It was also observed that there is no systematic information on current community and non-community resource use/impacts. The degree of community awareness of the ecological processes, status of biodiversity and how this affects the community is uncertain, and systematic collection of such information is not being undertaken. Gathering such information would facilitate identification of community stakeholders (who are the more inclusive community, e.g. resource owners, subsistence and commercial users, researchers).

There is no integrated planning in Fiji for large coastal water bodies like Suva Lagoon. Examination of the current planning system in Fiji indicates that most plans are land-based or address a specific topic/sector. There is minimal integrated planning at the catchment/receiving water body level. Early attempts at total catchment planning (e.g. FAO in

1980s) were never fully developed. Almost all foreshore planning is reactive rather than strategic, and therefore is generally ineffective thus emphasising the need for stronger linkages between the roles of, for example, the Department of Lands and the Port Authorities. While changes to administrative systems have been occurring in recent years, these do not fully address the requirements for managing important ecosystems.

The planning system needs to be revisited to move towards a modern environmental planning system (involving the integration of planning activities of rural authorities, local government agencies, Departments of Town and Country Planning, Environment and Lands). There is a lack of mangrove and foreshore planning, and therefore no ability to fill key gaps, e.g. health impacts of poor living environments. The Suva City structural plan (zoning) only covers land (with some uncertainty about the situation in mangroves and reclamation areas); the situation in the Lami, Nasinu and Nausori LGAs is also unclear as they have different priorities.

Community engagement is the basis of successful management – more effort/support is required in this area, and there should be a priority concern for the needs of traditional owners/users. There is an urgent need to determine community perceptions on issues relating to Suva Lagoon. The information needs of various communities should be determined, collected and appropriately disseminated, and there is a need to involve communities in research and intellectual property issues.

Based on the experience in other countries, the successful management of Suva Lagoon will require the establishment of a coordinating body to develop and *implement* a **Suva Lagoon Management Plan**. To be effective, this body must be a high-level national group and have jurisdiction covering the lagoon and relevant components of the adjacent catchments. Linked to the establishment of an oversight body, there is an urgent need for a review of current planning agencies in Fiji to facilitate restructuring of the system to incorporate the recent international developments in integrated and ecosystem-based planning (this might be a role for the National Environment Council, and/or the Law Reform Commission).

The successful management of Suva Lagoon will be a multi-sectoral activity, involving teams/groups from many traditional disciplines. This involves accurate identification of key stakeholders, clear declaration of their roles and responsibilities, with precise objectives in the management plan, and well-defined processes to achieve the desired goals. Mechanisms for enforcement of regulations must be established, including who will carry out the enforcement, how this will be done and what funding (e.g. national government, local government, private sector, and an environmental levy on shipping) and other resources will be available. As noted earlier, community engagement is the basis of successful management – more effort/support is required in this area, and the needs of traditional owners/users should be a priority concern.

One approach to developing and implementing a Suva Lagoon Management Plan could be to adopt Locally Managed Marine Areas (LMMA)-type alliances and strategies (Veitayaki et al., 2003) in concert with the Suva Lagoon Community. Further, there should be maximum involvement of visiting scientists (both local and overseas) with local

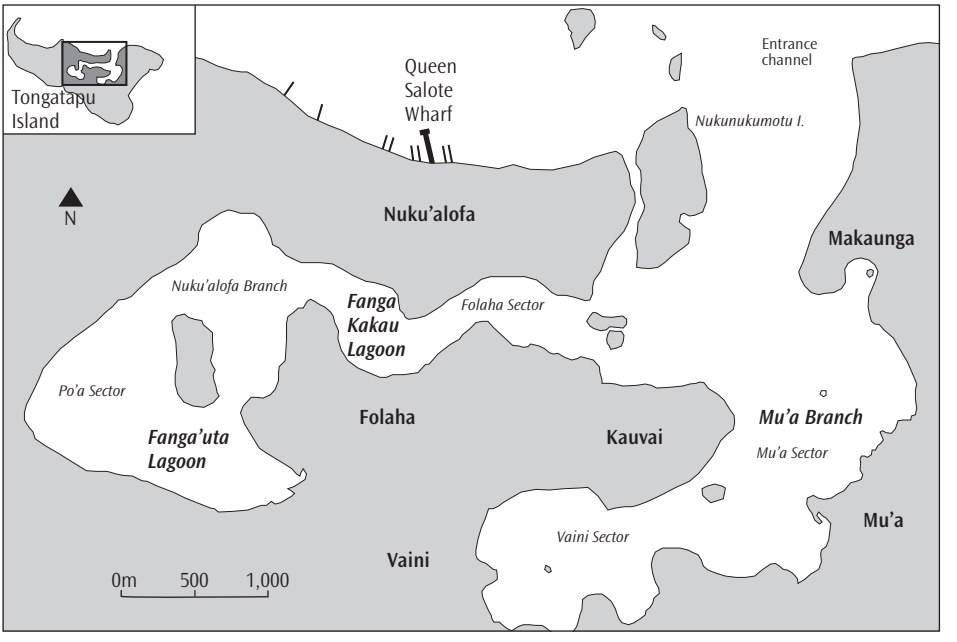
community members, schools and other community groups. Community-based programmes should be developed for the protection and replanting of native coastal trees, and a primary school programme (one-week module) should be introduced in all local primary schools to educate children on the importance of coastal ecosystems. In addition, a series of community-based workshops with appropriate presentations by relevant people should be established.

Improved links between poor-quality environmental conditions on human health could be determined through socio-economic and health surveys linked to resource use and degradation, including the collection of better health statistics for environmental planning. While this will require resources, effective linkages between the Department of Health and the local tertiary institutions (University of the South Pacific, Fiji School of Medicine, Fiji Institute of Technology) could achieve much, utilising student projects focused in this area. Topics that could be investigated include the effects of recreational use of contaminated shoreline waters, shellfish quality at time of consumption, and preparation of a comprehensive database on health statistics for residents of the foreshore areas around Suva Lagoon.

Fanga'uta Lagoon

The Fanga'uta Lagoon system is one of the most important water bodies in Tonga and is one of the dominant natural features of Tongatapu, the Kingdom's main island (Figure 15.2). The Lagoon system, located at 175º12'W, 21º18'S, comprises two major arms, one in the west including the Fanga'uta and Fanga Kakau sections, and one in the east including the Fangalongonoa and Vaini sections. In this chapter, the term Fanga'uta will normally refer to the whole system.

Figure 15.2. The Fanga'uta Lagoon System, Tongatapu, Tonga



Source: Tuvalu Map Server: http://map.tuvalu.tv

As the national capital (Nuku'alofa) and several large villages (Vaini, Mua and Folaha) are located immediately adjacent to the lagoon, the catchment population is approaching 40,000, and has been growing rapidly over the last 30 years. The Lagoon system has provided fish and shellfish supplies for the surrounding population for generations, but in recent years yields have dropped and some species are no longer sustainable. In addition, lagoon resources such as mangroves have been extensively exploited, and significant areas, especially in the western section have been 'reclaimed' for urban expansion (Kaly and Lloyd, 2001). The Lagoon system has also provided many recreational opportunities for local residents and visitors (Pelesikoti, 2003).

The first detailed ecological study of Fanga'uta Lagoon was carried out in 1981 (Zann et al., 1984). This study found that water clarity was >1m throughout and that the lagoon was dominated by extremely productive soft substratum communities. Zann et al. (1984) reported that even in 1981 the system was undergoing significant changes. The large mullet fishery (yielding about 185 t/yr) of the 1960s had gone into decline resulting in closure to commercial fishing in 1975. The lagoon was reported as shallowing, mangroves were being cleared, land reclamation for building was occurring, and the mussel (mainly Anadara sp.) fishery was in decline.

Studies in 1987–88 (Naidu et al., 1991) indicated that further changes had occurred in the lagoon. Although water clarity was still good (most readings >1m), sewage-related contamination with high nutrient concentrations, sufficient to impact on coral growth, was recorded. Further declines in mullet and mussel catches were noted with mussels reported as having disappeared from some locations in the lagoon.

In the early 1990s a major change occurred (Kaly and Morrison, 2005). Aerial photographs taken in 1992 showed Fanga'uta Lagoon with relatively clear waters as it was possible to see areas of seagrasses, coral rubble and patch reefs to depths of at least 2 m. Information was emerging by this time that the lagoon was occasionally turning green, that turbidity was increasing, and that fish catches continued to decline. Then, during 1993, the lagoon 'flipped' (changed for good). It lost its clear waters, fish kills started to occur and foam was often seen forming on its narrow muddy beaches. The many species of seagrasses in the lagoon became covered in algae and more and more mangrove areas were being cut and damaged. By that time many of the beaches were converted to seawalls and sewage was a common component of storm water entering through drains.

The early 1990s saw several activities in the policy, planning and management areas, including the production of an 'Environmental Management Plan for the Kingdom of Tonga' (ESCAP and GoT, 1990) and 'The Kingdom of Tonga: Action Strategy for Managing the Environment' (Thistlethwaite et al., 1993). In addition, based on the outcomes of the 1987–88 studies, an inception report on a proposed environmental management plan (EMP) for the Fanga'uta lagoon system was prepared by the Ministry of Lands Survey and Natural Resources and the Ministry of Health. Progress on the implementation of such plans was slow, and a number of major developments around the lagoon were proposed, including the possibility of causeways across the main lagoon entrance and the Fanga Kakau sector, and reclamation of major areas in the north and

south of the Pe'a sector. These proposals could have had dramatic environmental impacts and were of concern to the government and many people in the wider community.

Concerns for the health of Fanga'uta Lagoon reflected wider apprehension about the environment in Tonga, and in 1993 AusAID, in consultation with the Government, commissioned a team to design a project for Australian assistance to the environment sector in Tonga. The project aimed at strengthening the capacity of a range of Ministries and agencies in the Government of Tonga to undertake environmental management and planning roles. As a result of the community concern about the condition of the Fanga'uta Lagoon, the project was designed to utilise the lagoon and its adjacent communities as a case study for project training activities. Funding for the Tonga Environmental Planning and Management Strengthening Project (TEMPP) was approved in 1997 to run until 2001.

The TEMPP project provided a unique opportunity to gather new information on the Fanga'uta Lagoon system and to train national staff in a range of scientific, planning and management activities. A full suite of scientific investigations was completed including monitoring of various aspects of the lagoon ecosystem (e.g. water quality, seagrasses, fish and shellfish catches) over several years. Issues like mangrove loss, waste management (an identified key problem for the lagoon), chemicals management and reclamation/seawalls were also reviewed. About fifty technical reports were produced facilitating an accurate assessment of the condition of the Lagoon in 2001 (Kaly and Lloyd, 2001). Community education activities were also conducted and community perceptions and aspirations about the lagoon were assessed.

One of the main objectives of the TEMPP project was to produce an environmental management plan (EMP) for Fanga'uta Lagoon. This was completed in 2001 (Kaly and Lloyd, 2001) and submitted to the Government of Tonga. This plan contained a review of the current condition of the lagoon, the major issues facing the water body and the surrounding catchment. The approach taken attempted to accommodate all components through a zoning strategy for different usage areas, each with its own set of resources, stresses and human needs. The zoning plan and the recommended activities for each zone are given in Table 15.2.

The Fanga'uta EMP was relatively unique in the Pacific islands region in that it was based on a strong scientific knowledge base and had significant community input as the views of government, NGOs and the general community were taken into account in its preparation. The importance of the EMP and the Lagoon was given some recognition as the Tongan Cabinet endorsed the EMP in 2003, but minimal progress has been made on implementation because of funding limitations. Given the recent (November 2006) catastrophic damage to the Nuku'alofa business district during rioting, it is unlikely that substantial funds will be made available for undertaking the required actions to protect Fanga'uta Lagoon. This is of concern as it is inevitable that in the absence of such action the condition of the Lagoon is likely to further decline.

Table 15.2. Summary of recommended activities within each of the Fanga'uta management zones

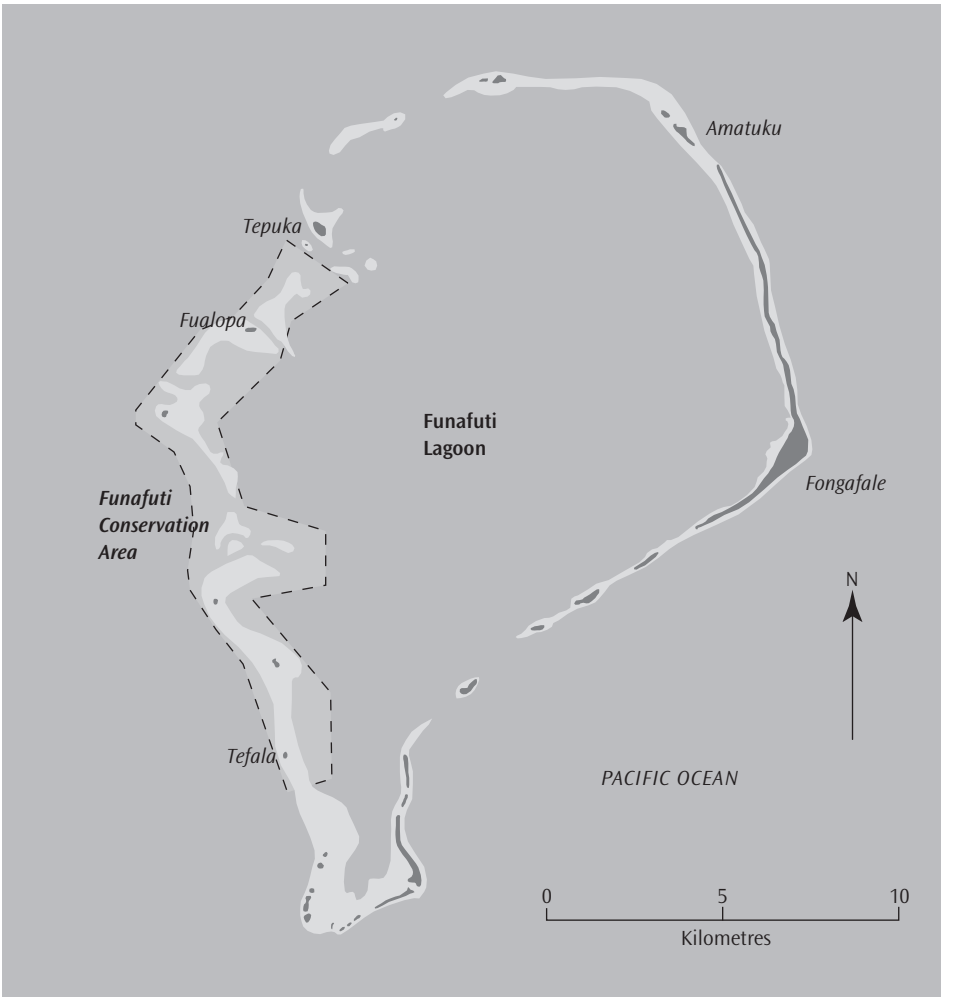
Zones	1	2	3	4	5	6	7	8
Activity	Mouth fisheries	Lagoon fisheries	Mangrove conservation	Mangrove use	Village & agriculture	Village special use	Urban	Public special use
Land allocation below present MHWM	✘	✘	✘	✘	✘	✘	✔	✘
Commercial fishing/ aquaculture	✔	✘	✘	✘	na	✘	na	✘
Subsistence fishing	✔	✔	✘	✔	na	✔	na	✘
Mangrove removal	na	na	✘	✘	na	✘	na	✘
Seagrass removal	✘	✘	na	na	na	✘	na	✘
Mangrove use (wood, crafts, medicine)	na	na	✘	✔	na	✔	na	✘
Mangrove rehabilitation	na	na	✘	✔	na	✔	na	✘
Reclamation	✘	✘	✘	✘	✘	✘	✔	✔
Seawalls	✘	✘	✘	✘	✘	✘	✔	✔
Dredging/sand & gravel extraction	✘	✘	✘	✘	✔	✘	✔	✘
Anchor/boat disturbance	✘	✘	✘	✘	na	✘	✘	✘
Buildings	✘	✘	✘	✘	✔	✘	✔	✘
Rubbish dumping	✘	✘	✘	✘	✘	✘	✘	✘
Industry	na	na	✘	✘	✘	✘	✔	✘
Tourism	✔	✔	✘	✔	✔	✔	✔	✘
Recreation	✔	✔	✘	✔	✔	✔	✔	✔
Research	✔	✔	✔	✔	✔	✔	✔	✔

MHWM = Mean high water mark; na = Not applicable; ✘ = Not permitted; ✔ = Permitted

Funafuti Lagoon

Funafuti is the capital of nine atolls and islands that form the nation of Tuvalu. The islands and atolls are all low, comprised entirely of reefs and their derivatives and stretch between Nanumea in the north-west (5°38'S, 176°07'E) and Niulakita in the south-east (10°45'S, 179°38'E) for a distance of approximately 680 km. The total land area is only 26 km^2, spread over an exclusive economic zone (EEZ) of almost 1 million km^2. Funafuti is located roughly in the centre of this geographic spread at 8°31'S, 179°12'E and comprises a large atoll lagoon (approximately 15 x 22 km) surrounded by a reef rim on which has formed 30 coral islets (Figure 15.3). The largest of these, Fogafale is about 5 km long and up to 500 metres wide and provides a land area of around 1.45 km^2 . About one-third of the nation's 16,000 population, and the seat of government, are located on Fogafale.

Figure 15.3. Map of Funafuti Atoll showing Funafuti Lagoon, the Capital District on Fogafale and the Funafuti Conservation Area (dashed line)



Source: Tuvalu Map Server: http://map.tuvalu.tv

Funafuti Lagoon represents the opposite extreme to the ecological conditions, human interactions and scientific knowledge and requirements described earlier for Suva. While Suva Lagoon is formed by fringing reef and estuarine areas bordering a high island, and Fanga'uta Lagoon is formed in the centre of the raised coral platform of Tongatapu, Funafuti Lagoon is formed as part of a true atoll in mid-oceanic conditions subject to no terrestrial influences. The country's shipping is mostly limited to about one tanker vessel per month, two inter-island transport vessels and a small fishing fleet. Funafuti is not a regional shipping hub and has no local manufacturing activity. The lagoon has several large channels connecting it with the ocean and a large sea-to-land ratio. Most of the impacts and management issues relating to the lagoon are derived either from relatively localised impacts of the small human population, natural events or global influences.

With a density of about 3,600 people per km^2, Fogafale islet is heavily populated and subjected to significant environmental stresses, including habitat modifications, damage to the groundwater lens, loss of tree cover, sewage and rubbish pollution. The surface of the island has been highly modified for housing, roads, an airport and the creation of 10 'borrow pits' during WWII to provide materials for building the airport runway. In recent times, the borrow pits have been used to dispose of the increasing quantities of solid waste being generated through the westernisation of the population's lifestyle. Open to the air and in communication with groundwater, these borrow pits threaten the freshwater supply and public health, further reduce the already limited useable land and increase the risk of island break-through by waves during storms. Added to this are the significant problems and risks presented by climate change and sea-level rise, problems with near-shore erosion on the lagoon and ocean side of the island, increasing problems with king tides inundating areas of the land and a loss of island-maintenance processes. There is evidence that demersal fishes and invertebrates of the lagoon are over-fished and reports of increasing algal growth in the near-shore areas of the lagoon and ocean side of the island.

Tuvalu has recently drafted an Environment Protection Bill which is expected to be passed at the next parliamentary session. The country is signatory to a range of international conventions and treaties (around 36 treaties recorded in the Columbia University ENTRI database – http://sedac.ciesin.columbia.edu/entri/) and there are environmental laws, policies and strategies embodied in the national development plans (Kakeega o Tuvalu), the National Environmental Management Strategy and the powers of the Island Councils. The Department of Environment was established in 1995 and is currently focusing on four main areas;

i Climate Change/Sea Level Rise and the National Adaptation Plan of Action (UN Development Programme under UN Framework Convention on Climate Change);
ii The International Waters Programme (GEF/UNDP, now concluded) which focused on lagoon and oceanic waters;
iii Ozone Depleting Substances Project concluded in 2006 to meet obligations under the Vienna Convention and the Montreal Protocol; and
iv Waste Management Programme (AusAID, now to be taken over by Department of Environment or Funafuti Island Council (Kaupule).

Scientific studies undertaken in Funafuti date back to the late nineteenth Century with the original investigations of the nature of atolls by the Royal Society of London (1896) and Edgeworth David (1896–68) who bored into Fogafale to a depth of 340 metres and gave support for Darwin's theory that coral atolls grow progressively on slowly sinking platforms. During the 1970s and 1980s, scientific attention was directed at Funafuti in response to the Cyclone Bebe disaster in 1972 which also created a large storm bank and decimated corals (Maragos et al., 1973; Baines et al., 1974) and later to identify natural resources in the form of arable land and sand and aggregates for development (McLean and Hosking, 1991, 1992). A large part of the recent work on beach profiling, wave dynamics, climate, geology, coastal erosion, disasters and sediment resources has been undertaken by SOPAC (e.g. Barstow and Haug, 1994: Smith, 1995a, b; Xue and Malologa, 1995; Xue, 1996). During the period 1987–2000, a series of studies focused on living lagoon resources was undertaken in response to development plans and/or treaty requirements. These included baseline surveys for dredging, channel blasting, ciguatera management and the establishment of the Funafuti Conservation Area on the western side of the lagoon (e.g. Kaly and Jones, 1994; Kaly 1997, 2000; Ramsay and Kaly 2003). These studies generated basic information on coral cover, demersal fish stocks, invertebrates (such as shellfish) and ciguatera-causing dinoflagellates at selected areas around the lagoon – particularly in the west within and around the Funafuti Conservation Area, along and to the north and south of Fogafale – and on selected patch reefs in the centre of the lagoon. During these studies it was noted that the reef fish and invertebrate faunas were depleted and that unexpected algal growth was occurring over reef areas close to the centre of human habitation.

The South Pacific Regional Environment Programme (SPREP) has been active in establishing the Funafuti Conservation Area in 1996 and in assisting Tuvalu to address common issues within a more regional and global framework (Berdach, 2003; Carter, 2007). SOPAC, in collaboration with a range of partners, has also assisted through the development of an Environmental Vulnerability index (EVI) and country profile which, if adopted, could assist with management of the lagoon (Kaly et al., 2005a, b). The Foundation for the Peoples of the South Pacific International (FSPI) has been working in Tuvalu in Nukufetau and Nanumea to establish community approaches to the management of living marine resources as part of its Communities and Coasts Programme. There are plans to expand the approaches to Funafuti and other parts of the country.

It is unlikely that Tuvaluans perceive any major threat to the integrity of their lagoon, though they do report changes in fish and invertebrate species (especially giant clams and beche-de-mer) abundance and/or catches and increasing algal growth. The Funafuti Conservation Area is considered an important step in lagoon management and has provided the impetus for the passage of the Conservation Area Act (1998) and Funafuti Council by-laws (1999). It is thought to have led to improved productivity of resources within and outside the conservation area. However, the project suffers from the lack of an integrated, community-based management plan to manage the area over the long term (Berdach, 2003).

In Funafuti, most of the environmental concerns are focused on threats to the coastal and

land area of Fogafale, and the integrity of the other islets around the lagoon (e.g., Tepuka vilivili which disappeared during a cyclone). The most important perceived threats to the ecosystem are through sea-level rise (which is seen as a cause of erosion), king tide flooding, loss of land and climate change, particularly in regard to increased frequency of storms. Although Tuvalu is actively seeking assistance with adaptation to these threats, there has not yet been any attempt to rationalise all the threats and develop an integrated management plan to optimise the use of resources while building island resilience and maintaining ecosystem integrity and productivity.

General discussion

The three case studies described above present different Pacific island scenarios – Suva being much more heavily developed with a broad-based economy; Fanga'uta being less well developed and having a narrower economy; and Funafuti with a very narrow and even less well-developed economy. The three locations also differ in geomorphology and ecological conditions. However, the pressures on the lagoons have many similarities, such as population changes and the desire to expand the local economies and improve living conditions (better housing, medical services and schools, as well as jobs availability).

The three locations describe different scenarios in terms of scientific information availability and its utilisation for planning. For Suva Lagoon, there is a good body of relevant information (although some key gaps have been identified), but minimal use is made of this information in the planning and management of the Lagoon. There is also little evidence of integration in the planning system and the development of knowledge priority listings. In Fanga'uta, much recent information was developed in the TEMPP project (less in total that for Suva, but still a significant quantity), and some of this was incorporated into the development of the environmental management plan. Effectively no implementation of the plan has occurred. In Funafuti, while there is significantly less scientific information available, some planning and management activities have been based on the available information and limited implementation has occurred. It is clear that there are different levels of scientific information, but in no case is the available knowledge being effectively applied for improved management of key coastal water bodies.

In all three locations, it is claimed that there are limited resources available for such management activities (information gathering/planning/implementation) despite the fact that nationally important water bodies are being impacted. Possible explanations lie in the fact that the water bodies are not as closely scrutinised as land-based issues by the wider local population, and that some problems (e.g. microbial pollution) are not clearly visible. There would also appear to be an issue with the planning systems themselves and there is no strong history of integration in the planning system, such that, for example, information needs are categorised and prioritised.

Despite advice and support from a number of sources, Pacific island communities have not made much progress in the development and implementation of integrated coastal management (ICM) or community-based management (CBM, apart from the locally managed marine areas type strategies mentioned above). This may be a result of local

decisions, but, in part, may also be a consequence of a substantial component of environmental planning and management activities being reactive (rather than pre-emptive), and driven by outside agency priorities, interests and funding. Development of locally driven integrated coastal planning should be a priority and support for this is available through regional organisations such as SPREP and SOPAC. One factor contributing to the limited success of earlier efforts in this regard is the relatively low levels of appropriate expertise and staffing changes that regularly occur in small government organisations (including losses through migration and movement to the private sector). It is hoped that it will not require national emergencies such as that arising from a cholera outbreak in Tarawa in 1977 (Johannes et al., 1979) for action to be taken to dramatically improve the management of important coastal water bodies.

Conclusion

Examination of the situation in three Pacific Island lagoons has shown that there is minimal effective utilisation of scientific information in the development and implementation of management plans for important coastal water bodies. Recognition of the importance and the fragility of coastal lagoons is a first step in moving towards better management. The extent of available information varies, but even where much has been done, some of the data has yet to be fully processed and published. In addition, the work completed has been somewhat sporadic in nature, and few systematic long-term studies that can be used to identify environmental trends are available. Key gaps in available knowledge, e.g. health data, make it difficult to develop 'cause and effect' relationships.

There is also little emphasis on integrated coastal zone planning; in some cases the planning arrangement covering the lagoons and the adjacent catchments could be said to be chaotic. The involvement of national agencies, regional and international bodies, and, in some cases, local government authorities, means that minimal coordinated planning is taking place. Until this planning issue is addressed, the management of the lagoons will continue to be ineffective and the overall quality of the local environment will deteriorate, to the detriment of both the residents and the ecosystems as a whole.

Greater community engagement is regarded as another key step in the improved management of coastal lagoons. Without the support and interest of the local communities, minimal progress will be made in making such water bodies better places for people to live near and raise their families.

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Chapter 16

Environmental policy for water resources development: A case study of Trinidad

Introduction

The Water Resources Management Policy for Trinidad and Tobago states the commitment of the government to transform the country into a developed nation by 2020. The objective of the policy is to improve water quality and equity in access to water and sanitation, promote water conservation, and ensure the optimal use and management of the nation's water resources. This chapter examines the developmental and environmental policies for the small and island state of Trinidad to determine if they conflict or complement each other.

Background

Trinidad, the most southerly of the Caribbean archipelago of islands, is an oil-rich country with a land mass of 4,828 square kilometres, which supports a population of approximately 1.3 million. Unlike some other Caribbean islands, Trinidad has an abundance of rainfall arising from orographic rainfall and its location in the Inter-tropical Convergence Zone. The Water Resources Management Unit (WRMU) estimated that water demand in 2002 was 368 million cubic metres (mcm) in contrast to water supply of 346 mcm. Countries are considered to be facing a serious water crisis if available water is less than 1,000 cubic metres per person per annum. Trinidad is not a water-scarce country as the data shows that the per capita annual water availability is approximately 2,500 cubic metres (WRA, 2002).

Approximately 76 per cent of the country's water supply is derived from surface water sources while the remainder is obtained from groundwater sources. Eighty per cent of the country's surface water resources originate in its Northern Range and 58 per cent of the groundwater is located in this same geographical area (Water Resources Authority, 2002). The available surface water is an estimated 3,600 mcm per year, which is 10 times the island's present water demand.

Domestic consumers are the largest single users of water accounting for 36 per cent of demand; total industrial demand accounts for 18%; and irrigated agriculture accounts for 3 per cent of demand. A challenge to water resources management is that 43 per cent of water is lost during transmission and is classified as unaccounted-for-water (WRMU I, 2001). Although difficult to quantify, ecological demand represents an important user of water and water itself is needed to maintain the productive ecology of the island's rivers and wetlands (Government of Trinidad and Tobago, 2003).

Despite rapid economic growth linked to spiralling oil prices in recent years, the disparity in income distribution is increasing. The poverty rate was estimated at 22 per cent in 2005 (Kedir and Sookram, 2005). In 2004 the country's Environmental Management Authority (EMA), highlighted that income disparities and poverty are driving many persons, households and communities to seek affordable living space, homesteads and livelihood opportunities on hillsides, in peri-urban areas, and along access routes into the valleys. This pattern of settlement is associated with deforestation which degrades the country's watersheds and pollutes its main water sources. The population of a country at risk to economic inequalities also places the environment at risk.

While the country's population growth rate has been decreasing over the past twenty years, and while the estimated average annual rate of increase in the urban population between 2000 and 2005 was 0.9 per cent (United Nations, 2005), the alarming aspect of Trinidad's demographic pattern is that 76 per cent of the population lives in urban centres. Moreover, a substantial portion of the urban population is generating a demand for land for housing and construction materials such as forests products and aggregate obtained from quarries near watershed areas, which is leading to degradation of these areas.

Overall challenges in water resources management in Trinidad include population increase, the growth of industrial activity which has high levels of water consumption, threats from seasonality and climate change, general misuse and the lack of a water resources management framework that includes sound policy formulation and effective implementation.

Framework for water resources management

Over the last decade, the government has been undertaking several measures to improve the framework for water resources management. In 1999, a Water Resources Management Strategy was developed; in 2003, the National Water Resources Management Policy was prepared; Water Pollution Rules were passed in 2007; and a Water and Wastewater Master Plan and Policy was completed in 2008.

The main focus of the National Water Resources Management Policy (NWRMP), adopted in 2003, is to effectively manage the country's water resources in an integrated and sustainable manner, and to resolve water resources management conflicts that arise from discordant policies and development practices. The policy embraces the four main Dublin Principles.

Box 16.1. The Dublin Principles

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.
3. Women play a central role in the provision, management and safeguarding of water.
4. Water has an economic value in all its competing uses and should be recognised as an economic good.

Integrated water resources management (IWRM), as defined in Box 16.2, is crucial to small island developing states where there is increasing competition for scarce land and water resources. Furthermore, given the small size of islands, damage inflicted in the watershed areas because of poor land-use practices pollute the coastal water sources including aquifers. The close proximity between the land in the watershed areas and the coastal plains necessitate an approach to water management that considers the integration of these two areas. The basis of IWRM is that there are a variety of uses of water resources which are interdependent. This interdependency coupled with unregulated use can lead to negative consequences of water resource wastage, and, in the long term, unsustainability of water resources.

Policy in action

Although the NWRMP was formulated to embrace IWRM and the key Dublin Principles, operationalising these principles is challenging and, as the following sections of this chapter will demonstrate, there have been inconsistencies in policy implementation arising from the weak monitoring and enforcement capacity of the various regulatory agencies that have an input into water resources management in Trinidad and Tobago.

Box 16.2. Definition of IWRM

IWRM may be defined as a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives (Global Water Partnership, 2000). It is cross-sectoral and therefore in stark contrast to the traditional sectoral approach that has been adopted by many countries. It has been further broadened to incorporate participatory decision-making of all stakeholders.

Land-use planning and management

The nexus between land-use planning and management and water resources management is strong because land use inevitably impacts on water quality and quantity. The NWRM policy states that where practicable, land-use planning will be conducted on a watershed basis, meaning that planning approval for new land development will consider the mitigation of potential negative impacts on watersheds, the supply of adequate water and sewerage services, and the protection of surface and groundwater resources.

The Capital Region Plan (1975), the Northern Range Hillside Development Policy (NRHDP) (1976), and the National Physical Development Plan of Trinidad and Tobago (1988) prohibit development above the 300-foot mean sea-level contour line and on slopes steeper than 1 in 6, to ensure watershed protection through the containment of settlement expansion in the Northern Range where the country's major watersheds are concentrated. Both plans also recommended reafforestation of hillsides above the 700-foot contour line in some valleys. The NRHDP guidelines indicate that forested areas are to remain intact, developments on steep slopes are to be controlled, and residential settlements are to be regulated.

The NRHDP policy has been ineffective as privately owned, forested areas are sold to developers (EMA, 2004). The previous paragraph states what are the NRHDP guidelines on the use of private lands. Hillside slopes are very attractive sites for high-income households that place a premium value on the scenic views of the valleys of the Northern Range, although the engineering costs are quite exorbitant. Moreover, the increasing pressure of limited land space, which is common in small and island states, has pushed built development onto the hillsides of the Northern Range.

However, this type of residential development is often in conflict with other uses such as catchment areas for freshwater resources (EMA, 2004). This fact prompted a review of the NRHDP – which was submitted to the Minister of Planning and Development in 2007 with the main recommendation that development in areas in excess of 1 in 3 degree slopes should be discouraged to facilitate watershed management. Additionally, since the enactment of the EMA Act 2000, all developers undertaking sub-division of land and other types of development in these areas are now required to apply for a Certificate of Environmental Clearance.

Increasing socio-economic inequalities have pushed poor households out of the formal land market and into squatting. Estimates of squatting range from 20 per cent in 1985, (Glen et al. 1991; Kairi 1999b) to 25 per cent in 1989. Driver (2002) estimated that 47 per cent of households in Trinidad and Tobago have improper title and 55 per cent of farmers have no proof of land ownership. Faizool (2002) noted that increasing socio-economic pressures have been accompanied by an increase in squatting especially on the upper slopes of the western half of the Northern Range, both on private and state-owned lands.

Squatting in hillside and forested areas arises from the dysfunctionality of Trinidad's land market and this has alienated the poor from the land. One reason for the malfunctioning of the market is the failure of land-use planning to release land for development in the right place and at the right time, thus creating artificial land shortages that drive land values up and beyond the reach of the poor to purchase land. State failure to embark on land assembly/land banking has also encouraged a shortage of land in areas deemed appropriate for housing and livelihood practices especially agriculture. The unaffordability of low-income housing and the inefficient and expensive land registration system has also contributed to squatting by marginal groups in areas that are highly sensitive from a water resources management perspective. Moreover, the policy on the link between land tenure and integrated water resources management is still weak.

The landless poor are not the only threat to water resources degradation. The EMA (2004), concluded that 'The Northern Range is affected by authorised high-income housing as much as by unauthorised settlements. There is need to highlight high-income housing and land developers, as often the attention falls on the poorer squatters who have more limited options. The associated road construction and the houses decrease the surface area for ground-water infiltration while increasing the pollution load on the surface and ground-water resources'.

Agricultural squatting on the upper slopes of the valleys of the Northern Range where the country's main rivers originate has also had a deleterious impact on available water

resources. There has been a reduction in groundwater recharge resulting from soil loss associated with slash and burn cultivation, which is common among subsistence, landless and therefore transient farmers, who are, paradoxically, both the victims and agents of environmental degradation.

Watershed management

The legal and policy framework for watershed management in Trinidad and Tobago is inadequate. Toppin-Allahar (2001) noted in relation to several Caribbean SIDS like Trinidad and Tobago that specific legislation governing soil and water conservation is scarce and generally out-dated and that sound land management practices are being abandoned. A particularly interesting anomaly that is drawn from Toppin-Allahar's (2001) research is that '... old laws, such as measures which accelerate the acquisition of title to public lands by adverse possession where the land is "improved" by squatters, offer indirect incentives to environmentally unsound practices, such as the deforestation of marginal lands and the draining of wetlands for cultivation'. The issue was brought before the courts of Trinidad and Tobago in a case relating to the illegal occupation by rice farmers of land in the Nariva Swamp, which is protected under the Ramsar Convention. The court ruled that: the investments made by the squatters in the Nariva Swamp were destroying a protected area; that they were not property improvements and therefore could not give rise to an equitable interest in the land.

The legal and policy framework for forestry, national parks and protected areas is equally fundamental to watershed management. The Main Ridge Forest Reserve in Tobago has the distinction of being the oldest forest reserve in the western hemisphere, having been declared in 1764. The reserve was established expressly for watershed management purposes (Toppin-Allahar, 2001). However, the forestry legislation, as noted by Toppin-Allahar (2001), is directed at the regulation of production forestry on publicly owned lands and weak on the issue of deforestation on private lands and watershed management, including the control of forest fires.

Weak enforcement of laws and policy over the last 30 years has resulted in a decrease of forest cover from nearly 60 per cent to less than 50 per cent. The last official forest inventory for Trinidad and Tobago dates back to 1980 and is still used in official statements. This estimated that there was 50 per cent forest coverage, but the University of Maryland Global Land Cover Facility using MODIS satellite coverage, which mapped forested areas with crown cover greater than 75 per cent, estimated it as 46 per cent (Agard and Gowrie, 2003). The most recent estimate, using aerial photography suggests that the forested area is 33 per cent inclusive of natural and re-growth vegetation. The rate of loss of vegetative cover was approximately 4 per cent between 1998 and 2003 (Agard, 2006).

The Forestry Division (2003) estimated that between 1980 and 1988 forestry accounted for 2.5 per cent of the country's gross domestic product. However, this is a gross underestimation of the role and value of forests in providing environmental services such as water cycling and replenishment, soil preservation and flood mitigation. The Forestry Division's current policy is that licences for timber harvesting in the Northern Range will not be issued (Faizool, 2002), but trucks with logs are often seen traversing parts of the

East–West Corridor, the most urbanised zone in the country. Assumptions have been made by public officials that such activity may be originating from private lands in the Northern Range. Much of this activity appears to be taking place on weekends which also suggests that it may be illicit logging.

The failure to enforce the regulations and policy in respect of deforestation is partly related to the inability to place a monetary and environmental value on forests and has had negative consequences for water resources management (Government of Trinidad and Tobago, 2007a).

Quarrying

The oil boom has caused a surge of construction activity that has generated a high demand for aggregate. Trinidad's main watersheds are located in areas where the major sources of blue limestone and other non-hydrocarbon construction materials are located (Faizool, 2002). However, quarrying activity has had a deleterious impact on water quality. In 1993, two engineering companies reported that the quarrying operations in one of the main valleys of Trinidad were dictated by profit maximisation to the detriment of the environment. Subsequent studies conducted by the EMA concluded that several main rivers suffered from reduced water quality because of poor quarrying methods and inadequate mitigation of quarry-floor runoff and effluent discharge that led to changes in sediment dynamics and river ecosystems (Alkin-Koo et al. 2004). Many quarry operators were granted licences prior to the EMA Act 2000 and therefore did not have a Certificate of Environmental Clearance (CEC) based on an Environmental Impact Assessment. All new operators now require CECs and must rehabilitate the vegetation and terrain where they are quarrying. However, enforcement of conditions drawn up in the issuing of the licences remains difficult to enforce. Furthermore, the Quarry Policy White Paper (Government of Trinidad, 2007b) makes no reference to the potential impact of increased quarry activity on forest resources and, by extension, water resources.

Water quality and pollution

The country has historically enjoyed good potable water quality, but this is being threatened by increasing pollution from sewage, industrial effluents, and accelerated soil erosion triggered by authorised and unauthorised land clearance and building activity. All of these sources of water pollution make treatment costs higher and have implications for public health and natural ecosystems.

Alkins-Koo et al. (2004) argued that Trinidad's rivers and other natural waters are used as solid waste and liquid effluent disposal sites especially in areas that are poorly serviced by waste collection and treatment facilities. According Alkins-Koo et al. (2004), the lack of adequate regulations and alternatives for waste disposal make rivers function as informal, low-cost, liquid-receiving, and transportation systems.

Of particular concern is the pollution of surface water from high levels of biological oxygen demand (BOD), bacterial content, turbidity and chemical pollutants in rivers. The main sources of pollution are unregulated, point-waste discharges from industries and

settlements and high erosion levels in the upper catchment of rivers. Only 23 per cent of the population is served by a central sewage treatment system and these are located in the main urban centres of Port-of-Spain, San Fernando and Arima (EMA, 2004). The majority of the burgeoning urban centres where more than half the population resides are serviced by private package treatment plants, many of which are malfunctioning and contributing to BOD, faecal coliforms, and low dissolved oxygen values for several key rivers. Concerns about the risks to the water quality of the aquifers, due to the prevalence of septic tank sewerage disposal systems in urbanised areas, influenced the Water and Sewerage Authority in the 1970s to make it a policy that developments of 25 lots or more should build package sewerage treatment plants. However, a study done in 1990 found that many developers went into receivership, abandoned their projects or had their electricity supply to the plant disconnected because of arrears to the electricity company (Toppin-Allahar, 1992).

Mandatory effluent standards for wastewater treatment have been issued in the new water pollution rules passed in 2007. However, enforcement of these standards remains ineffective because of limited field inspection capability especially of the burgeoning small enterprises and factories that can cumulatively do as much or more damage to water resources than large industries. The other exception is the household that is allowed to discharge a wide range of toxic household chemicals. In the absence of a national wastewater system households are polluting water resources. The Water Pollution Rules of the EMA are supposed to protect freshwater resources via the use of standards, permits and fines, but while sources of industrial pollution are tackled, neither the Water Pollution Rules nor the NWRMP addresses ambient water quality, which would be more relevant to the diffused sources of pollution from agricultural and housing activity.

Excessive and continuous discharge of untreated agricultural and livestock wastes feed directly into two of the country's rivers – the Tacarigua and Aripo Rivers – at a rate that sometimes exceeds their capacity for biodegradation (EMA, 2004). This results in increased BOD and a subsequent overall decrease in water quality as in the case of the Arima River (EMA, 1998). Surface water pollution not only depletes potable water sources but degrades the ability of rivers to host productive habitats for both terrestrial and aquatic species.

Apart from surface water pollution, over-extraction of water from groundwater sources led to saltwater intrusion of two main wells in the 1980s. Although there have been no major occurrences of groundwater contamination in recent times, intermittent high levels of nitrates were detected in three sub-aquifers of the Northern Gravel System. Additionally, recent preliminary surveys detected trigalmethanes, lead and methyl tertiary butyl ether in the groundwater of the East–West Corridor, which is the most urbanised zone in Trinidad. These pollutants can be traced to hazardous waste dumps, underground fuel storage tanks, untreated sewage and industrial effluents.

Conclusion

Trinidad has several policies and plans which articulate the need for effective water resources management but these are not being implemented. The *State of the Environment*

Report, (EMA, 2004), cites several reasons for weak environmental policy implementation, which are applicable to the water resources management policy. One explanation is that the enforcement of policy stipulation is not rigorous enough. Another is the highly sectoral organisation of the public administration system, in which water resources management responsibilities are scattered amongst a plethora of government departments and statutory authorities that restricts the systematic application of these official policies. The dichotomisation of policies and fragmentation of responsibility is clear. The EMA (2004) also noted that there is no co-ordinating mechanism to ensure that all relevant agencies are operating consistently with these policies, or to make use of synergies or manage trade-offs among their objectives. Finally, the discordance in policy and action arises from the non-existence of practice in the public sector to monitor and evaluate outcomes and impacts of activities on water resources management. After a decade of policies that deal directly with water resources management, much still needs to be done in developing the institutional capacity to monitor and enforce these policies, and ensure consistency in other policies that indirectly impinge on water resources management.

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Chapter 17

Sustainable energy from renewable biological resources: Sugarcane bagasse energy cogeneration in Mauritius

Introduction

A sustainable environment is a precondition for sustainable economic development. When an economy produces GDP by using energy and other inputs, the planet produces an invisible product, known as photosynthetic product of the planet (PPP) as a natural process. This PPP however contributes to the production of GDP as an invisible input. As GDP increases, there are adverse effects on the growth of PPP due to utilisation of environmental and natural resources. If degradation of the environment is not arrested and exhaustible natural resources are not conserved, the natural growth of PPP and consequently, future GDP growth will decline. In other words, the environmental cost of producing GDP will tend to increase, alongside the threats posed by global warming.

Energy is important for any economic activity in modern times. There are various sources of energy, which can be broadly classified as renewable and non-renewable. In recent years, greater emphasis is being placed on renewable sources of energy because they are sustainable as well as clean. UNDP (2000) defines sustainable energy as energy that is produced and used in ways that simultaneously support human development over the long term in all its social, economic and environmental dimensions. Sustainable energy not only refers to a continuing supply of energy, but to the production and use of energy resources in ways that promote – or at least are compatible with – long-term human well-being and ecological balance.

Negative environmental externalities in electric power markets contribute extensively to erosion of PPP. Acid rain, depletion of ozone, and climate change are attributed to the use of non-renewable resources, such as fossil fuel and coal in power generation. Renewable resources are considered to be critical to attaining the objective of environmental sustainability. There are important sources of renewable energy, namely wind, solar, ocean current, water and agricultural crops such as corn and sugarcane.

Sugarcane is a plant whose ancillary products and waste streams have a value such as: bagasse (cane trash) for energy, filter cake/furnace ash as soil conditioner, molasses for ethanol and spirits, and vinasse as fertiliser. Bagasse is the fibrous residue remaining after sugarcane or sorghum stalks are crushed to extract their juice. The use of sugarcane bagasse as an alternative energy source has assumed a special significance in sugarcane-producing countries. Sugarcane is a major commercial agricultural crop in the vast majority of African countries. As one of the plants with the highest bioconversion effi-

ciency in terms of using solar energy for photosynthesis, the sugarcane plant is able to fix 55 tonnes of dry matter per hectare of land on an annually renewable basis. Under current practices, about half of this dry matter is harvested in the form of cane stalk for sugar recovery with the fibrous fraction, known as bagasse, combusted to fulfil the energy requirements of the sugar recovery process. A number of countries, in particular those without fossil fuels, have implemented bagasse-based energy production to minimise the use of co-generated energy from steam and electricity during sugarcane processing and to export excess electricity to the power grid of public power stations.

Box 17.1. Renewable v. non renewable energy

Sun, wind, water and geothermal energy have been around since the Earth was formed and are renewable (self-sustaining) energy sources. However, they can be difficult and often expensive to harness and large amounts are needed to produce only small amounts of electrical or fuel energy. The process of generating and using such energy sources is nevertheless more environmentally friendly.

Oil, natural gas and coal are economically efficient energy sources because with small amounts we can produce relatively large amounts of electrical or fuel energy. However, they are non-renewable energy sources, which once used up, can't be replaced and large-scale pollution may be created when oil and coal are used for energy.

The use of biomass (plants, corn and waste) energy has the potential to greatly reduce greenhouse gas emissions. Burning biomass releases about the same amount of carbon dioxide as burning fossil fuels. However, fossil fuels release carbon dioxide captured by photosynthesis millions of years ago – an essentially 'new' greenhouse gas. Biomass, on the other hand, releases carbon dioxide that is largely balanced by the carbon dioxide captured in its own growth (depending how much energy was used to grow, harvest, and process the fuel). So it is the net environmental benefits of biomass energy, and its renewable nature from local resources, which attract our attention. Moreover, developing new sources of environmentally friendly energy reduces dependence on fossil fuels and coal, which are not widely available in small islands.

Box 17.2. Definition of photosynthesis

Photosynthesis is a series of enzyme-catalysed steps for the conversion of light energy into chemical energy by living organisms. Its initial substrates are carbon dioxide and water; the energy source is light (electromagnetic radiation); and the end-products are oxygen and (energy-containing) carbohydrates, such as sucrose, glucose or starch. This process is arguably the most important biochemical pathway, since nearly all life on Earth, either directly or indirectly, depends on it. It is a complex process occurring in higher plants, algae, and bacteria such as cyanobacteria.

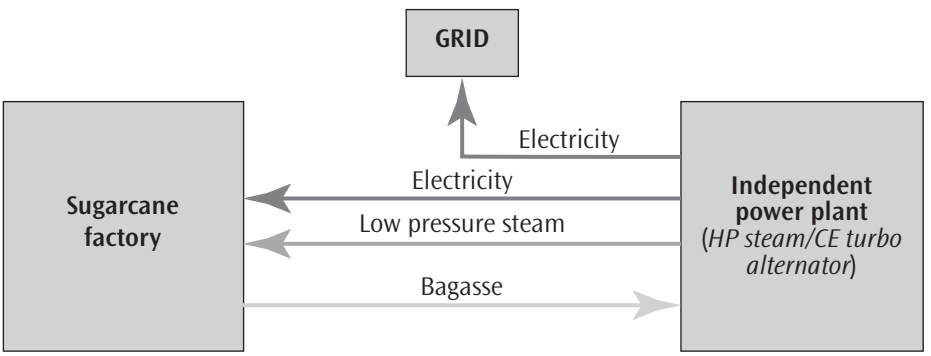
The remainder of this chapter is set out as follows: The next section discusses the meaning and the process of cogeneration. The positive environmental impacts of cogeneration, use of bagasse and the underlying environmentally friendly technology are also analysed. A case study of cogeneration in Mauritius follows. The fourth section is devoted to an

analysis of critical success factors and constraints underlying cogeneration. Next, an attempt is made to discuss the potential of bagasse-based renewable energy and sugarcane agriculture along with case studies. This section also discusses the prospects of developing sustainable energy islands. The last section offers some concluding remarks.

Cogeneration and positive environmental impacts

Cogeneration is the simultaneous production of electricity and steam (or heat) in a single power plant (see Figure 17.1). It represents a saving when compared to separate generation of electricity and steam (or heat). It is most commonly used in sugar mills where bagasse, a fibrous residue after cane crushing, is used as fuel. Sugar factories and individual power producers are required to utilise bagasse to generate low pressure heat as well as electricity. In the absence of cogeneration, bagasse will be used to generate heat and electricity will be purchased from public power stations. It is important to note that in the absence of an aggressive policy of cogeneration, sugar mills will fully utilise bagasse to meet their heat and part of their energy requirement. An appropriate cogeneration policy will not only make sugar mills independent in terms of their energy needs but they can also produce energy for use by other sectors, including households. Cogeneration is prevalent in Brazil, Thailand, India and many African countries, including Mauritius.

Figure 17.1. Typical sugar factory annexed to a cogeneration plant (adapted)



The technology used for cogeneration has many attractions. It is incremental and modular, that is, it can start small as a 1–2 MW investment and then grow incrementally to 50–70 MW installations which lowers initial risk and facilitates local participation. It depends on a local supply of resources such as bagasse and other waste material from sugarcane after sugar or ethanol has been produced. It provides a secure power supply at cheaper rates along with enterprise creation potential in the form of local technology development. Further, its use will create jobs at the sugarcane plantation level.

Cogeneration generates greater thermal efficiency compared to traditional mills because less heat is rejected. It releases limited atmospheric emissions (particulate size <100 mg/Nm^3, SO2 – almost non-existent with bagasse and in line with international regulations due to use of low-sulphur coal and NOx and the use of spreader-stoker technology). Since bagasse is a renewable fuel, it can be used to secure carbon credits. These characteristics of bagasse-based cogeneration provide a relief to global warming.

Energy status in Mauritius and role of bagasse-based cogeneration

Mauritius has limited renewable energy resources and no known oil, gas or coal reserves. Its main locally available energy resources are hydropower and sugarcane biomass (bagasse and cane tops and leaves). Hydropower and power exported to the grid from sugar factories (bagasse based) amounted to 22 per cent and 13 per cent respectively of power supplied to the public grid of the Central Electricity Board. The remaining 65 per cent of demand is met by imports. Hydro power is almost fully exploited through nine hydro stations.

The demand for electricity has increased due to rapid economic growth driven by export processing and international tourism. Residential power demand has also expanded with increased demand for electrical appliances and enhanced construction activities. These developments required additional investment by the public electric utility. The situation has changed in recent years. An alternative was considered comprising bulk purchasing of power from bagasse-cum-coal plants. In this alternative, private sector investment displaced public sector investment. Bagasse energy development was a logical component of the Sugar Sector Action Plan wherein government and the private sector participated in the restructuring process of the sugar industry. The enhanced use of by-products, such as bagasse for electricity production, was one of the major objectives. (See Table 17.1 for development of sugar sector reform initiatives and bagasse energy.)

Table 17.1. Sugar sector reform initiatives and bagasse energy

Year	Policy initiative	Emphasis on
1985	Sugar Sector Action Plan	Bagasse energy policy evoked
1988	Sugar Industry Efficiency Act	Tax-free revenue from sales of bagasse and electricity Export duty rebate on bagasse savings for firm power production Capital allowance on investment in bagasse energy
1991	Bagasse Energy Development Programme	Diversify energy base Reduce reliance on imported fuel Modernise sugar factories Enhanced environmental benefits
1997	Blue Print on the Centralisation of Cane Milling Activities	Facilitate closure of small mills with concurrent increase in capacities and investment in bagasse energy
2001	Sugar Sector Strategic Plan	Enhance energy efficiency in milling Decrease number and increase capacity of mills Favour investment in cogeneration units
2005	Roadmap for the Mauritius sugarcane industry for the 21st century	Reduction in the number of mills to 6 with a cogeneration plant annexed to each plant

Source: Mauritius Sugar Industry Research Institute

Mauritian sugar factories produce 525–575 tons of sugar from 5.2–6.8 million tons of sugarcane, which is grown on about 85 per cent of total arable land area. During the process of sugar production, about 1.8 million tons of bagasse is produced as a by-product (about one third of the sugarcane weight). There are currently 10 sugarcane mills operating with crushing capabilities ranging from 100 to 300 TCH (total cane harvested), all of which generates surplus electricity. Three power plants operate throughout the year using coal as a supplementary fuel during the off-season, whereas the remaining 7 are continuous power producers, only generating electricity from bagasse during the crushing season. Bagasse-cum-coal electricity reached 838 GWh in 2007 (347 GWh from bagasse), equivalent to 42 per cent of total electricity generated (Table 17.2).

According to information provided by Seebaluck et al. (2007), an average of 60 kWh per ton of cane crushed is generated for sale to the national grid. The amount of electricity exported using bagasse increased from 84 GWh in 1995 to 347 GWh in 2007. Figure 17.2 shows electricity generation for various configurations in cogeneration plants, along with electricity sale per ton of cane and electricity sale per ton of fibre. It is felt that there is further scope for energy generation from already commercialised state-of-the-art technology. From the same source of information, it is contended that the cogeneration of the total sugarcane biomass (tops and leaves) can further increase electricity generation by 350 GWh annually based on 50 per cent collection of the raw material from the sugarcane fields.

Table 17.2. Evolution of cogeneration in Mauritius (1995–2007)

Year	Cogeneration		Total	Bagasse %		Bagasse + Coal	
	Bagasse	Coal					
	IC	GWh	GWh	IC	GWh	IC	GWh	% Total
1995	43	84	41	332	1047	13.0	8.0	11.9
1996	43	119	–	322	1151	13.0	10.3	10.3
1997	53	125	23	370	1252	14.3	10.0	11.8
1998	90	225	62	397	1365	22.7	14.2	18.7
1999	90	184	155	425	1424	21.2	12.9	23.8
2000	160	274	327	478	1527	33.5	17.0	39.4
2001	246	300	411	660	1657	37.3	18.1	42,9
2002	242	299	447	656	1715	36.9	17.4	43.5
2003	242	296	433	729	1840	37.0	16.1	39.6
2004	242	318	407	725	1923	37.0	16.5	37.7
2007	355	347	880	838	2160	42.4	16.1	56.8

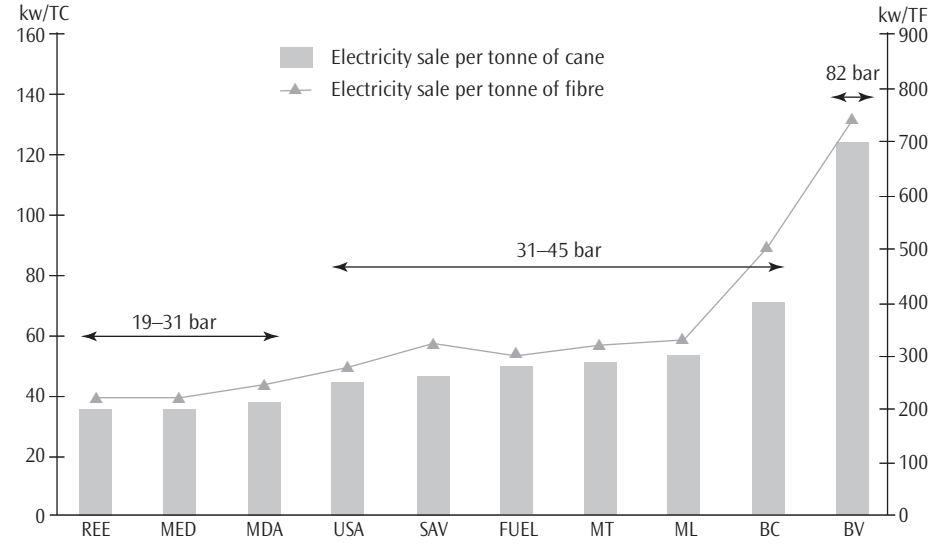
IC: Installed Capacity

Source: Information supplied from Mauritius Sugar Industry Research Institute

The other key features of cogeneration in Mauritius can be summarised as follows:

- It is attractive as it offers an alternative revenue stream to Mauritius's key economic sector – the sugar industry.

Figure 17.2. Surplus electricity yield from cane in Mauritius (2003)



Source: Seebaluck et al. (2007)

- Due to the developments on the cogeneration front, revenue from power sales for some sugar millers has recently exceeded that from sugar exports.
- It offers diversified sources of power thus providing protection against unstable and high oil price increases as well as drought-induced, hydropower crises.

Critical success factors

Government policies, particularly fiscal policy, tariff policy and funding initiatives have played major roles in the development of cogeneration enterprises and in the efficient utilisation of bagasse and other residues[1]. Moreover, it is important to recognise that the equitable distribution of revenue created during sugarcane production and generation of electricity has made a significant contribution to the growth of this renewable source of energy. Further stages in the evolution of policies regarding co-generation in Mauritius include:

- **Revenue sharing as an incentive package:** Revenue sharing increased incomes of all stakeholders including small sugarcane farmers. Cogen firms receive 50 per cent of the proceeds transferred via the Bagasse Transfer Price Fund (BTPF) in proportion to electricity exported to the national grid. Payment of income tax for 60 per cent of accrued proceeds is also exempted. The remaining 50 per cent of BTPF is distributed on a pro-rata basis between non-miller and miller planters on sugar production.
- **Facilitating a regular supply of bagasse:** Electricity generating plants had to rely on large amounts of bagasse from the satellite factories. These factories were pricing their bagasse on the price of coal and at the condensation stage of operations, resulting in a high imputed cost and price. This price had a negative impact on the financial viability of the energy project.

  These issues have been resolved through various measures, including:
  - consolidation of cane milling activities through an appropriate level of centralisation has allowed the sugar industry to realise economies of scale; and

- the payment of income tax for 75 per cent of proceeds from sale of bagasse by a miller to one utility was also exempted.

- **Rationalisation of pricing and tariff structure:** A form of pre-defined and attractive feed-in tariff exists, which reduces risk to investors. Higher prices are offered to more efficient 'cogen' plants as a key incentive. Government played the 'honest broker' role in power purchase agreements and in setting the feed-in tariff which has helped to speed up negotiations and make them less acrimonious. Different prices were applied to the type of electricity being sold to the national grid. The underlying factors included the type of electricity provided (intermittent, continuous and firm power producer), investment in new or second-hand equipment, and changes brought to existing plants. For continuous power producers, 44 per cent of GWh price is indexed to changes in oil prices and the other 56 per cent is fixed. The electricity price of the electricity producer varies according to the plant's set up and is mainly indexed to the price of coal, cost of living indices in the country and foreign exchange rate fluctuations. The price of intermittent power was frozen so as to exert a disincentive on the adoption of less-efficient technologies in the renewable energy sector.
- **Fiscal measures to boost investment in 'cogen' plants:** The government introduced budgetary measures to make investments in energy projects more attractive. Investors were allowed to raise tax-free debentures for the generation of electricity from bagasse and for the modernisation of sugar factories. Furthermore, a performance-linked rebate on export duty was extended to producers of electricity firms who saved and used their own bagasse and also to millers selling bagasse to continuous power stations. A proportion of capital expenditure incurred in the installation of efficient equipment to enhance bagasse saving and energy generation is entitled to a refund of export duty payable. The other component of the programme was related to improvements in mill efficiency to produce surplus bagasse that could be provided to the planned power plant.
- **Long-term commitment** in terms of government policy support is critical. The Government of Mauritius executed two loans: one with the US government and the other with the Global Environment Fund implemented by the World Bank, with the explicit objective of ensuring the proper implementation of projects and enhancement of bagasse savings in the cluster of factories. The long-run commitment is displayed through the design of legislation and accompanying built in measures. Examples are the Sugar Sector Strategic Plan (2001–2005) which emphasises:
  - technology modernisation;
  - the diversification of products and by-products;
  - energy conservation and export of cogenerated energy to the national grid; and
  - a Roadmap for the Mauritius Sugarcane Industry for the twenty-first century (2005) as an extension of the current policy, laying more emphasis on global warming, climate change and the quality of the environment.
- **Public–private co-ordination:** The success of this programme can be attributed to the close collaboration between policy-makers, the sugar industry and public utilities. Investors' response to policy measures, fiscal incentives and stiff competition with traditional energy enterprises has been credible.

Other case studies and prospects

There are several issues involved in cogeneration of steam and electricity as part of sugar production. The development of bagasse-based electricity generation requires strong linkages between developments in the sugar industry and those in the power sector, as well as a greater emphasis on multipurpose benefits of base-load power from bagasse/coal plants. Brazil is one of the countries which has exploited its potential to solve the problem of power shortage (Searamucci et al., 2003). Moreover, sugarcane bagasse cogeneration technology is environmentally friendly because fossil fuel based electric generation emits carbon adding to global pollution. Brazil's net reduction of greenhouse gases due to the use of alcohol fuel for transportation and replacement of fuel oil by sugarcane bagasse has made it a net exporter of carbon credits.

Many islands are aiming to attain the status of a Renewable Energy Island (REI). An REI is an island that is 100 per cent self-sufficient from renewable energy sources, including transport (FED, 2000). For example, Faroe Island of Denmark became an REI because its only energy source is wind, which supplies 100 per cent of its electricity demand. In this context, sustainable community development plans to diversify energy sources, assume special significance[2]. These experiences are not limited to island countries. Brazil and India are two major non-island countries in this field[3]. Moreover, many countries in the tropical climate zone are in the process of diversifying their energy portfolios with the explicit objective of reducing their dependence on imported fuel and adopting clean environmental practices[4].

The sugarcane plant is known to have a high bioconversion efficiency of sunlight as a result of which a high amount of atmospheric carbon is fixed into biomass. The main interest until recently was to recover only sugar from this biomass. It can now be considered as a major renewable energy resource in sugarcane-producing countries. Strong government support, and a clear definition of its policy with respect to bagasse energy development is critical to the success of the set objectives of substituting bagasse for imported fossil fuels. The bagasse-coal power development policy and programme has multiple benefits in that it is associated with environmental advantages, it offers a diversified alternative, it is a secure source of power from locally available and renewable resource and it brings additional financial revenue to the cane sugar industry.

Conditions must be created to enable all the stakeholders to participate fully in the whole process, as well as to ensure a transparent flow of information among them. In this respect, the World Bank played a key role in providing the necessary support in areas in which the local stakeholders had little or no experience, and acted as an honest broker among the stakeholders. Prior to the start of a bagasse power plant, it is of utmost importance that a detailed feasibility analysis be done. A reliable cost estimate for a bagasse/coal plant and an agreement on a financing plan from the private entrepreneur must be standardised and made available. This would avoid delays in project implementation.

It has been indicated earlier that bagasse-based cogeneration activity is more prominent during the sugarcane season and it is linked with the seasonal sugar production stage.

Box 17.3. Global Sustainable Energy Island Initiative (GSEII)

Whereas Island 2010 aims to develop and promote 100 per cent renewable energy initiatives on islands within the European Union, the Global Sustainable Energy Island Initiative (GSEII) focuses on Small Island Developing States (SIDS) worldwide.
The Initiative is supported by a Consortium consisting of the Forum for Energy and Development (FED) and the four other international non-intergovernmental organisations: Counterpart International, The Climate Institute, Winrock International and the Organisation of American States. The GSEII has been organised to support the interests of all SIDS and potential donors by bringing renewable energy and energy efficiency projects, models and concepts together in a sustainable way for SIDS. The GSEII seeks to display national efforts to significantly reduce greenhouse gas emissions.

Global Objectives:

- To develop SIDS as sustainable energy nations;
- To establish donor support and private sector investment for the sustainable development; and
- To increase awareness of experiences, potential, and advantages of renewable energy utilisation and energy efficiency on SIDS and other island nations.

Regional and Island Nation Objectives:
The Caribbean:

- To develop St Lucia into a sustainable energy nation, thereby fulfilling its commitment made at COP5;
- To further develop sustainable energy plans for one or more Caribbean SIDS to become sustainable energy nations;
- To develop regional energy efficiency and renewable energy private business activities, including solar thermal photovoltaic, biomass, and wind turbines; and
- To establish funding schemes for large-scale dissemination of sustainable energy.

The Pacific Region:

- To develop wind-energy activities on Niue and one more island nation as regional door-opener projects;
- To develop sustainable energy plans for one or more SIDS to become sustainable energy nations;
- To develop regional energy efficiency and renewable energy private business activities, including solar thermal photovoltaic, biomass, and off-gird wind turbines; and
- To establish funding schemes for large-scale dissemination of sustainable energy.

The Indian Ocean:

- To develop a sustainable energy plan for one SIDS to become a sustainable energy nation.

During the off-season therefore, coal is used as a substitute for bagasse for electricity generation. The question is what happens to the products of combustion as emissions? In particular, how does bagasse-based cogeneration compare with electricity generation from coal?

While the main environmental argument is that bagasse is a renewable resource and its toxicity is minimal as compared with coal. Now if coal-based cogeneration is less environ-

mentally friendly, it introduces a trade off between 'within' industry supply of electricity and supply of electricity from outside. If non-coal electricity is bought from outside and used in the sugar industry, it will be more environmentally friendly. The only problem is the uncertainties due to dependence on external supply. On the grounds of self-sufficiency in power generation, however, coal-based cogeneration has continued. It takes us to another important question that is how to ensure a supply of baggase the year round. Constraints on the year-round supply of bagasse deserve the attention of the sugar industry and policy-makers. It is worthwhile to consider the possibility of cultivating sugarcane for electricity generation also. The experimentation with such plans will depend on whether a country wants more sugar or more electricity from sugarcane. Sugar-exporting islands may go for such plans provided they have secured sugar export markets. Since, in recent years, European Union has decided to slash sugar prices for exports in a phased manner, it may not be feasible for island countries to think in terms of these alternatives.

The majority of the islands are endowed with agro-climatic conditions that are conductive to sugarcane production. With proper investment and management of this resource, high yields are potentially obtainable. Amongst other energy carriers, electricity from bagasse has been shown to be commercially viable in island states like Mauritius and Réunion which are devoid of any fossil fuel[5]. Islands can benefit in the development of this energy source under different schemes, such as Island 2010 and the Global Sustainable Energy Island Initiative (GSEII). Whereas Island 2010 aims to develop and promote 100 per cent energy initiatives in the EU, GSEII is a long-term plan focusing on SIDS world wide (see Box 17.3).

Exploitation of sugarcane bagasse as an annually renewable energy resource carries a high priority in the context of global warming. Apart from replication possibilities across countries and locations with a sugarcane base, it has the potential of strengthening the agro-industry sector because it is applicable to most forestry products such as wood/timber, pulp and paper, coffee, sisal, palm oil, tea, cocoa, and tobacco, among others.

Concluding remarks

Planning for sustainable energy resources will become a major preoccupation in islands, which have been heavily dependent on proceeds from sugar exports. Energy from sugar cane could provide a valuable cushion in terms of reduced oil import bills and in generating revenue for the sugar industry through the alternative use of sugarcane as a major input. This additional revenue source is of particular significance for Mauritius, which faced a 39 per cent cut in the sugar price from the EU in 2009.

Countries like Mauritius can also consider sugarcane cultivation only for electricity and ethanol. A shift from sugar to electricity and ethanol will also have an impact on the sugarcane variety that countries may chose to produce. There will be a trade-off between sugarcane with more sugar content and sugarcane with more bagasse. In this scenario, sugar can become a by-product because the major activity surrounding sugarcane may become bagasse-based electricity and ethanol production.

During the intercrop period when sugarcane bagasse is not in supply, coal is used as a sub-

stitute for bagasse for energy generation. The distinction between continuous and firm power producers should be eliminated by developing the storage capacity of unutilised excess bagasse during the season to be used during the off-season without involving coal in this electricity generation exercise. Moreover, the negative externalities due to coal used in cogeneration plants can be mitigated by finding alternative energy sources. The environmentally friendly alternatives worth considering are solar, wind and ocean currents. The substitution of coal by these energy sources would go a long way in meeting the objective of sustainable energy.

There is need to develop an aggressive renewable energy policy. Mauritius's coastal location and the availability of renewable energy sources, namely solar, wind, and possibly wave, and sugarcane bagasse should constitute an integrated renewable energy package. The success of bagasse-based energy cogeneration can provide avenues for Mauritius to move towards the objective of becoming an REI in the near future. Thus, the challenge of the demise of the sugar trade becomes an opportunity for saving small and island states in a new era of renewable energy production with, at its core, harvesting the yield of PPP (photosynthetic product of the planet).

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Notes

1 For a comprehensive discussion of policy measures aimed at efficiency, see Deepchand, 2001; Seebaluck et al., 2007.
2 See Dale et al., 2006, for community management of renewable energy in Prince Edward Island.
3 See Seebaluck et al., 2007, for some recent information on sugarcane bagasse cogeneration in these countries.
4 For an experience of a non-island country, Zimbabwe, with bagasse-based cogeneration, see Mbohwa, 2004; for Peru, see Dellepine et al., 2003.
5 For an excellent world wide overview of renewable energy on small islands, see FED 2000.

Department of Sustainable Development of the OAS

Trade liberalisation and environmental considerations for the Caribbean[1]

Introduction

Since the 1980s, countries have pursued a series of economic policy reforms to accelerate rates of growth and attract investment. International trade remains a key aspect of these reforms. However, the struggle for consensus on a balanced development agenda has significantly slowed down global trade talks, resulting in an increase in bilateral and RTA negotiations. In fact, WTO statistics show that as of December 2006, 368 RTAs were in force.

In the midst of this package of reforms, interest and concern has focused on whether welfare-enhancing benefits associated with trade liberalisation are automatically delivered. A closely associated concern revolves around the relationship between trade liberalisation and environmental protection. This is especially pertinent for countries of the Western Hemisphere and more especially in the Caribbean, where trade in goods and services is not only a major source of foreign exchange, national income and employment but also a major charge on the fragile and limited natural resources of the region. In this regard, the question that must be answered is whether or not the multilateral trading system, including RTAs can be shaped in such a way that it promotes not only economic growth but also sustainable development in the small island developing states (SIDS) in the Caribbean.

The key economic sectors and industries in the Caribbean that are affected by trade are natural resource based and primarily resource intensive sectors. Thus, there is the distinct possibility that trade liberalisation and the opening of new markets, while creating economic, social and environmental benefits will also intensify environmental pressures associated with the expansion of the productive system, especially if appropriate regulatory mechanisms are not in place or are not being effectively applied.

The issue of trade and environment has been addressed on the trade front since the Marrakesh Agreement. Efforts towards sustainability in trade liberalisation go back to the Rio Declaration in 1992[2] and to Agenda 21[3] which together called for:

a a supportive international climate for achieving environment and development goals by promoting sustainable development through trade liberalisation;
b the need for countries to make trade and environment mutually supportive;
c the provision of adequate financial resources to developing countries dealing with international debt; and

d the implementation of macroeconomic policies conducive to sustainable development.

The World Summit on Sustainable Development (WSSD)[4] also highlighted some trade-related issues of importance to the Caribbean. Consensus from the Summit included the need to:

i strengthen international co-operation in forest resource management through environmentally-sound trade, capacity building and law enforcement; (ii) enhance access to existing agricultural markets and develop new markets for value-added agricultural products; and

iii implement instruments through the auspices of the International Maritime Organization (IMO) to enhance maritime safety, protect the marine environment from pollution caused by ship traffic through increased trade, address invasive species in ballast water, and implement the BASEL Convention on the Transboundary Movement of Hazardous Waste.

Subsequent international fora have also sought to promote a beneficial link between trade and the environment. For example, the Barbados Program of Action (BPOA-1994) recognised that SIDS are limited in size, have vulnerable economies and are dependent both upon narrow resource bases and on international trade, without the means of influencing the terms of that trade[5]. Further, it encouraged co-operation and promotion of sustainable development through fair, equitable and non-discriminatory trading arrangements and a supportive international economic system and addressed issues of poor market access by SIDS, the heavy reliance on single or few commodities and the need to generate local value-added, export products and diversify commodity sectors, among other issues.

Overview of environment within the World Trade Organization

Global awareness of trade-related environmental issues and concerns increased in the 1990s with the creation of the Committee on Trade and Environment (CTE) within the WTO[6]. Paragraph 31(i), (ii), and (iii) of the Doha Declaration includes a mandate to the countries to negotiate regarding the relationship between Multilateral Environmental Agreements (MEAs) and WTO rules[7]. The discussion in this regard has essentially focused on concepts and definitions. The CTE has deferred issues on environmental goods and services to the WTO Negotiating Group on Non Agricultural Market Access. The CTE's latest work programme approved in Cancun[8], highlights several important activities, including an analysis of the relationship between the provisions of the multilateral trading system and requirements for environmental purposes related to products (including standards and technical regulations, packaging, labelling and recycling) effects of environmental measures on market access, especially in relation to developing and least developed countries, and the environmental benefits of removing trade restrictions. However, since its inception, the CTE has primarily focused on reconciling the relationship between specific trade obligations in MEAs with WTO trade rules – a core challenge for all countries involved in trade liberalisation efforts[9]. **These commitments are increasingly relevant to developing countries, as they face global environmental challenges and pursue trade as a propeller of growth. However, progress in the negotiations overall in realising the Doha Round package of commitments**

remains limited. Consequently, the only outcome reflected in the Hong Kong Declaration approved at the most recent WTO round in December 2005 was the call to countries to 'intensify the negotiations'[10].

Trade liberalisation in the western hemisphere and the Caribbean

Since the 1960s, economic reform and integration in the western hemisphere has been pursued through consolidation of trading blocs and agreements. This is illustrated by the maps of Western Hemisphere Intra and Extra Regional RTA Networks produced by the WTO (Annex I and II).[11] The Caribbean region has been very proactive in global liberalisation efforts with the establishment of a free market in 1965, a Common Market in 1973[12] and a single market and economy (CSME) in 2001[13]. Between 1994 and 2004, CARICOM as a bloc had negotiated free and preferential trade agreements with Colombia, Costa Rica, the Dominican Republic and Venezuela. These agreements cover most key economic sectors for the region and include gradual tariff reduction schemes. They also contemplate Most Favored Nation and National Treatment consistent with WTO principles. The agreements in Table 18.1 are key examples of CARICOM's efforts in economic reform and integration.

Table 18.1. Examples of Trading Blocs and Regional Trade Agreements signed by CARICOM[14]

Trade Agreement	Type/Structure	Signatories
Caribbean Common Market (CARICOM)	Common Market, Customs Union	Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Trinidad and Tobago St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Suriname
CARICOM-Dominican Republic	Free Trade Agreement	All CARICOM countries and the Dominican Republic.
CARICOM-Colombia	Preferential Agreement	All CARICOM countries and Colombia
CARICOM-Costa Rica	Free Trade Agreement	All CARICOM countries and Costa Rica
CARICOM-Venezuela	Preferential Agreement	All CARICOM countries and Venezuela

Another major step towards trade liberalisation has been the region's participation in the Caribbean Basin Initiative (CBI). This broad programme is designed by the US government to promote economic development through private sector initiatives in countries in the Caribbean Basin and is seen as a way of expanding foreign and domestic investment in non-traditional sectors, diversifying CBI country economies and expanding their exports[15]. The major benefits of the programme include duty-free entry to the United States, in perpetuity for a wide range of products manufactured in CBI countries as an incentive for investment and expanded export production. Additionally, there is a tax deduction for companies that hold business conventions in qualifying Caribbean Basin countries to increase tourism and a US Government Special Access Program for textiles

and apparel. Canada has implemented a similar initiative known as CARIBCAN, a package of trade development and economic assistance measures for countries in the Caribbean Basin, including duty-free entry for products to Canadian markets.

The European Economic Community (EEC) with whom CARICOM countries and the Dominican Republic are negotiating an Economic Partnership Agreement expected to enter into force in 2008 is another bloc that provides CBI countries duty-free access for several products through the LOME Convention[16]. All of the mentioned unilateral commitments have helped to stimulate economic growth in Caribbean SIDS.

Since NAFTA and the creation of the CTE, the approach to environment in trade negotiations has been open and proactive, resulting in environmental provisions in trade agreements that follow the path of the North American Agreement on Environmental Cooperation (NAEC) by focusing on environmental co-operation. Recent agreements such as the US-Chile, US-Singapore, Canada-Chile, Canada-Costa Rica US-Jordan, the Dominican Republic-Central America Free Trade Agreement (DR-CAFTA), the US-Peru and US-Colombia Trade Promotion Agreements all include a mechanism for environmental co-operation as well as provisions on the environment.

Treatment of the environment in trade agreements: A look at CARICOM

Three recent agreements negotiated by CARICOM are noteworthy by virtue of their environmental provisions. These are the CARICOM – Dominican Republic and CARICOM – Colombia agreements and the Revised Treaty of Chaguaramas (RTC).

The CARICOM-Dominican Republic Free Trade Agreement

This Agreement which has been in force since December 2001 is regarded as innovative in many respects. It provides reciprocal duty-free entry for a significant amount of trade between the two parties. It also includes special arrangements for trade in selected agricultural products and in services and for the promotion and protection of investment. In addition to recognising the importance of sustainable trade, the agreement also includes three specific considerations related to environment as follows:

1 it allows the parties to conduct risk assessments of environmental implications as long as they are not used as technical barriers to trade;
2 it defines dangerous wastes and hazardous substances and establishes concerns regarding the environmental and health implications associated with trade in and movement of these goods within the region; and
3 it establishes specific obligations regarding environmental protection.

On the first consideration, the agreement defines risk assessment as '*the evaluation of the potential of adverse effects to the health and safety of human, animal or plant life onto the environment resulting from any goods or services traded between Parties.*' In this regard, it is important to note that once the protection level has been established using scientific evidence, the parties are to avoid making arbitrary or unjustifiable distinctions between similar goods and services, if those distinctions:

a result in arbitrary or unjustifiable discrimination against goods or service providers or the other Party;
b constitute a disguised restriction on trade between the Parties; or
c discriminate between similar goods or services for the same use under the same conditions, that hold the same level of risk and that result in similar benefits[17].

With regards the handling of hazardous waste, the agreement requires that: '*The Parties shall apply the provisions, guidelines or recommendations of the pertinent United Nations Convention, the Basel Convention and the relevant international agreements and standards to which the Parties adhere, in addition to the existing legislation of the Parties.*' The agreement also obliges each party to regulate the introduction, acceptance, deposit, transport and transit through its territory, of hazardous substances or dangerous waste, whether originating inside or outside of its territory[18].

The CARICOM-Colombia Agreement

This preferential trade agreement specifically includes provisions regarding technical co-operation in environmental management as one of the areas of co-operation[19]. However, it is not clear to what extent this Article is being implemented and by whom and what implementing mechanisms are in place to ensure the attainment of the objectives of the provisions.

The Caribbean Single Market (and economy)

While the majority of the 240 provisions in the Revised Treaty of Chaguaramas (RTC) governing the CSME have a trade focus, a valiant effort has been made to address the trade and environment nexus, both in terms of enhancing the contribution of environmental products and services to economic growth and reducing the negative impacts of economic growth on the environment. In this latter regard, notable features include:

- Article 13.2(h) requiring the Council for Trade and Economic Development (COTED) to promote and develop policies for the protection and preservation of the environment for sustainable development;
- Article 51.2(g) requiring that Community industrial policy should aim at enhanced industrial production on an environmentally-sustainable basis;
- Article 55 which calls for the formulation of proposals for sustainable tourism development and which recognises the importance of the tourism sub-sector to the economic development of the region and the need to conserve the cultural and natural resources and to maintain a balance between a healthy ecology and economic development;
- Article 56.1(a) requiring that Community agricultural policy should aim at the fundamental transformation of the agricultural sector towards market oriented, internationally-competitive and environmentally-sound production of agricultural products; and
- Article 58 requiring the Community to adopt measures for (a) the effective management of the soil, air and all water resources, the exclusive economic zone and all other maritime areas under the national jurisdiction of the Member States;

and (b) the conservation of biological diversity and the sustainable use of biological resources, especially those of important medicinal and traditional value[20].

The RTC charges the Council on Trade and Economic Development with the responsibility for (a) establishing and promoting measures to accelerate structural diversification of industrial and agricultural production on a sustainable and regionally-integrated basis; and (b) promoting and developing policies for the protection and preservation of the environment and for sustainable development. Reasonable progress has been made at the national level towards ensuring that producers do not infringe the environmental standards of importing countries. However thus far, only limited progress has been made towards ensuring that trade-related activities at the national and regional level do not impair the quality of the physical environment or over-exploit the natural resource base. In this latter regard, strong and legitimate concern has been raised over the negative environmental impacts of tourism, which is the region's leading export industry.

Challenges for the environment at the regional level

Trade liberalisation has been advanced in many fora and by many developed countries, because of its role in fostering economic growth. Governments also see trade as a potential catalyst to environmental protection. However, given the relationship between economic growth and the environment in general and natural resources in particular in small island economies such as those of the Caribbean, it is critical that Caribbean governments take full account of the inherent challenges which the trade agenda poses for the environment. Ideally, these challenges should be assessed both at a macro level as well as part of the analysis of each trade agreement. It is against this background that question marks emerge over the contribution of the above-mentioned trade agreements to sustainable development.

The main challenges posed by the trade liberalisation process could be subsumed in three broad categories. These are:

1 regulatory and administrative,
2 export-derived, and
3 import-derived challenges.

Regulatory/administrative challenges

This category includes meeting obligations related to domestic environmental protection and requirements for market access. Historically, with respect to environmental provisions such as those in trade agreements referred to here, the deficiency has been related to enforcement and compliance of national standards and regulations and the administrative burden this could potentially impose on governments and the private sector. Developed countries have been concerned with the possibility of developing countries using lax environmental protection as a means to attract trade and investment, also known as 'ecological dumping'. Additionally, physical/environmental challenges cannot be addressed unless adequate environmental standards and regulations are in place to prevent environmental degradation from economic activities. For instance, to address this kind of challenge, emis-

sion standards and controls should be in place and authorities should have the technical capacity to monitor emissions and enforce air quality standards.

Export-derived challenges

The main challenges here derive from increases in exports due to the elimination of tariffs and are related to:

a tariff schedules;
b increased demand for goods and services including environmental goods and services,
c increased production capacity which impacts on waste and effluent management and infrastructure demands; and
d overexploitation of natural resources.

In addition countries must comply with the provisions of WTO agreements on Technical Barriers to Trade (TBT)[21] and Sanitary and Phyto Sanitary measures (SPS) as well as fulfill MEA and WTO requirements[22].

Increased economic activity can have both positive and negative impacts on the environment. If more goods are produced for export using the same amount of resources, then potential negative scale effects are offset by efficiency gains. However, such production and/or trade efficiencies though desirable at this level are not always possible, especially for small economies, since they would need to devote considerable resources to build capacity in export sectors in areas such as waste and chemicals management. Therefore, developing the capacity of the private sector to address environmental issues is one of the key challenges facing the Caribbean.

Satisfying the demand of new trading partners due to Free Trade opportunities can also be stressful to the environment in the Caribbean, given it might mean over-exploitation of an already limited and fragile natural resource base and an increase in solid and liquid waste generation, and air pollutants. This effect can be reduced by ensuring that adequate regulations are in place to address environmental pollution and degradation generated by export-driven trade agreements. Unfortunately, in the Caribbean region very few countries have a basic environmental law and the financial and technical resources to enforce them.

Regulations, standards, testing and certification procedures create conditions for market access and may create unnecessary obstacles to trade. It is recognised that countries adopt WTO-compliant standards for health, environmental, plant and animal life. Therefore, all countries face prerequisites for exporting, including standardised and accurate labeling of food and manufactured goods, heightened quality standards and application of quality improvements to ensure the required quality and presentation of goods, and standardised and acceptable packaging to meet environmental health and safety standards of the importing country. Some market access requirements stipulate that certain goods such as paper products must contain a certain percentage of recyclable material. Similarly, many food products need to be certified regarding their pesticide residue content and in the specific case of the export of fish species such as marlin and tuna,

regarding their heavy metal content. For example, the Ministry of Environment of Mexico (SEMARNAT) released a final rule on import and export of wood packaging material (WPM), requiring that imported WPM complies with the guidelines issued by the International Plant Protection Convention Secretariat (ISPM 15)[23].

The main challenge here is to ensure that national regulations and standards of trading partners are met for exporting countries. Therefore, Caribbean countries need to quickly address TBT and SPS issues including through joint government and private sector efforts, institutional strengthening, obtaining financial resources for upgrading of equipment and manpower and becoming pro-active in upgrading production standards and product quality to meet the rigors of an openly competitive market. However, a major part of the challenge is about having the technical and financial capacity to prove when a trading partner is imposing discriminatory standards that violate international trade law. Because of the importance of agriculture and food exports, attention should be given to plant and animal-derived export products. Domestic producers must consider compliance with sanitary and phyto sanitary measures (SPS). Such standards have proven to be particularly onerous for banana producers in the region, who in addition to being faced with high production costs, volatile prices and frequent disruptions due to extreme weather events and pest infestation must now meet the increased costs of adhering to phytosanitary measures.

Another challenge that Caribbean countries must address is meeting obligations under MEA's and WTO rules at the same time. As the Shrimp-Turtle case[24] and the Chile-EU Swordfish dispute[25] indicate, this challenge is made more onerous by the potential incompatibility of some provisions (Box 18.1). Certain specific trade obligations in many MEAs that have been ratified by Caribbean countries, such as Convention on International Trade in Endangered Species (CITES), the United Nations Convention on Biological Diversity (UNCBD), the Montreal Protocol and the Basel Convention have been under discussion in the GATT and WTO since 1991. However, no WTO-MEA case regarding trade measures has ever arisen.

Box 18.1. The shrimp-turtle dispute

The shrimp-turtle debate began in 1996 when the US banned imports of shrimp from several countries not in the practice of using TEDs (turtle excluder devices) to prevent by-catch mortalities of sea turtles including many endangered species. The ban was made under § 609 of the US Sea Turtle Protection Law (United States, Department of State, Office of the Spokesman Media Note 2005/31 Washington, DC, January 5, 2005), which was implemented as part of US response to operationalising CITES Article III (United Nations Convention on International Trade in Endangered Species (CITES) Article III '… members can take appropriate means to enforce the provisions of the present Convention and to prohibit trade in specimens in violation thereof …'). Banned exporters called upon the WTO to rule the sanctions 'as unjustified discrimination' inconsistent with most favored nation rules, since identical shrimp products were being allowed from other countries. The US claimed its position was justified under GATT Section XX (b) and (g) allowing exceptions 'related to conservation of exhaustible natural resources'. The WTO Appellate Council

found that US law was justified but its implementation amounted to 'arbitrary and unjustifiable' discrimination. The Council also noted that CITES covered only US legal jurisdiction and could not be forcibly implemented in the jurisdiction of other countries. This case is particularly relevant to the Caribbean because imports of wild shrimp from Trinidad and Tobago to the US have been banned since December 2004, for non compliance with the US Sea Turtle Protection Law1. Before this ban, demand from the United States accounted for 67 per cent of Trinidad and Tobago's shrimp exports, and its impact has been significant as shrimp currently represents 40 per cent of that country's total export value (2000, Ministry of Agriculture Land and Marine Resources Fisheries Division. Impact of Shrimp Fisheries In Trinidad And Tobago).

http://www.fao.org/docrep/007/y2859e/y2859e12.htm. Caribbean Regional Fisheries Mechanism. http://www.caricom-fisheries.com/members/tt.asp

The Chile-EU swordfish dispute

The Chile-EU Swordfish dispute mainly addressed obligations of United Nations Convention on the Law of the Sea (UNCLOS) and the open and non-discriminatory nature of the multilateral trading system. In this case, the European Union banned imports of swordfish from Chile based on unsustainable fishing practices that according to the EU far exceeded the maximum sustainable yield of the fishery at the time, thus jeopardising the survival and continuity of that fishery. The EU implemented the ban citing that Chile was violating its obligations for the conservation and sustainable management of renewable marine fisheries resources under the UNCLOS (see International Tribunal for Law of the Sea, Special Chamber. 20th December 2000. Conservation and Sustainable Exploitation of Swordfish Stocks in the South Eastern Pacific Ocean, Chile versus European Union). Chile then retaliated by claiming unfair discrimination under WTO rules and brought an action against the EU at the WTO for resolution. Eventually, the dispute was settled bilaterally, but the settlement does not diminish the fact that there was a debate, which was legitimate under the jurisdiction of two different bodies of international law and a dilemma as to which provision would take precedence.

Import-derived challenges

Global trading rules also require Caribbean countries to ensure that the standards they set for imports are not discriminatory and that environment is not used as a barrier to trade. Some countries in Latin America and the Caribbean are seen as having arbitrary SPS measures and standards and this has been directly linked to lower levels of US investment[26]. A significant challenge will therefore be streamlining of SPS's which can lead to more US and foreign investment. To do so, Caribbean governments must commit resources to improving the standards infrastructure while protecting the environment. In this regard, a main challenge includes ensuring national technical regulations provide for the screening of chemicals, pesticides and even genetically modified organisms (GMOs) as well as maintaining and enforcing standards for imports, while abiding by WTO regulations on TBTs and SPS.

Increased competition in similar and new goods and services by foreign investors can potentially oust domestic producers from the marketplace or at the very least marginalise them. This can generate social, economic, and environmental repercussions. For instance, forestry managers could lose the incentive to sustainably manage their timber resources since they can sell lumber and value-added products at competitive prices to foreign buyers. With the onset of trade liberalisation and the opening of markets to more cost-efficient foreign producers, domestic producers of wood products have seen a reduction in demand and in prices. Further, due to free trade, countries in the region may see an influx of foreign investment in the form of new production plants for more refined and value-added, secondary and tertiary manufactured products. This then introduces not only increased quantities of waste, but new forms of waste which may require special disposal treatment facilities that are generally not available in developing countries of the Caribbean.

Another outcome could be increased transshipment of hazardous waste or even volatile primary, manufacturing materials such as lubricants, paints and flammable chemicals. Spillages in marine and coastal areas can devastate coastal ecology, reefs and mangroves with serious economic and environmental implications. In this regard, the potential conflicts between MEAs and WTO rules also come in to play, given that most of the countries in the Caribbean have ratified the Basel Convention on Transboundary Movement of Hazardous Wastes which restricts import–export activity of Parties with non Parties. With increased oceanic transportation traffic in Caribbean waters due to increased trade, Caribbean countries may face conflicts with non parties to the Basel Convention as to whether or not such hazardous waste can be shipped through Caribbean waters. Article 141 of the RTC sets out the determination of CARICOM member states to '… protect the Caribbean Sea from the potentially harmful effects of the transit of nuclear and other hazardous wastes, dumping, pollution by oil or by any other substance carried by sea or wastes generated through the conduct of ships operations'.

To enable increased trade, countries of the region will have to upgrade their ports, transshipment areas, piers and related infrastructure. Further, countries may have to consider not only fisheries, forestry and agriculture, but also the impact of an increased influx of tourists on beaches, coral reefs, coastal and marine resources which underpin the attractions of the tourism sector.

Environmental benefits and opportunities from increased trade

Free trade can lead to increased foreign direct investment (FDI), national income, foreign exchange and employment for the Caribbean countries. Governments must take advantage of these benefits by creating appropriate incentives to attract FDI and mechanisms through which the benefits from economic growth can be distributed in an equitable way, thus increasing social development and social cohesion. Increasing social welfare and bringing people out of poverty creates broader social livelihood options, increases skill levels and generates employment, thus helping to reduce pressure on natural resources.

Increased FDI inflows also carry the potential for an increase in technology transfer. If the

right encouragement is given by government and environmental agencies, companies will invest in new environmental innovations, cleaner production technologies, recycling and energy efficiency schemes and optimised material utilisation. This kind of corporate behaviour can have a significantly positive impact on the environment both by reducing pollution loads and through greater efficiency in natural resource use. At the macro level, increased FDI can give developing countries the opportunity to invest in cleaner industries, which have less environmental impact and reduce pressures on natural resources. Changes can be made in practices regarding economically important but resource-intensive activities such as fisheries, agriculture and petrochemical processing by engaging in and marketing sustainability. New markets will be opened up for domestic firms, including markets for recycled products, recycling services, and green markets for environmentally-friendly or organically-produced products. It is estimated that 20 per cent of the U.S. consumer market will buy environmentally-friendly products if readily presented in the market place[27]. This is an enormous opportunity for Caribbean producers given the importance of the US market, as the main export market for the region. An additional major benefit of trade liberalisation is the increase of environmental awareness among local consumers. Further, with an influx of foreign products, consumers in the Caribbean must be made aware of issues such as increased amounts of packaging and the environmental effects of newly available chemicals, pesticides and common household items such as detergents.

The trend of trade liberalisation, as mentioned has been accompanied by numerous co-operation efforts, providing small economies the benefits of technical co-operation at the expense of developed countries and international organisations. Examples of these efforts are the former FTAA Small Economies Group and the Hemispheric Cooperation Program, through which initiatives related to environmental protection and sustainable development have been funded and implemented.

Finally, Doha paragraph 33(iii) acknowledges the potential of countries to benefit from expanding markets of environmental goods and services. Recent estimates suggest that annual expenditures on environmental goods and services exceeds $600 billion per year, with quickly growing markets in such areas as sustainable tourism services, sustainable agriculture, certified forest products and emerging carbon markets. In 2006, international carbon markets alone exceeded $30 billion. Although some of these goods and services are not explicitly covered under the WTO or regional trade agreements, they underscore the overall opportunities that exist for the Caribbean region in identifying new opportunities in 'green' markets.

A role for the OAS

The OAS through its Department for Sustainable Development (DSD) has been assisting Member States to respond to trade-related capacity building development needs in the area of environmental management. Working through various initiatives the DSD has supported countries in assessing the impacts of trade liberalisation on the environment, focusing on regulatory aspects and how to address emerging challenges from the policy angle. The DSD has also supported countries in Trade Capacity Building negotiations in

bilateral and regional agreements. More recently through a cooperative initiative with the Canadian International Development Agency (CIDA) the DSD has been supporting OAS member states in addressing the priority challenges identified in their national strategies for trade-related capacity building under the Hemispheric Cooperation Plan, in the following areas:

a strengthening capacities in the sound management of chemicals, based on empirical evidence which shows that the total concentration of agro-chemicals increases with trade, while the composition of agro-chemical applied to export-oriented crops shifts, thereby creating new challenges to national authorities;
b enhancing public participation and the effective enforcement of environmental laws;
c improving market-based approaches to the conservation of biological diversity, through the support of Payments for Ecological Services (PES); and
d strengthening educational capacities in the area of trade and environment, through the development and dissemination of a 'tool kit' on trade and sustainable development.

Based on the observations made in this paper regarding the depth and breadth of the policy and institutional challenges faced by Caribbean countries, it is clear that an enhanced hemisphere-wide, co-operation agenda is a critical and a long-term response required by the OAS, thus justifying the search for new and additional financing and technical assistance modalities to expand ongoing efforts and assist the region in overcoming the challenges identified.

Notes

1 Printed with permission from the Organisation for American States. This was prepared as a background paper by the Department of Sustainable Development of the Organization of American States for the Conference on the Caribbean, Washington, DC, June 19–21, 2007. The paper benefitted from contributions by Scott Vaughan, Cletus I. Springer and Claudia S. De Windt of the Department of Sustainable Development of the Organization of American States; and Kalim U. Shah, Research Fellow of the Caribbean, Central American, Action.
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8 World Trade Organization WT/CTE/8 11 July 2003 – Committee on Trade and Environment Report to the 5th Session of the WTO Ministerial Conference in Cancun, Mexico.
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15 This initiative is formed by the Caribbean Basin Economic Recovery Act (1983), the Caribbean Basin Economic Recovery Expansion Act (1990) and the U.S.-Caribbean Trade Partnership Act (2000) each of which has been ratified by the U.S. and CARICOM countries.
16 Negotiations officially launched in Kingston on April 16, 2004.
17 Agreement Establishing the Free Trade Area between the Caribbean Community and the Dominican Republic. 22nd August 1998.
18 Agreement Establishing the Free Trade Area between the Caribbean Community and the Dominican Republic. 22nd August 1998. Appendix VI to Annex 1: Technical Barriers to Trade – ARTICLE XII – HANDLING OF HAZARDOUS SUBSTANCES AND WASTE.
19 Agreement Establishing the Free Trade Area between the Caribbean Community and Colombia, 24th July 1994. Article nineteen – Technical Cooperation. *'The Parties agree "to encourage and promote co-operation in areas such as human resource development, institutional building, science and technology, research and development, environmental management, disaster preparedness and management, health research and management, energy, tourism and agricultural development." '*
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Chapter 19

Intellectual property rights and anti-competitive behaviour: Major deterrents to ecology and economic progress of SIDS

Introduction

Small Island Developing States (SIDS) increasingly rely on emerging new opportunities in the high-tech and information and technology sectors to overcome limitations of isolation and remoteness. As examples, the sunrise industries for SIDS have been enumerated as e-commerce, telecommunications and tele-medicines and distance learning. In this quest, geographic information systems (GIS) and other information systems are believed to play a significant role. As a result, significant emphasis has been placed on the development of national, regional and supra-national information and database centres. It is therefore not an overstatement that information and communication technologies (ICT) are a critical ingredient in the pursuit of sustainable development in many SIDS. It is important to note that insofar as these industries have relatively smaller ecological footprints than other more traditional fields of industrial production, they will contribute to the ecological sustainability of SIDS. In reviewing the economic performance of these states, the experience over the decade has been a mixed bag. Most states, except the least developed ones, registered positive economic growth since 1994. Especially, over the same period, most of these nations achieved very satisfactory human development indices mainly in literacy and health. Most of these social and economic successes have been attributed to appropriate economic diversification, tourism, and the development of niche markets in goods and especially services

Many of the success stories among SIDS relied heavily on the high-tech sectors and on financial services as in the case of The Bahamas, Barbados and Mauritius. As an example, the contribution of the financial services sector to the gross domestic product of Mauritius increased from 10.1 per cent in 1992 to over 20 per cent by 2005. The emergence of high-tech sectors must be viewed against the steady decline in the terms of trade of primary products in which these countries specialised before. It is also important to note that the increase in the costs of exporting bulk products is largely due to energy price shocks. Because of these twin factors, one has come to realise that the knowledge sector and management of this sector may well be key drivers for the future prosperity of these nations. As a simple observation to support this point, between 1980 and 2000 the share of SIDS in global merchandise trade dropped by 50 per cent while their share in global trade of services stayed unchanged due mainly to telecommunications and high-tech service sectors.

The sticking point is that, because of intellectual property rights issues, high-tech sectors do not offer a level playing field and instead have given rise to a digital divide between developed countries and those nations belonging to the SIDS. It is widely argued that the presence of intellectual property rights promotes innovation that drives economic growth and economic prosperity (see Demestz, 1966; Boldrin and Levine, 2002). Strong property rights are therefore regarded as a collective good, based on a simplistic notion that they provide appropriate incentives for the production of any goods and services. If this perception is correct, then one is left to conclude that strong and well-defined property rights are a pre-requisite for the production of ideas as well. Unfortunately, this perception is at best a *howler*, since ideas and knowledge are typically considered means of production – inputs for the production of other goods and services.

The problem is that the presence of strong intellectual property rights takes away from the purchaser the freedom to utilise this input as he/she sees fit. This gives rise to what is known as 'intellectual monopoly'. We highlight a vertical market model to argue a case against strong intellectual property rights. We call for an appropriate regulatory framework to control royalties by international players like the United Nations. Thus strong intellectual property rights can lead to serious anti-competitive behaviour in industries that rely on knowledge.

The Chapter is organised as follows:

This chapter begins with a review of intellectual property rights (IPR). The next section develops a game-theoretic model that is appropriate for examining IPR in a vertically-related industry. The section following examines the need for regulation in the light of the proposed game. Finally, some conclusions are drawn.

Intellectual property rights and global forums

The World Trade Organization (WTO) is a recent development in the context of intellectual property rights (IPR) agreements. The World Intellectual Property Organization (WIPO) has been a relevant forum since its creation in 1967, through the Stockholm Convention. The WIPO, which is based in Geneva, administers more than 20 international IPR treaties. The WTO has an interesting IPR agreement, known as the agreement on Trade-related Intellectual Property Rights (TRIPs). When the agenda for the Uruguay Round was being set in the mid-1980s, serious opposition was mounted against the idea of TRIPs being included. Traditionally, two main arguments were advanced against such inclusion: first, it is widely held that IPR and international trade are unrelated. At a face value, this may seem to be true. But a proper analysis will show that this view is incorrect. If India exports computer software to Germany, one cannot argue that protection granted to software has nothing to do with trade. If German firms export computer hardware to India, one cannot argue that protection granted to hardware is a non sequitur for trade-related issues. The upshot is that trade is usually predicated on investments. So, if foreign direct investment (FDI) into a nation is hamstrung by a lack of IPR protection, one cannot convincingly argue that IPR and international trade are unrelated issues.

The second argument against the inclusion of IPR in a trade agenda is more convincing.

One may argue that given that the WIPO already exists and that it has agreements on IPR, why does one need the WTO to safeguard IPR? It is important to highlight that the relevance of the WTO is predicated on the notion that the WIPO has not been effective for various reasons. To understand this point, note that, in terms of inclusiveness, the WTO has 145 members. In contrast, very few countries are signatories to various WIPO conventions or treaties. Thus, the WTO seems to provide a broader umbrella than the WIPO has done over the years. One may also argue that incorporating IPR into the WTO fold has several advantages. Not only are more countries members of the WTO, more importantly, the WTO provides an effective dispute resolution mechanism and this can be used against countries that fail to protect IPR. Following favourable judgment in a dispute, retaliatory action can be taken against a country that breaches IPR conventions. The WTO as a disciplinary mechanism is thus far more credible, which is why IPR was brought into the WTO.

The forms of IPR covered in the WTO are copyright and related rights, trademarks, geographical indications, industrial designs, patents, layout designs (topographies) of integrated circuits and undisclosed information. On transitional arrangements, nations are to gradually achieve higher norms. Developing countries had until 2005 for patents. In some sectors, some countries such as India only allowed process patents in food, chemicals and drugs. It is important that product patents should protect property rights in all sectors and not just for a select few. At the moment, the choice between a process patent and a product patent is usually left to the applicant.

At the conclusion of WTO's Fourth Ministerial Meeting in Doha in 2001, least developed countries (LDCs) were given until 2016 to implement higher norms. Other than the issue of product patents vis-à-vis process patents, the duration of patent protection has also to be uniformly implemented in the coming twenty years. Towards this end, compulsory licensing provisions have been tightened. These provisions are used when a patent is not workable. The government can then instruct that the patent-holder has to compulsorily execute a license in favour of another manufacturer.

There are three main issues about the TRIPs agreement that give rise to concern in South Asia. India and Brazil have asked for dilution of the Uruguay Round's TRIPs agreement. The Commission on Intellectual Property's document represents one of the best examples of the concerns. For integrating intellectual property rights into development policy, the Commission on Intellectual Property Rights was set up by the British government in 2002. On health issues, there are also various reports produced by the Global Forum for Health Research, WHO. The expression '10/90 gap' is now used, meaning that less than 10 per cent of global spending on health research is devoted to diseases or conditions that account for 90 per cent of the global disease burden.

There is a concern that patent protection in the pharmaceutical sector will result in monopolies, increase drug prices and prevent access to health care. Similar concerns are also expressed about monopolies in fertilisers and seeds. Given the spread of AIDS, countries in sub-Saharan Africa and South Asia have also been concerned about the cost of public health. This concern was reflected in a WTO Ministerial Declaration in Doha on TRIPs and access to public health. On public health issues, there are three kinds of concerns – price

controls, parallel imports and compulsory licensing. The major concerns with IPRs at the global level are that they:

1 promote monopolisation of an idea;
2 protect and promote monopoly power;
3 place at the discretion of the owner the power to decide how an idea can be utilised; and
4 require that every time an idea is used, a royalty has to be paid by the licensee to the owner, thus distorting competition.

The following section offers a game-theoretic model based on the issues (1), (2) and (4) to examine an anti-competitive element in the entire set-up.

Formalisation of the model

Ecological footprints of economic progress: The relevance of knowledge assets

Environmental economics, economic development and sustainability have triggered one of the most interesting debates of the modern civilisation. One strand of thought by leading natural scientists is that the current interrelationship between human beings and nature is vitiated by a deep 'malaise' as the current standard of living of an average human is not ecologically sustainable. This negative opinion comes to us as a prediction of doomsday awaiting humanity when the ecological system will collapse and fail to sustain our future. The other strand of thought, mainly posited by economists and business specialists, is that the standard of living of an average human being today is better in many ways than humans have ever enjoyed. Some, therefore, tend to argue that there is no impending crisis and the foundation of the doomsday prediction is an overreaction.

It is early days for anyone to make a clear and definitive judgment about the empirical tenability of either of these opposing views. Yet what is at stake is a fragile ecological system that can suffer irreversible damage from unbridled economic development and population growth. If over time the first strand of thought prevails many states, especially the SIDS, will need to quickly adopt a pattern of sustainable development program in order to rapidly rectify ecological damages. If the existing ecological damage has been serious enough, the potential survival for such SIDS will be already in question. So a critical question for SIDS is how to contain ecological damage that typically accompanies economic development within some reasonable and acceptable bounds. In this chapter, we call this damage rather euphemistically the 'ecological footprints of economic progress', or simply ecological footprints.

In what follows, we constructively argue two important drawbacks of economic development in the context of ecological sustainability:

- First, we will argue that through an appropriate economic development strategy SIDS can achieve ecological sustainability by promoting industries that intensively use 'knowledge assets' in their production. One may call these industries 'knowledge-specific industries'. These industries, we will establish, have relatively smaller ecological footprints.

- Secondly, we will argue that the nature of knowledge-specific industries is such that SIDS cannot rely on global market mechanisms to achieve ecologically sustainable economic progress. It is, therefore, essential that SIDS collectively engage in a multilateral negotiation/bargaining with the advanced nations on regulating and controlling royalties on knowledge assets.

Let us take a quick glimpse at the implication of ecological footprints of economic development/progress. Economic activities directly, or indirectly, utilise natural resources. Natural resources are directly used in consumption and indirectly as inputs in the production system. The main natural ingredients in the production process are oil, coal and natural gas, which generate adverse environment impacts such as water and air pollution. In modern work natural resources are considered those natural assets that create a complex ecosystem on which life is based. These natural assets provide a complex set of services to all living organisms of a specific ecosystem. The main pillar of our argument is that economic activities leave irreversible impacts on the ecosystem and different industries have different impacts on the ecology. In other words, the production process of an industry releases pollutants that adversely impact on the ecosystem. In most cases the concomitance of economic development and pollutants is a degradation of ecosystems. Economic development also causes a deterioration of various environmental assets (like water and air quality). The environment is the proverbial 'sink' and pollution is an unintended consequence of economic development on the quality of environmental goods. For us, one of the important quests of economic sustainability is to minimise the deterioration of environmental assets.

In support of our argument that SIDS can significantly arrest environmental degradation by choosing an optimal development strategy that focuses on knowledge-intensive industries, we offer the consumption, or utilisation, of energy by an industry as a proxy for the measure of its ecological footprint. The measures give an estimate of the pollution that is directly caused by production in each industry. We examine the energy consumption of 22 industrial sectors from the United States of America in 2002. The industry classification codes (NAICS) and their names and various measures of energy consumption are presented in Table 19.1. The details are given at the bottom of the table. For our argument it is important to note two of the measures CPE and CPV as proxies for ecological footprints. The index CPE is the consumption of energy per employee and CPV is the consumption of energy per value added. For our reference, Industries 334, 335, and 336 are the knowledge-intensive industries.

In Figure 19.1 we present the energy consumption, or CPE measure, of each industry. It is evident from the figure that the ecological footprint of Industries 334, 335, 336 are significantly lower than the other. These are the high-tech and knowledge-specific industries. In Figure 2 we present the CPV measure of energy use for 22 industries, which graphically describes how the ecological footprints of Industries 334, 335, and 336 are close to zero.

Thus, our main argument is that knowledge-specific industries and their development in SIDS can play an important role in ensuring economic development without compromising their ecological sustainability. What we argue in the next section is that we cannot

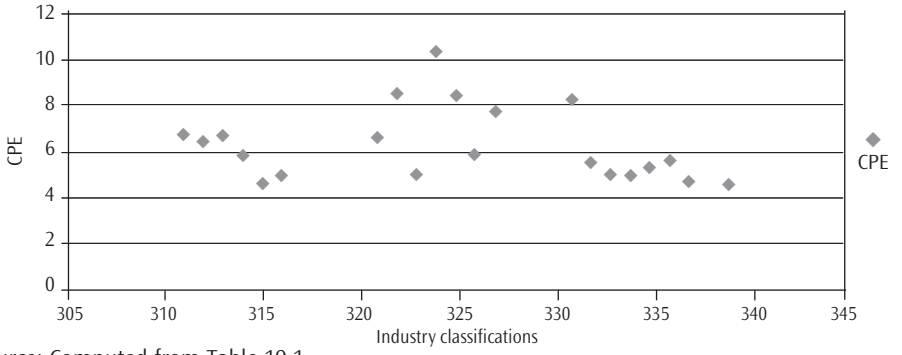
leave the development of these important industries to the vagaries of the global market mechanism which can significantly marginalise SIDS and compromise their future development.

Table 19.1. Price and consumption of energy by the American manufacturing industries in 2002

NAICS	Sectors	POE	CPE	CPV	CPVS
311	Food	6.42	6.766	6.0	2.6
312	Beverage and tobacco products	7.53	6.508	1.6	1.0
313	Textile mills	7.73	6.683	11.2	4.3
314	Textile product mills	7.38	5.844	4.7	1.6
315	Apparel	11.16	4.622	1.8	0.9
316	Leather and allied products	9.66	5.025	2.4	1.1
321	Wood products	3.95	6.609	10.6	4.2
322	Paper	4.78	8.525	31.1	15.2
323	Printing and related support	12.54	5.028	1.8	1.1
324	Petroleum and coal products	3.97	10.354	91.3	15.0
325	Chemicals	5.03	8.481	15.3	8.5
326	Plastics and rubber products	10.90	5.928	2.9	2.1
327	Non-metallic mineral products	4.66	7.798	20.7	11.7
331	Primary metals	4.94	8.336	34.6	14.2
332	Fabricated metal products	10.39	5.555	3.0	1.7
333	Machinery	11.38	5.059	1.4	0.7
334	Computer and electronic products	9.24	4.949	0.9	0.5
335	Elec equip., appliances, components	6.84	5.353	1.9	1.0
336	Transportation equipment	8.65	6.30	1.8	0.7
337	Furniture and related products	8.82	4.734	1.6	0.9
339	Miscellaneous	13.26	4.620	0.9	0.6

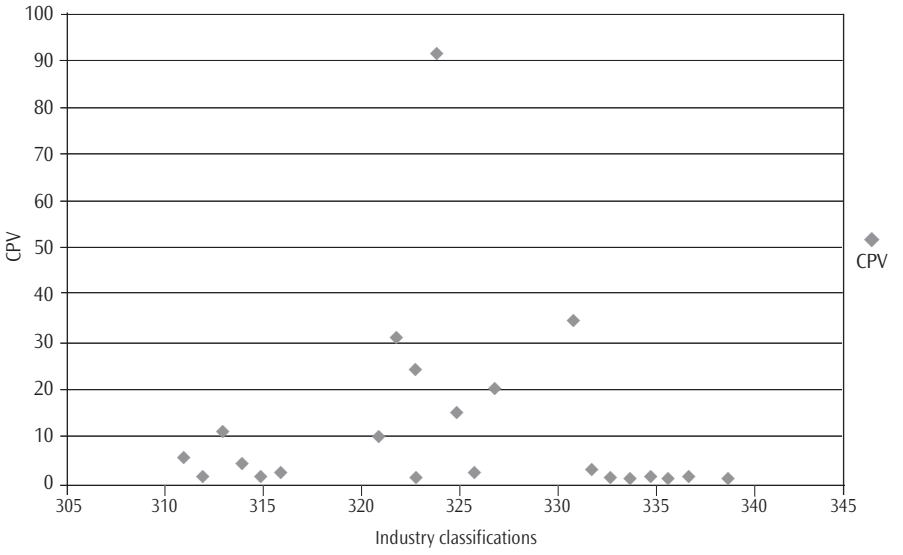
Notes: NAICS: North American Industry Classification System, POE: Average Price of Purchased Energy, CPE: Consumption of Energy Per Employee, CPV: Consumption of Energy per Value Added, CPVS: Consumption Per Dollar Value Shipment.
Source: Energy Information Administration, U.S. DOE (2002 index), Department of Energy survey data on energy intensity in industrial sectors.

Figure 19.1. Specific industries and their ecological footprints (CPE measure)



Source: Computed from Table 19.1.

Figure 19.2. Industrial sectors and their ecological footprints (CPE measure)



Source: Computed from Table 19.1

Knowledge assets and vertical structure: Basic intuition

We argue that a strict enforcement of IPR of global firms by the WTP can cause problems of vertical foreclosure in relevant markets. As an example, suppose there is a global player in the pharmaceutical industry that invests significant resources to develop a drug to prevent the dreaded bird flu. Once the global giant is successful in developing the vaccination/drug, it has effectively established (intellectual) property rights over this drug. If this drug is subsequently produced in India by a local firm for the Indian and other regional markets, then this local firm combines two types of inputs to produce this drug: first and foremost, it pays a royalty to the global firm to acquire the formula that one may call a 'knowledge asset'. Secondly, upon acquiring this knowledge asset as a key input, the local firm uses necessary ingredients and inputs to manufacture this drug. For each unit produced, the local firm pays a royalty to the global firm. The local firm competes with the global firm in the downstream drug market to sell the drug. Thus, the industry has a vertical structure since this key input, knowledge asset, is monopolised by a global firm that sells this input to a local firm and both these firms compete in the downstream market of the final good. In the subsequent discussion we call the global firm an integrated firm and the local firm a non-integrated firm.

The optimal royalty

We postulate an industry that supplies a single final product. Each unit of it is produced by combining necessary input, called a knowledge asset, from the upstream industry with labour and other inputs from competitive markets. The upstream firm is an integrated firm which has monopolistic control over the supply of the knowledge asset and competes with

the downstream firm in the market for the final product[1]. The downstream firm is competitive in the input market as it takes the input price as a datum. We postulate Cournot type quantity competition in the downstream duopoly market while the integrated firm has naturally monopolistic power in the upstream market (see Ordover, Saloner and Salop, 1990 for relevant details). It is natural that the degree of (actual) competition in the downstream market is determined by the royalty/price of the knowledge asset of the upstream market. We assume a highly stylised sequential game that is played out over two time periods. The integrated firm faces a duopoly in the downstream (final product) market while it wields naturally monopolistic power in the upstream market (knowledge asset).

During the first time period, or Stage I, the integrated firm announces the royalty at which it will sell the knowledge asset in the second period, or Stage II, to the rivals in the downstream market. During the second period, or Stage II, both the integrated and non-integrated firms will compete as Cournot duopolists in the downstream market to sell the final product. If the information is complete, in the relevant rational expectations equilibrium, both the firms correctly predict the Cournot-Nash equilibrium of the second period, or Stage II, competition and both the firms will seek to maximise their profits in Stage II given the royalty as determined in Stage I. When the integrated firm chooses the royalty in Stage I, it seeks to maximise the overall profits in Stage I and Stage II[2]. Thus, in order to solve the game we will apply the logic of backward induction: we start with Stage II and characterise the Cournot-Nash equilibrium of the duopoly game. Rationality and complete information dictate that both firms and the regulatory body will form their expectations by looking ahead and foreseeing the duopoly outcome. If agents behave this way, they are said to have rational expectations. In Stage I, relevant agents adopt their optimum, actions based on their rational expectations. The resultant outcome is the solution to the sequential game, which is called the perfect Nash equilibrium.

In order to derive the perfect Nash equilibrium, we need the following details:

Definition 1: The profit of the integrated firm (Π^m) is given as:

$$\Pi m = (A - w)q_n + (P(Q) - c - w)q_m \tag{1a}$$

where Q (= $q_m + q_n$) is the market output of the final product while q_m is the output of the integrated firm and q_n is the output of the non-integrated firm and A is the royalty for each unit of final output produced by the non-integrated firm, w is the cost of producing the essential input, c is the cost of producing the final good for both firms, and P(Q) is the inverse demand function.

Definition 2: The profit accruing to the non-integrated firm from the downstream market is:

$$\Pi n = (P(Q) - c - A)q_n \tag{1b}$$

Assumption 1: We assume the inverse demand function to be linear:

$$P(Q) = a - bQ \tag{1c}$$

Based on the above, we derive the Cournot-Nash equilibrium of the duopoly at Stage II.

Stage II: Cournot-Nash equilibrium of the duopoly in the downstream market

In Stage II, the integrated firm earns Π^{m1} from the sales of final product:

$$\Pi^{m1} = (P(Q) - c - w)q_m \tag{2a}$$

Substituting (1c) in (1a) and simplification would yield:

$$\Pi^{m1} = (a\text{-}c\text{-}w)q_m - bq_nq_m - bq_m{}^2 \tag{2b}$$

The Cournot-Nash equilibrium of the downstream market is given as:

$$\begin{aligned} q_n{}^* &= [(a - c - 2A + w)/(3b)],\ q_m{}^* = [(a - c + A - 2w)/(3b)], \\ Q^* &= [(2(a - c) - (A + w)]/(3b)], \\ P^* &= [(a + 2c + A + w)/(3)] \end{aligned} \tag{2c}$$

In an unregulated industry, the integrated firm fully controls the royalty A. It also has the full knowledge about the Cournot-Nash equilibrium of Stage II and expects the rival to respond by equation (2a). In Stage I, the integrated firm thus sets A to maximise (1) subject to the Cournot-Nash equilibrium of Stage II as given by equations (2a). This outcome is the perfect Nash equilibrium of the two-stage game.

Theorem 1: In the perfect Nash equilibrium of the proposed sequential game the optimal royalty, A^E, as set by the integrated firm in Stage I, is given by equation (2b). This optimal royalty, in turn, determines the equilibrium output response of the non-integrated firm, $q_n{}^E$, equilibrium output of the integrated firm, $q_m{}^E$, and the equilibrium market price, P^E, at Stage II as[3]:

$$\begin{aligned} P^E &= [(a + 2c + A^E + w)/3],\ A^E = [(a - c + w)/2],\ q_m{}^E = [(a - c - w + A^E)/(3b)], \\ q_n{}^E &= [(a\text{-}c\text{+}w\text{-}2A^E)/(3b)] \end{aligned} \tag{2d}$$

The optimum, A^E, is derived as:

$$\Pi^m = [\frac{(a - c - 2w + A)^2}{9b} + A\frac{(a - c + 3w)}{3b} - \frac{2}{3b}A^2 - \frac{w\,(a - c + w)}{3b}] \tag{2e}$$

The first order condition to maximise (2e) with respect to A yields:

$$A^E = \frac{(a - c + w)}{2} \tag{3a}$$

Theorem 2: In the perfect Nash equilibrium of the sequential game, the optimal royalty, A^E, of the integrated firm will drive the profit of the rival (non-integrated firm) to zero. Hence the non-integrated firm will leave the downstream market if the industry is unregulated.

Proof: Simple maximisation yields the result. QED.

In an unregulated and vertically-integrated industry, as captured by the above sequential game, the resulting equilibrium is one in which the integrated firm chooses A^E in Stage I to maximise its overall profits. At this pre-committed price A^E, the non-integrated rival will make zero profits and, hence, will quit the industry leaving the vertically integrated

firm to enjoy the monopoly profits. Thus, if the royalty for knowledge asset is not subject to regulation, such an industry will be characterised by significant market distortions. The integrated firm will have anti-competitive incentives and the ability to choose a royalty rate for the knowledge asset, which will eventually evict its rivals from the downstream sector. In order to protect the non-integrated firms, the regulator must therefore introduce caps on the royalty to avoid A^E. From the profit functions, it is evident that both the firms cannot simultaneously gain from an increase in the input price.

From these results we make the following remark: It is evident that

$$\text{for } A < A^E, \frac{\delta \Pi^m}{\delta A} > 0 \text{ and that for } A > A^E \frac{\delta \Pi^m}{\delta A} < 0$$

The above results show that the regulator must introduce restrictive measures in the upstream market to protect the non-integrated firm, otherwise the integrated firm can use its power in the upstream market to 'leverage'[4] into a position of power in the downstream market. It is interesting to note that the optimal royalty of the integrated firm may not be too high or too low: it is the price of knowledge asset that raises the cost and lowers the market share of the non-integrated firm in order to drive the non-integrated firm's profit to zero. At this optimal royalty the integrated firm maximises its profit and, hence, this anti-competitive behaviour appears as an equilibrium phenomenon. To prevent this equilibrium vertical foreclosure, it is necessary to regulate royalties in such markets.

Concluding comments

One of the major characteristics of SIDS is their isolated nature. More often than not, the transport network and communication networks in SIDS are poorly developed, maintained and managed. Poor long-term planning is partly responsible for this. It is of utmost importance that the fragmented nature of these nations and their linkage problems with the rest of the world must be redressed in order to lend economic and social stability in SIDS. The impact of geographical distance, in conjunction with high fuel costs, will further isolate these nations. These challenges are substantial and will determine the fate of these small and fragmented economies as the forces of globalisation take different turns with the energy price shocks of 2007–2008. There is increasing reliance by these nations, their economic advisors and also among experts from the United Nations, on the rapid development of ICT for establishing the requisite networks with the regional and global markets. In an ever-increasing appetite for economic progress these nations are gaining access to and implementing technologies to modernise their relevant sectors, which will also ensure reduced ecological footprints as the high-tech sectors are more energy efficient. Unfortunately, the global market for high-tech goods and services is dominated by a few firms and intellectual property rights are a major characteristic of these technology-intensive sectors. In this chapter, we have highlighted how intellectual property rights can pose a threat to sustainable economic development of SIDS and thereby compromise their ecological sustainability.

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Notes

1 In order to simplify the analysis we assume that there is a single non-integrated firm in the downstream market and, hence, this market is postulated to be a duopoly. The conclusions will extend to the case with a finite number of firms.

2 Profits accrue to the integrated firm from two sources: first, it receives profits from the sales of knowledge assets; secondly, it receives profits from the sales of the final product.

3 Here what we mean by an equilibrium is the perfect Nash equilibrium of the proposed sequential game.

4 This argument is similar in spirit to the equilibrium vertical foreclosure as propounded by Ordover, Saloner and Salop (1990) who consider a market in which supply of inputs is competitive. After the merger, the upstream division of the now-integrated firm refuses to supply necessary inputs to the rivals in the downstream market. Thus, the input-supply to the rivals is foreclosed which leads to increased input price as well as increased output prices. The integrated firms benefit from reduction in competition resulting in price hikes. Ordover, Saloner and Salop (1990) provided a coherent model to argue that anti-competitive foreclosure arises as an equilibrium phenomenon in a four-stage game.

John L Roberts

Making sense of the Millennium Development Goals

Introduction

This chapter critically reviews how well the United Nations (UN) system of the Millennium Development Goals (MDGs) is suited to the needs of natural resource analysis for sustainable development in small and island states. The MDGs have been promoted through the UN system as a tool for policy development and planning but are seriously flawed both for this purpose in general and for use in relation to the special environmental concerns and needs of small and island states. The chapter examines the scope and content of the UN MDG system and its relevance to the policy and planning needs of small and island states. It identifies the principal gaps and deficiencies which need to be taken into account in establishing priorities for sustainable development in such countries that are especially vulnerable economically and environmentally to exogenous shocks, and which in many cases have little capacity for resilience.

In trying to make sense of the MDG system, it is first necessary to recognise that it was not designed to embrace a concept of universal well-being, based on reducing inter-country inequities. Nor was it designed to track the impact of economic and social change on the natural resources of the planet. The MDG system is not built on a coherent social welfare strategy, nor does it seek to incorporate a framework of policy modelling for sustainable progress within the planet's limited natural resources. These design limitations of the MDG system must encourage us to look to adapt it and to seek other complementary tools if we wish to use it to assist us in the tasks of policy and planning for sustainable development.

The MDG system

The MDGs are a system of strategic goals agreed at the UN Millennium Conference in 2000 for the achievement of greater global development. The MDGs have associated indicators and targets for each country to achieve by a prescribed date, for most Goals by 2015, against a 1990 baseline.

The eight Millennium Development Goals relate to poverty reduction, education, gender equality, child health, maternal health, control of major diseases, environmental sustainability and partnerships for development. Their pursuit has been integrated in the process of National Strategies for Sustainable Development and Poverty Reduction Strategy Papers.

Crucial gaps in MDGs on environmental concerns for small and island states

The environmental targets and indicators include forest cover, protected areas, energy use, CO_2 emissions, safe water, sanitation provision, and reduction of slum property and insecure housing tenure. Many environmental issues of concern to small island developing states (SIDS) are not included in the system. For example, the following are absent: coastal and marine management, biodiversity, waste management, and natural disasters. The exposure of SIDS to exogenous change from climate change and sea-level rise is not considered; and the implications of their economic and environmental vulnerability and capacity for resilience are ignored.

Structural flaws

The MDG system is coming under increasing critical review. The editorial of the March 2007 edition of *Nature* asserts that '*The MDGs could be buried in history's graveyard alongside other well-intentioned but failed development efforts …*'. But, more fundamentally, they have been criticised as an example of '*welfare colonialism*', promoting a flow of aid to the former colonies, which has the effect of undermining existing livelihoods, putting the people under systems of unemployment benefits and failing to promote the diversification necessary for real economic growth. Reinert (2007) considers that '*from the point of view of economic theory, the MDGs can be seen as a system where the nations producing under increasing returns (industrialised nations) pay annual compensation to nations producing under constant or diminishing returns (raw material producers) for their losses*'.

The system of MDGs may also be seen as a complement to a largely discredited approach of national planning in which targets are externally set to be pursued by a centralised state over a specified time period unrelated to capacities, cultural values, diversity, and to local priorities, nor to any assessment of the total and marginal costs benefits of achieving them. The promotion of consultation and participation that is being promoted as part of the process cannot make up for the inherent deficiencies at the heart of the MDG system itself.

The MDG system lacks an economics framework at either macro or micro levels. In assessing results, it excludes consideration of the stage of development of countries in terms of their economic, demographic, social and epidemiological transition. For example, in Goal 8 on Partnership the system assumes that progress will be made through greater allocation of development assistance. This implies that such assistance has been effective in promoting development and that the countries themselves have the effective capacity to respond.

The goals and targets in the MDG system are not devised from any analysis of what can and has been achieved; nor of the models through which successful development has been achieved. They provide no analysis of the technology and physical infrastructure required to achieve progress, nor the conditions required for that to be effective and sustained. Moreover, the system, which is focused on national indicators, takes no account of the regional economic, environmental and social setting, nor those other factors that are

critical to development in small states and islands such as size, isolation, fragmentation, economic and environmental vulnerability.

Whilst most National Sustainable Development Strategies and Poverty Reduction Strategies incorporate references to MDGs, it is clear that, by the close of the planning period in 2015, many countries will fall far short of their targets. In few states does the process of MDGs or that of NSDSs appear to be integrated into the real mainstream of policy and national development in the public and private sectors. The goals, targets and indicators are not integrated into the policies of the mainline ministries, sectors or industries, but are often assigned to environmental ministries without sufficient mandate, capacity and clout to ensure that the results are taken into account in national policy formation, budgets, sectoral policy systems and business commitments. The MDG system thus operates in the insubstantial shadows of national decision-making and in itself would not show up well under the sustained rigorous scrutiny of realpolitik.

Ignoring the value of natural resources

The limited range of indicators on environment and environmental governance in the MDG system ignores the value of natural resources and thus may have the effect of diverting the attention of policy-makers from investment in natural resources and their sustainable development. This is a vital omission in the system for small states and islands whose future progress is intimately concerned with the sustainable quality of the environment for the pursuit of both social and commercial interests. Overfishing, water stress, unregulated natural resource extraction, land polluted by industry and unmanaged waste disposal, urban sprawl, desertification, and pressure on land from population growth, are not covered in the MDG system. Further, no information is provided in the MDGs on the deployment of opportunities for sustainable use of natural resources for promoting economic development, jobs and social welfare.

In reviewing the place of MDGs in the business of government, Downes (2007) has emphasised the lack of attention in the analytical process of sequencing, administrative support, project management skills, education and training, and the non-linear process of the dynamics of change. He also distinguishes between those indicators that are concerned with outcomes and those that are related to performance drivers. The overall picture that emerges is that the MDG system is composed of fragmentary sets of data lacking a coherent theoretical framework and thus poorly suited to the policy challenges of small and island states.

Ignoring the exogenous pressure on small and island states

The MDGs scarcely touch on the core issues for development in small and island states. At the centre of any development process in small and island states is human capital formation, social infrastructure, systems of resilience and protection from natural and economic shocks, action for improved trading conditions, incentives for business development, the promotion of employment, productivity and competitiveness, and measures to reduce intra-country inequalities in the gains that emerge from the development process. None

of these essential conditions for progress features in the MDG system. Without these issues being clearly addressed, the plight of small and island states and the task of salvaging their sustainable future is not on the agenda. Whilst such states may seek to address these issues themselves, many of their economic and environmental sustainability challenges are linked to exogenous factors such as energy prices, globalisation of trade, diseconomies of scale, skills migration to large states, climate change and sea-level rise over which they have little control.

Methodological issues

Apart from the structural flaws in the MDG system considered above, the assessment of progress with MDGs is beset with technical problems within the data sets themselves. These issues are now examined, many of which are common to any system of national and international data relevant to decision-making.

Missing data

In Downes's (2005) assessment of progress with MDGs for 73 small states of the Commonwealth, he found overall 29 per cent of the data was missing. UNEP found in its African regional assessment of 53 states that for the seven indicators examined, covering five of the eight MDGs, there was 2 per cent missing data on Goal 4, Child Health, and 74 per cent missing data on Goal 2, Education. In another assessment for the AIMS group of countries, 48 per cent of the indicators had missing data, thus inhibiting a complete assessment of the status on progress towards the targets.

The problem of missing data is likely to persist until the system of MDGs is integrated into the mainstream of data collection and analysis at national level. For this purpose, the task should be placed within the functions of the national statistical services and subjected to regular audits for timeliness, accuracy and conformity to international standards. Missing data are in themselves a measure of the importance that countries attach to the MDG system, as one tool, however flawed, for policy-making.

Baselines

The use of an arbitrary baseline of 1990 for assessment of progress on indicators for all countries tends to obscure how far results are affected by both major differences in baseline values between countries, and by variations in the secular trends of values within the time period of assessment. This is one of the fundamental design elements of the UN system of MDGs that needs to be reviewed if the system is to be used as a mainstream tool for policy-making.

Equity and inequity

The promotion of global and inter-country equity is limited to two of the eight Goals, namely Goal 2, Target 3 Education, and Goal 3, Target 4, Gender Equality. In both these Goals the target values for each indicator are identical for each country[1]. For all the other six Goals the method adopted for target setting varies in relation to the 1990 baseline val-

ues placed on the indicators. Thus, for the other six Goals, 16 targets and 36 indicators, the bulk of the MDG system, the target values promote the preservation of inter-country inequity at current relative levels.

Gaps in data coverage most critical to small states and islands

There are certain vital missing elements in the MDG system that are of special relevance to SIDS. These elements are set out clearly in the 20 thematic chapters of the UN SIDS Mauritius Strategy (UN MS) of 2005 (UN 2005). UN MS is an internationally-approved guideline for SIDS for their future sustainable development. The elements in the MS but absent from the MDG system include: climate change and sea-level rise (UN MS Chapter 1), natural and environmental disasters (UN MS Chapter 2), management of wastes (UN MS Chapter 3), the state of coastal and marine resources (UN MS Chapter 4), tourism (UN MS Chapter 8), biodiversity (UN MS Chapter 9), management (UN MS Chapter 18), and indigenous culture (UN MS Chapter 19). Other elements not included in the MDG system but vital to all small countries include: demographic change, non-communicable disease and injuries, expectation of life, social well-being, governance and security, trading partnerships, productivity, competitiveness, and probity. These are major holes in the MDG system as a tool for policy-makers. In devising an indicator system for effective use in small and island states, these gaps need to be plugged to ensure a focus on the core issues of country strategy, priorities for action and decision-making for sustainable development.

Interpolated data

Care must be taken in using the UN data reports, as they not only include nationally reported data, but values adjusted by UN agencies 'to achieve international comparability' such as: variously modelled values to compensate for absent data; simulated values using UN statistical models; running averages spread over short periods of two to three years, and reported data which may not cover the full reference time periods. The use of interpolated values can be misleading and diverts attention from the task of collecting and reporting the data at local levels.

Concealed denominators, technology and costs

Many of the indicators in the MDG system and their related targets are expressed as ratios or percentages without reference to the denominators on which they depend. This has the effect of concealing the size of the task presented to different countries, even in achieving similar percentage improvements on the indicators. It also conceals the differences in size of countries and the cost and benefit implications of narrowing the gaps from target values. For example, a two-thirds reduction in infant mortality in Guinea Bissau would save nearly 6,000 lives a year; in Singapore a two-thirds reduction of the infant mortality would save 40 lives a year. Moreover the technology required for achieving these reductions in infant deaths and their associated costs diverge greatly between the countries. Achieving targeted reductions in the infant mortality in Guinea Bissau could be achieved at low unit costs by large-scale extension of safe water and sanitation. In Singapore, the key technology could be small scale, but with high unit cost, by providing better intensive

care for premature and sick babies. The identification of the hidden denominators and the relevant technology is a key step in the process of policy appraisal for the pursuit of the MDG targets and the assessment of national and regional impact and relative priorities.

The MDG system is a poor tool for global policy-making in the absence of measures of volume, technology, and marginal and total cost. A technically-based economics framework can greatly assist such decision-making at regional and national levels. Thus, the MDG system needs more development in this dimension, building up from reports of the cost and impact of investments for the pursuit of the targets where priorities may widely differ.

Conclusion

The effective management of development depends upon doing the right things right. The MDG system appears to promote change through the publication of indicators without reference to what are the right things to do and how best they can be accomplished. The system lacks both an evidence base and a theoretical framework within which development can be pursued. It implies that the task of narrowing the gap to targets is technically the same for all countries, without recognising the technical and economic issues peculiar to small states such as the absence of economies of scale and the dearth of specialists in many technical fields. Furthermore, the MDG system neither embraces a concept of well-being as a goal in human endeavour, nor the impact of change on the natural resources of the planet. It is not built on a coherent social welfare strategy nor does it seek to incorporate a framework of policy modelling for sustainable progress within the planet's limited natural resources.

To make sense of the MDGs, however, we must recognise them for what they are, not what they may seem to be. They are but a fragmented set of conveniently available measures of the state of common features of the human and natural environment in which people live in very different social, environmental and economic settings. They provide a perspective on aspects of the world about us at the level of nation members of the UN. They allow us to review the agenda for change but they fall short of a robust perspective on global priorities and a framework for action. As tools for policy and planning, they are flawed both in structure and content. They may be amongst the best that are available, but that should not promote the indulgent belief that a better system cannot and should not be developed.

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Notes

1 Goal 2, Education: target 3, Indicators 6–8 the targets are 'universal', 100%, achievement, for primary education enrolment, for completion of primary education, and for youth literacy, Goal 3, Gender Equality, Target 4 Indicators 9–12, the targets are equality in girls to boys in education, literacy, employment in the non-agricultural sectors and proportion of seats held by women in national parliaments.

John L Roberts

Methods of analysis used in global and regional assessments and indices of performance in environmental governance

Chapter 21

Introduction

This chapter examines the analytical methods used in the United Nations Environment Programme's (UNEP) reporting on the state of the environment. The flawed methods embedded in the DPSIR framework have significant implications for projecting the future of the planet. Policy-makers and their advisers need to be giving more attention to deficiencies in these frameworks, the inadequacies of the evidence base, and the consequences of using data whose focus is on administrative regions and national states as distinct from geographical areas with common ecological, geological, topographical, economic and cultural coherence. The review also stresses the need for greater attention to the complexities of the ecology of small states and islands and drawbacks in attempting to apply simplistic causal and effect models to the process of change and intervention attending fragile ecosystems and their vulnerability to exogenous shocks.

The DPSIR Framework

In the development of its Environmental Outlook publications UNEP adopted the so-called DPSIR framework for presenting its model of the relationship of the environment to human activity and for analysing relevant policy responses to the issues identified.

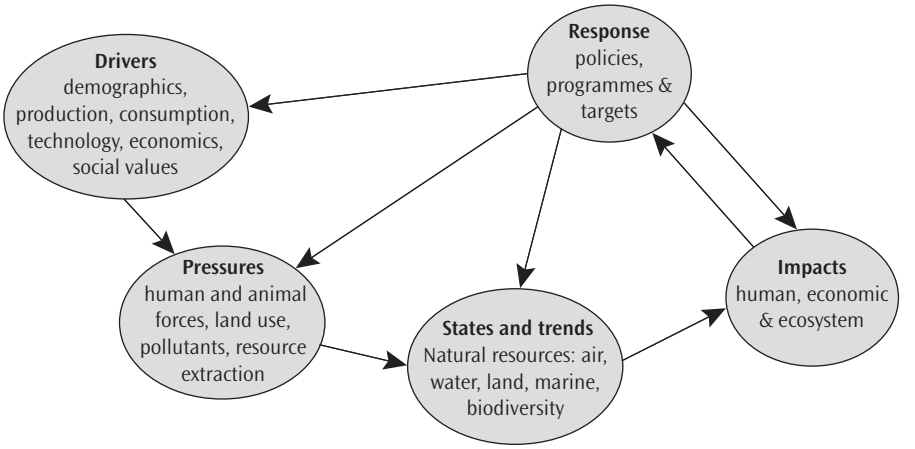
DPSIR stands for:

- Drivers,
- Pressures,
- States and trends,
- Impacts, and
- Response.

Figure 21.1 presents a stylised picture of the imputed relationships between these elements.

The DPSIR Framework is a common feature in the other main conceptual frameworks (see Figures 21.1–21.3 and Box 21.1). UNEP has used them in the development of the analysis for the *African Environment Outlook 2*, published in 2006, and for the *Global Environment Outlook 4* published in 2007. The DPSIR framework has a series of implied assumptions and inherent logical flaws in its use as a tool in critical review of the thematic areas for policy development.

Figure 21.1. The DPSIR framework



Source: Adapted from UNEP (2006) AEO2, Earthscan for UNEP

In the basic DPSIR model, whilst the 'circuit' diagram depicts, it seems, causal relationships between drivers, pressures, states and trends and impacts, the science base for this is assumed, but not evident. The case studies presented by UNEP in *AEO 1* in 2004 indicate a more complex, paradoxical or delinquent relationship between components and their likely illumination on outcomes[1]. In DPSIR, the states and trends are assumed to be identifiable, measurable and accurately measured by standard methods; the nature, power and direction of the impacts are assumed to be knowable, non-catastrophic and reversible; the capacity and commitment to respond is inferred to be present and sufficient; the relationship of benefits to intervention cost is assumed to be positive over whatever timescale is required for fruition.

Box 21.1 sets out the definitions of the terms used by UNEP with examples of the scope and content of each of the elements within the different analytical frameworks that have been developed for the African Environment Outlook and the Global Environment Outlook publications.

Box 21.1. Definitions of terms used in the methods of analysis

Framework: an essential supporting or underlying structure, which identifies the principal elements and their interdependencies. The concept of a framework in natural resource analysis may include ecosystems concepts which link living organisms to their immediate physical, chemical and biological environment; it may also include economic and management systems, concepts concerned with human groups, institutions, power, governance, social relations, the market place, flows of goods and services, and the impact propensity of interconnections. In examining a defined framework, it is illuminating to ask: what has been omitted and what are the meanings to be attached to the form of representation and the metaphors implied by the terms and the interconnecting lines and symbols? Examples of commonly-used frameworks in natural resource analysis are: **ecosystems**, **DPSIR** framework, **Opportunities** framework, the **Sustainable Livelihoods** framework, and the **GEO 4** Frameworks (see later).

The DPSIR framework consists of the interconnected elements of **Drivers, Pressures, States and Trends, Impacts,** and **Responses** as defined below.

Drivers: fundamental processes in society that drive activities with a direct impact on the environment. Examples of drivers include: demographics, consumption and production, technology, trade, value systems. These may be seen as the causal factors in pressures on the environment.

Pressures: forces exerted on an object by something in contact with it. In natural resource analysis, pressures arise from human or other living forces on the environment disturbing the equilibrium or homeostasis that is the steady state. Whilst it is recognised that both ecosystems and human systems are in states of continual change and that homeostasis may be a misleading theoretical concept, major changes in ecosystems are occurring globally and locally. Changing pressures on the natural environment derive from factors such as human changes in land use, extraction of natural resources, the use of chemicals in farming, and emissions of waste and pollutants.

States and Trends: The observed conditions of objects and the rate and direction of change in those conditions. Examples of environmental conditions include air and water quality, biodiversity, ice and forest cover. The change in such states may be positive or negative, and the trends continuous, cyclical, fluctuating or irreversible. Changes may arise from endogenous or exogenous sources, natural, or induced by a driver or pressure. Examples of natural factors affecting environmental states and trends include solar radiation, precipitation, diurnal and seasonal weather changes, fertilisation, extreme natural events such as volcanoes, cyclones, floods and droughts, and climate change. The complexity of the physical, chemical and biological factors in the ecosystem and their interrelationships makes it difficult to predict and to model environmental change. The vulnerability of the environment to change and its natural capacity to absorb change and to respond and adapt varies between regions and countries. Small states and islands are commonly considered to be more fragile, vulnerable and less naturally resilient to pressures on their natural environment. Their carrying capacity for absorbing shocks is believed to be low and therefore in need of more careful protection than other geographical types of country.

Impacts: The action of one object coming forcibly into contact with another, thus affecting its state. The impact may be on the state of the environment or on human well-being or both. It may be positive or negative, large or small. The nature of the impact may affect security, physical relationships or adaptive capacities.

Responses: The re-actions to an impact or to a change in the state of trend of an environmental or human condition. Responses take place in treaties, laws, institutional systems, policies and programmes and at global, regional, national and local levels. They may be positive, negative, effective, catastrophic, temporary or permanent.

The Opportunities framework: Opportunities are the circumstances affecting the choice of action in the use of natural resources. This concept within a framework of policy and programmes promotes a positive and anticipatory, forward-looking perspective, rather than one which merely responds to drivers, pressures, states, trends and impacts. This approach

embraces the precautionary principle, preparedness and sustainable management of natural resources rather than merely protection and conservation (see Figure 21.2). This framework incorporates the DPSIR components with the addition of the core issue of opportunities and the options for reviewing current and future policy and actions through programmes and projects. The Impact component more explicitly identifies human, economic and ecosystem dimensions and through the opportunities linkage it considers opportunity costs; that is, the benefits to be gained by particular policies and actions and not merely the adverse costs of shocks and damage. The hallmark of this analytical framework is the posture of review of proactive policy and institutional development and action in the pursuit of opportunities for sustainable development. The DPSIR framework tends to exclude precautionary action to restrict and prevent environmental, human and economic loss.

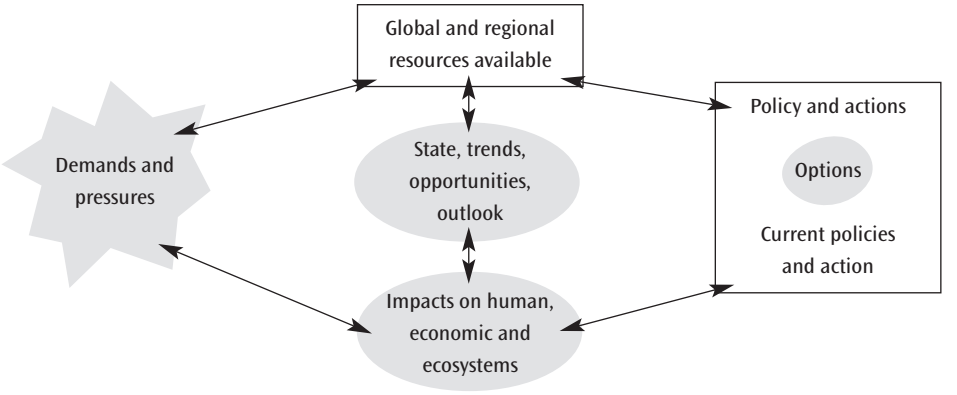
The sustainable livelihoods framework: This framework was developed for *AEO 2* in 2006, couples science-based environmental information, environmental policy-making and the interplay between economic, social and environmental dimensions of policy and action, in the pursuit of sustainable development. It takes livelihoods as an asset and examines how far these become vulnerable to external pressure (here denoted as shocks, meaning sudden large pressures, which can overwhelm the capacity for resilience). The assets are considered as capital stock and include human, natural, financial, social and physical capital (following a classification developed by Jeffrey Sachs[2]). Through the transforming structure component (public and private sector, laws, policies, culture, institutions, etc.), these elements of capital can be sustained, adapted and further developed to become more resilient to existing and future pressures. This is accomplished through livelihood strategies giving rise to new livelihood outcomes, with more income, greater well-being, increased resilience, improved security and more sustainable use of natural resources (see Figure 21.3).

GEO 4 Conceptual Framework: This framework was adopted for *Global Environment Outlook 4* (UNEP 2007). It incorporates the DPSIR framework components, but gives more emphasis to human well-being, ecosystem services and their interaction[3]. The stylised figures presented by UNEP indicate short-term and long-term time scales, the perspectives of global, regional and local inter-linkages. The sub-title of the review is 'Environment for Development', which shifts the focus from environment towards sustainable development.

The **Opportunities Framework** was devised to overcome some, but not all, of the deficiencies perceived in the basic DPSIR framework, but since it embraces the basic DPSIR model many of the assumptions and logical flaws remain, not least the idea that intervention is both effective and efficient in the use of human and natural resources.

This framework has an even more optimistic perspective than the basic DPSIR framework from which it emerged. It begins with future favourable options as the starting point for analysis, meeting the fundamental criticism of DPSIR that it only begins with the recognition of degradation of natural resources and asks what can we do about it. The opportunities are at the centre and all other components are depicted as operating through this box. This implies a liberal narrative of future progress and assumes an integrated rational process of systems' governance at global, regional, sub-regional and national levels.

Figure 21.2. The opportunities framework



Source: Adapted from UNEP (2007) GEO 4, and from AEO2 Progress Press, Malta for UNEP

This flies in the face of evidence that shows that both economies and ecosystems are more complex and operate especially at local and multi-national levels unrelated to international regions, sub-regions and nation states. The tragedy of the commons with respect to fisheries, air quality and land use for grazing, the extraction of natural resources and the disposal of waste, evidently, are major exceptions to the vision presented by this framework. It is especially ill-fitted to regions like Africa where the arbitrary boundaries of states and of the UNEP sub-regions have little rational linkage to the geography, topography and distribution and use of natural resources of the continent and its islands.

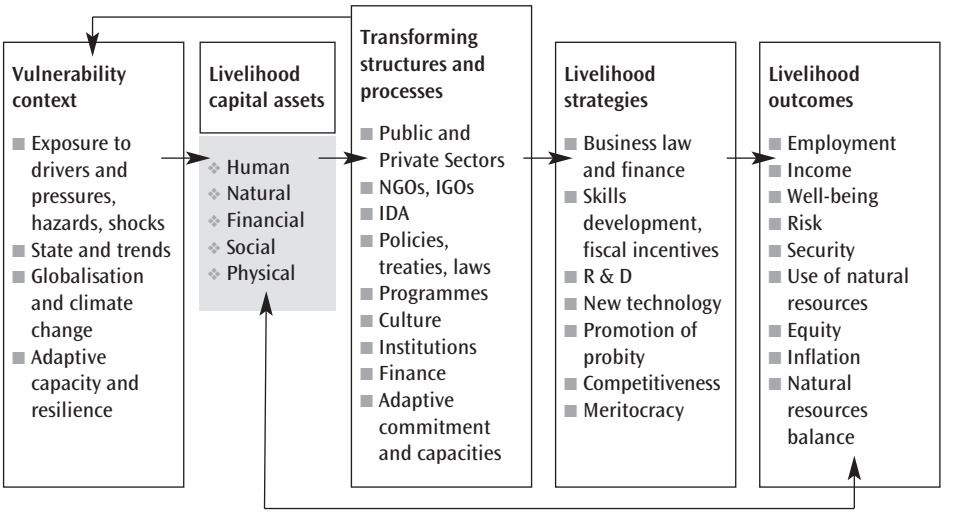
One strong feature of the framework is the recognition of exogenous factors affecting demands and pressures, states and trends, and policies and actions. This has been apparent in issues like global warming, climate change and sea level rise. This perspective supports a common need for developing relevant and effective responses to such common threats to promote better opportunities for sustainable development and the protection of vulnerable ecosystems and human welfare.

The **Sustainable Livelihoods** framework goes further in adapting the basic DPSIR framework to overcome its principal demerits. Nevertheless, the overall narrative for the framework is optimistic, instrumental and embedded in a simplistic set of causal relationships between the main components, with an underlying axiom that the intervention of mankind is worthwhile for sustaining the planet for the benefit of man[4].

The advances claimed for this adaptation of DPSIR are that it promotes a fresh awareness in analysis to the vulnerabilities of people, economies and ecosystems, the relevance of transforming structures (laws and institutions) and the effect these can have on promoting better livelihoods in the face of a changing social, economic and natural environment. It also elaborates on the nature of capital assets recognising the importance of distinguishing between physical and natural capital and the capital inherent in humans, finance and institutions.

The GEO 4 analytical framework in its various forms goes further in adapting the basic DIPSR framework to the task of analysing the issues for the pursuit of sustainable development. The framework has a time dimension and a clearer distinction between the

Figure 21.3. Sustainable livelihoods framework



Source: Adapted from DFID (1999) framework, Sustainable Livelihoods Guidance Sheet, London DFID

human and ecosystem areas. It contains more explanatory words within the component boxes, but does little to address the assumptions and logical flaws in the basic DPSIR model.

A central weakness in all these analytical models is the absence of an analysis of the nature of governance, the implications of market and policy failure and the valuation of natural capital as an integrated requirement for assessing progress in the creation and the protection of ecosystems and animal, including human, welfare. These issues are more consistently dealt with in the economic literature but are beginning to emerge in the processes now at the core of decision-making for sustainable development and in political science[5].

Tools for policy analysis

The UNEP frameworks for analysis were adopted for two purposes. First, to provide a method for reviewing the linkages between the environment, and development polices and programmes; second, to provide a set of consistent sub-headings for authors of the publications on the environmental outlook that UNEP was obliged to produce as part of its mandate. Through this process the frameworks have become common tools for policy analysis in the field of sustainable development.

There are certain key elements in undertaking policy analysis, only some of which are embraced in the UNEP frameworks approach. The missing elements are emerging as priority concerns in moving from theoretical review to policy commitment and programme development.

In addition to the knowledge elements in the DPSIR-based frameworks, policy analysts are increasingly engaged in:

- Identifying and consulting with stakeholders in the public and private sectors and with NGOs, for agenda setting, policy formulation and adoption, implementation and evaluation;
- Interactive processes for reviewing basic DPSIR type assessments, involving key players in discussions, conferences, briefings and public hearings;
- Preparation and dissemination of policy option documents, white papers, review of formal responses, public communications, public meetings, media briefings, website presentations and interactive discussions; and
- Commissioning research, expert reviews and special studies.

If DPSIR and its related frameworks offer a guide to problem and issue structuring, definition and review of evidence, further work is essential before policy analysis can effectively move forward into policy options, choices, prescription and implementation. An essential step in this process is in forecasting or modelling the likely outcomes of action and inaction and the evaluation of the expected outcomes and their technical, economic and political feasibility.

When the stage of making recommendation for the course of policy and action has been reached, it is helpful to assess the levels of risk, uncertainty and the constraints under which the future may emerge, including the externalities and the capacity building necessary for accomplishing the programmes. It is not uncommon for policies to be formulated, and for finance to be made available on estimates of expected costs, with little attention to the range of capacities that are needed for fulfilling the tasks, including skills, infrastructure, institutional development, education, public communication and consultation and effective management.

Humans and ecosystems are complex. Many problems exist because the existing systems are unsuited for accomplishing change or because changes that have been introduced have failed to resolve the issues and have perhaps made matters worse. The DPSIR framework has an optimistic linear narrative which compels users to assume that effects simplistically follow causes and responses, avert adverse impacts and promote a new equilibrium. Policy analysts need to be aware of these flaws in the models and ensure that at each stage in the development of responses and interventions, adequate and timely monitoring and evaluation is undertaken to provide feed-back on the real outcomes as distinct from political aspirations. In such circumstances, the existing institutional frameworks may be part of the problem rather than the solution.

The processes of analysis entailed in Environmental Impact Assessment (EIA) and Strategic Impact Assessment (SIA) are reviewed elsewhere[6]. These common tools are being supplemented in many countries with other tools that are helpful to analysts in the field of natural resources management and sustainable development. Some of these are reviewed below.

Triple Bottom Line Assessment

This tool differs from Environmental Impact Assessment in that it covers not just the impact of innovations on the environment but also their expected impact on two other areas of concern: social and economic outcomes.

Trade Sustainability Impact Assessment (Trade SIA)

In this approach, the analysis is concerned with trade and its impact on development. It emerged as a tool within the European Union to assist the process of reviewing the impact of trade negotiations on development. It is undertaken during trade negotiations to spot and explore potential economic, social and environmental implications of the trade regulations.

Integrated Environmental Assessment (IEA)

This is replacing the DPSIR based approaches to ensure that biophysical bias is balanced within analysis of the social and economic issues and that these are incorporated in examination of the current and expected outcomes of change, trends and intervention. Moreover, IEA is an inter-disciplinary exercise which includes participatory components that identify policy and programme options to promote multi-sector decision-making for sustainable development.

Integrated Scientific Environmental Assessment

The essential features of this approach to analysis is that it is based upon peer review of evidence-based assessments for guiding public decision-making on complex issues. It typically involves multiple stakeholders in inter-sector decision-making and engages experts from the key fields in a transparent and open public and professional process. The technical analytical concepts include review of eco-efficiency, waste minimisation, pollution prevention, green productivity, sustainable consumption and production. Initiatives adopting this approach are supported through the UN Commission on Sustainable Development and UN DESA.

Corporate Social Responsibility

There has been a long and distinguished history in the contribution of private sector companies to social development and the protection of the environment. Parallel to the development of current methodologies for analysis for sustainable development, this history has underpinned important fresh initiatives and movements in the private sector through a process of corporate social responsibility. These initiatives have been driven partly through professional management education but also through the re-engagement of private and corporate shareholders in the recognition of 'green' and 'ethical' concepts inherent in environmental governance addressing the global issues of market and policy failure[7]. In particular, this movement towards more ethical corporate governance draws attention to the need for greater engagement with the private sector, more environmental accountability and clearer recognition of the essential elements for corporate accountability in sustainable development policy and practices. This covers corporate reporting, directorial accountability for environmental issues, the publication of environmental reports in the accounting

process to shareholders and to Boards of companies, and the selective purchasing of 'green' shares in the 'ethicals' market.

Conclusion

The chapter reviews a number of methods which are commonly adopted in the analysis of policy options for better use of natural resources for promoting sustainable development. Each method has its strengths and weaknesses which are often left implicit in the system of analysis, with their own narrative overlain with ideological metaphors. It is important as a first step in applying any analytical method to explore its hidden agenda taking care to make transparent its concealed bias and the effect of this on the selection of evidence, the choice of indicators and the ensuing pattern of results.

Further reading

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Madhoo, Y.N. Chapter 3 in Nath, S., J.L. Roberts, and Y.N. Madhoo, (eds.) *Saving Small Island Developing States*.

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UNEP (2007). *Global Environment Outlook 4*, pp. xx–xxiii and Figures 1 and 8.2, (p. 368), Progress Press Ltd, Malta for UNEP.

www.greenfacts.org/ecosystems Summary of the UN millennium Ecosystem Assessment.

Notes

1 Nightingale, D.L.M. et al. (2004). AEO, case studies, human vulnerability to environmental change. Earthprint for UNEP. See especially Fuggle, R.F. Case study 3, Lake Victoria, a case study of complex interrelationships, and Roberts, J.L. Case study 12, Malaria Control in Mauritius.

2 Sachs, J.D. (2005). p. 256.

3 See UNEP (2007). *Global Environment Outlook 4*, pages xx–xxiii and Figures 1 and 8.2, (p. 368).

4 Cf Lovelock, J. (2006). *The Revenge of Gaia*, Penguin Books; 'The concept of Gaia ... counters the persistent belief that the Earth is a property, an estate, there to be exploited for the benefit

of humankind ... (p. 173) 'Evolution is iterative, mistakes are made, blunders committed ... Perhaps our ... greatest error was the conscious abuse of fire ... It has haunted us ... and combustion could now be our auto da fe, and the cause of our extinction'. (p. 186)

5 The theme for AEO 3 has been proposed as management of the environment for development.

6 See Madhoo, Y.N. Chapter 3 in Nath, S., J.L. Roberts, and Y.N. Madhoo, (eds.) *Saving Small Island Developing States*.

7 See Brown, M.M. et al. (2003).

John L Roberts

Chapter 22

Managing the sustainable development of small island states

Introduction

Garrett Hardin, in his seminal examination of the un-sustainability of openly-accessible natural resources in the face of population growth, noted that the dilemma of market failure could not be resolved by technical means. Since Hardin's analysis in the 1960s, global annual population growth rates have declined to below 1 per cent in industrialised countries and in Eastern Europe to just above replacement level. The role of population growth as the principal factor in denying future generations the benefits of current levels of natural resources is diminishing. But, in small and island states, the tragedy of the commons[1] is exacerbated by their inherent economic and environmental vulnerability. A loss in the value of environmental quality can quickly have a negative effect on economic development, quality of life and social welfare of local communities.

Opportunities for solutions to Hardin's dilemma can be sought in improved governance. However the application of managerial theory to environmental governance is in its infancy. Much effort has been given to the identification of outputs and outcomes (such as through the development of performance indicators, the monitoring of climate change and the development of specific economic and regulatory instruments); but less attention has been given to the institutional framework for management, the public-private interface, the study of management behaviour and the economics of production functions in the delivery of environmental goods and services.

This chapter explores what action is being taken in small states and islands to improve the management of the Commons in the pursuit of sustainable development. Using fresh data, indices and information this chapter reviews the linkage between economic and social development and environmental governance. It emphasises the importance of establishing evidence-based guidelines for efficient investment for securing social well-being in SIDS and other small states. It is the small states, especially SIDS, that have most to lose if their environmental quality should decline in their quest to overcome their economic vulnerability. This chapter identifies areas for further study.

Economic resilience

Briguglio et al. (1995) have shown that capacity for economic resilience varies for differing levels of economic vulnerability. From available data, it is evident that many SIDS and other small states have built levels of economic resilience in the face of high economic vulnerability (the '**self-made**' states).

The '**self-made**' states[2] have levels of economic resilience as high as that achieved by other developed countries with lower economic vulnerability (the '**best-case**' states). Singapore has been shown to have both high economic vulnerability and high economic resilience and it has been argued by Briguglio et al. (2006), that, in these economic terms, it is a model case, although its marginal capacity for resilience is low by comparison with countries with lower economic vulnerability.

From a perspective of economic policy for SIDS, we may ask what options are available to those SIDS with high inherent economic vulnerability and low nurtured economic resilience (Briguglio's '**worst-case**' states) to increase their economic resilience and to cross the threshold into '**self-made**' status? The rationale of the Briguglio index implies that the road to success is by improvement in the component elements in the index itself, such as nurturing greater macro-economic stability, market efficiency, good governance and social development.

So from a sustainability perspective, and in line with the Mauritius Strategy (UN, 2005), we should also ask what is the environmental price of achieving such transition and what can be done to mitigate this price whilst sustaining economic growth. SIDS are also vulnerable to environmental shocks, from their inherent exposure to extreme weather conditions, natural disasters and from the increasing risks of exogenous factors promoting climate change (UNEP, 2007 pp. 333–336, IPCC (2007) AR4). However, their capacity for adaptation is more constrained than that of larger, less isolated and fragmented countries, due to lack of specialisation in technical skills, and elevated population density and growth rates that put environmental pressure on limited coastal areas with their fragile ecologies. In many islands these combined pressures have induced substantial migration, as in the Pacific islands of Tonga, Tuvalu, Kiribati and Fiji and produce major adverse affects on basic infrastructure, industrial facilities, services and housing.

Roberts (2006) argues that sustainable use of natural resources in SIDS requires appropriate information which in many places is fragmentary and insufficient for strategic decision-making. Further, he has noted that the use of MDGs may adversely bias investment as they omit reference to key aspects of natural resources and environmental vulnerability especially in SIDS. This information is vitally relevant to island states whose development is closely linked to the quality and sustainability of natural capital such as coastal and marine resources, biodiversity, land resources and the effective management of the risks of natural disasters. Moreover, it was argued that, for each small island state, the development stage that it has reached affects the pressures on its natural capital, and its priorities for building resilience.

Roberts (2006) further argued that the capacity to overcome adverse economic and environmental pressures needs to be built across a range of elements of governance, including environmental systems, environmental stress, human vulnerability, social and institutional capacity and global stewardship. Technical fixes in specific areas such as energy production, waste management and marine conservation are not enough. Only by a long-term and multi-sector process can SIDS expect to achieve sustainable development, to provide nurtured resilience against inherent and acquired vulnerability from exogenous and endogenous sources. This does not imply that central planning holds the key to solving

Hardin's dilemma. The forms of governance may be varied but it is the evolution of a wider range and a sharper focus that is likely to be critical. At the core of the issue is clarifying the concepts of development, well-being and the nature of progress.

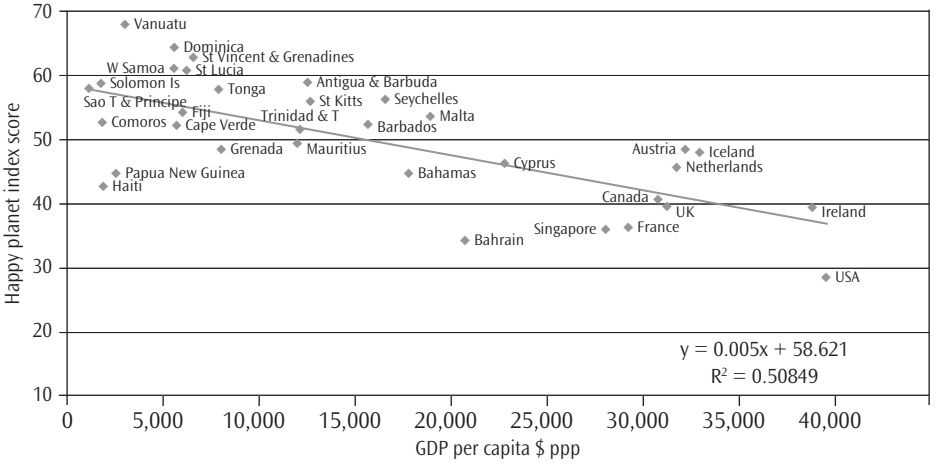
Examples of resilience building have been categorised against classes of factors associated with vulnerability, including isolation, small resources base, risk of climate change and sea level rise, land degradation, water, pressure from visitors and tourists, security and health risks, and restricted mobility (see Roberts, 2006).

Well-being and development

Marks et al. (2006) have used the Happy Planet Index (HPI), which is based on the ratio of social well-being over ecological impact[3], to show that many SIDS seem more efficient at deriving social well-being from the use of environmental resources, than more developed, richer and larger countries. Indeed there emerges from the New Economic Foundation (NEF) data a negative correlation between HPI and Gross Domestic Product (GDP) per capita (see Figure 22.1).

It can be seen that SIDS in various regions, such as Vanuatu (in the Pacific), St. Lucia (in the Caribbean), Sao Tome and Principe (in the Atlantic) and the Seychelles (in the Indian Ocean) – which together contribute less than 2 per cent of the projected population growth in SIDS – appear more efficient at deriving social well-being from the use of their natural resources, given the level of their GDP per capita, than other island states such as Bahrain and Singapore, together with larger developed countries such as USA and France. Singapore has a heavy per capita ecological footprint and its population is expected to rise by over 600,000 by 2015, the fourth highest growth in population in all SIDS, after Haiti, the Dominican Republic and Papua New Guinea[4].

Figure 22.1. GDP per capita and Happy Planet Index – SIDS and other countries



Sources: UNDP (2006) and Marks, N. et al. (2006)

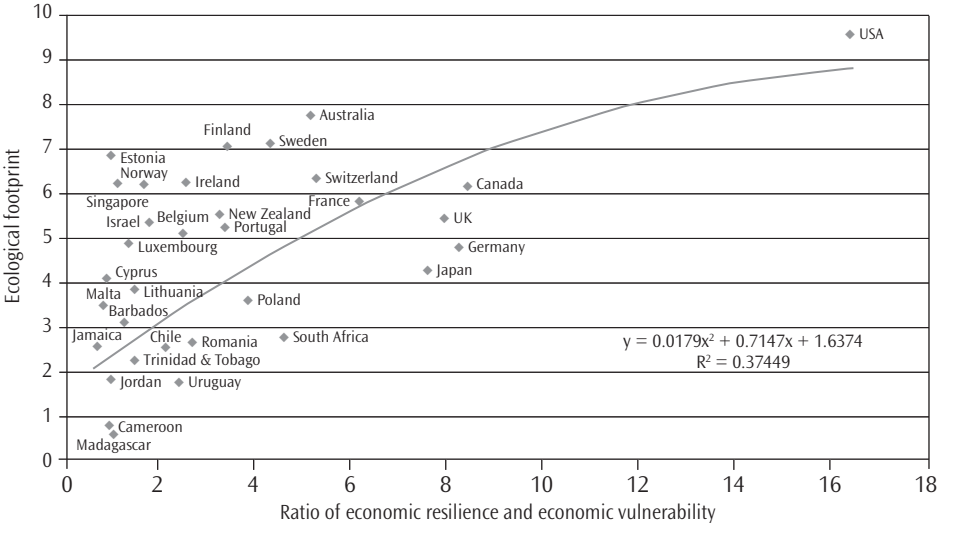
This analysis raises important questions for defining progress. For example, is the Singapore development model to be followed? We may also ask what can countries like Singapore do to reduce the impact its economic development is having on its environmental sustainability? Briguglio et al. (2006) have shown that the economic resilience of countries is strongly and positively associated with GDP per capita. But is the economic development and the nurtured economic resilience they have achieved worth the adverse impact on their natural environment? Sustainable development requires that economic resilience building must also incorporate responses to the risks of environmental damage from the externalities of economic and social development.

Assessing the environmental price of economic resilience

Using the HPI disaggregated data combined with Briguglio et al. (2006) data, it is evident that overcoming economic vulnerability with nurtured economic resilience can carry a heavy price (see Figure 22.2). Some economically '**self-made**' SIDS, such as Singapore, Cyprus and Malta have an ecological footprint as heavy as that of Japan, Germany, Canada and France, though below the levels of USA, Australia and Sweden. Other self-made SIDS such as Barbados, Trinidad and Tobago, and Mauritius, carry a rather lower ecological footprint.

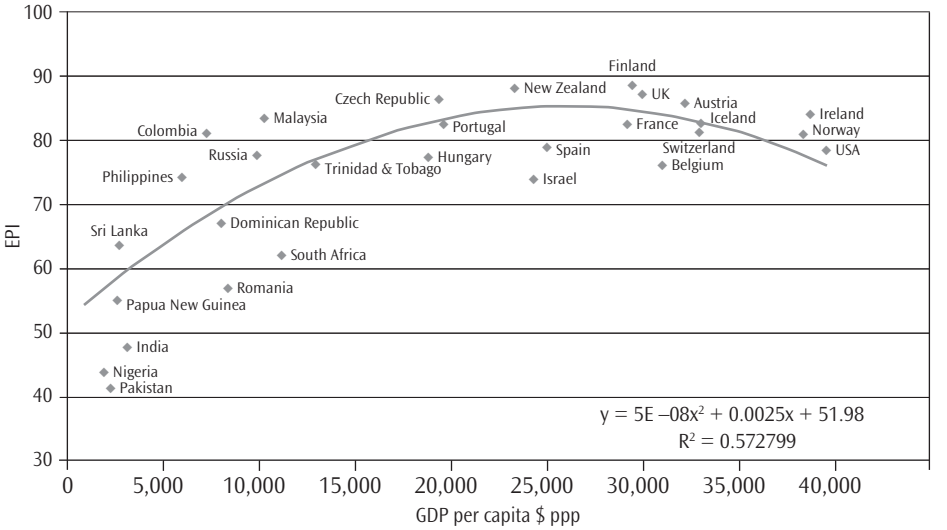
The Yale Environmental Performance Index[5] is one tool being developed for assessing progress made by countries in meeting a range of environmental governance targets (Esty et al., 2006). Using data from a 2006 pilot study, it appears that EPI increases with GDP per capita

Figure 22.2. Ratio of economic resilience to economic vulnerability and ecological footprint



Sources: data from Briguglio et al. 2006 and Marks, N. et al. (2006)

Figure 22.3. GDP per capita and environmental performance index



Sources: data from UNDP (2006) and Esty, D.C. et al. (2008)

to a point, but then, with each increase of GDP per capita, the score on the HPI declines (see Figure 22.3). This suggests that there may be an environmental cost at higher levels of economic development[6]. The interpretation of these data should, however, take into account a number of factors, such as the absence of many small and island states from the study; the use of performance targets separately assigned to each country; and the limitations inherent in cross-sectional analysis rather than longitudinal analysis of data for each country.

The challenge of de-linking growth and environmental degradation has been documented through broad theoretical analysis of the potential for establishing a Kuznetz curve of declining environmental degradation with increasing GDP per capita after a certain point of growth (Steer et al., 1992) and more recently with detailed inter-country, secular comparisons focusing on pollution outcomes (Dasgupta, P.S. et al., 1999).

Costs of environmental protection

Countries with high economic resilience tend to have higher income per capita and an economic structure that emphasises industrial production and service industries, with high use of energy. In such countries we can expect the marginal utility of income to be falling and the marginal disutility of pollution to be rising as people with higher incomes increasingly seek environmental quality in their lives. At the same time, the marginal costs of abatement are likely also to be rising. In SIDS and other small states, their size determines that the costs of abatement are spread over a small volume of production and the benefits enjoyed by a small population, severely limit the cost-effectiveness of abatement. It should also be recognised that in SIDS and other small states, technical, and institutional capacity for developing effective abatement is low, and environmental NGOs are few and weak. Furthermore, local commercial and political pressures to maximise short-term gains tend

to ensure a high discount rate for securing long-term benefits for environmental protection for future generations (Dasgupta et al., 1999).

Juxtaposing costs against benefits

Many small and island states are low income countries with large sections of the population at a modest level of human development. Such social groups may have a low aversion to pollution and comparatively low levels of education and exposure to information and media pressure for protecting environmental quality. However, investment in tourist services in SIDS produces a sharper focus on the environmental and commercial costs of pollution which can act as a countervailing pressure for regulation and voluntary controls and standards, in contrast to the demands and priorities of the local resident population. The costs of environmental protection of the tourist industry in SIDS are increasingly being assessed by international operators against the benefits relating to quality of life and long-run economic development, especially in those remote SIDS where the transport costs encourage high-priced tourism. SIDS are also developing regional capacities for providing environmental protection as part of their sustainable development strategies, through which the fixed costs of R & D and abatement technology and their benefits can be spread over a larger market.

The misery of overpopulation

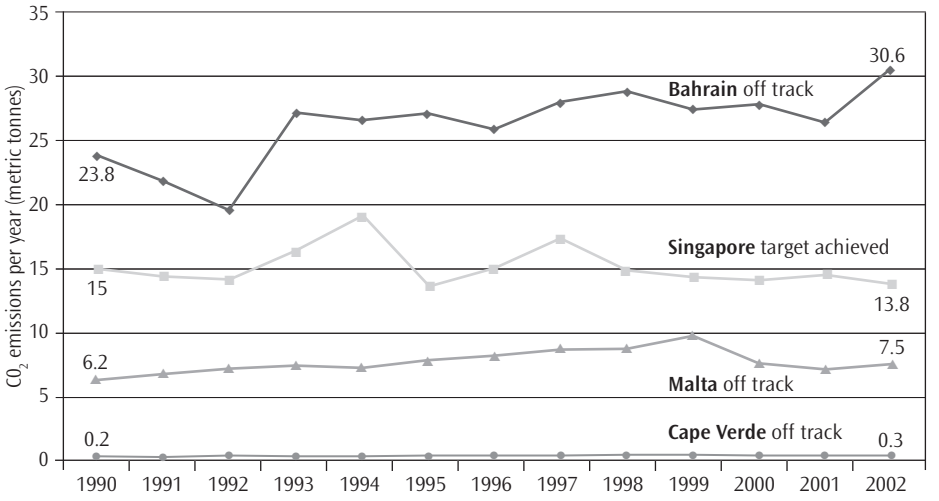
Analysing the impact of development in terms of the ecological footprint per capita conceals the core of Hardin's dilemma in the *Tragedy of the Commons*, namely the 'misery of overpopulation'. In the 1960s, like Meade[7], Hardin was justifiably concerned at the alarming prospects of a global population explosion. Population growth has markedly slackened since then[8] and in SIDS over 80 per cent of the projected increase in population of 7.9 million from 2003–2015 is concentrated in just seven of the 46 states for which UN population data are available[9]. The demographic issue is also shifting in just one generation from over-fertility to longevity. This demographic transition is accompanied by a re-examination of the economic production function, in which security, quality of life, positive health, disease free longevity, life satisfaction and the use and non-use values of the natural environment are counterpoised in the social scales against forever increasing the volume of income from production of goods and services[10].

Loss of natural resources

The loss of environmental quality in small and island states is being monitored internationally but the results are ambiguous. Take for example the UN target to improve air quality. The UN reported data from 1990 to 2002 for four of the AIMS region SIDS, Bahrain, Singapore, Malta and Cape Verde, with the implied assessment of progress with meeting the UN MDG target (Figure 22.4).

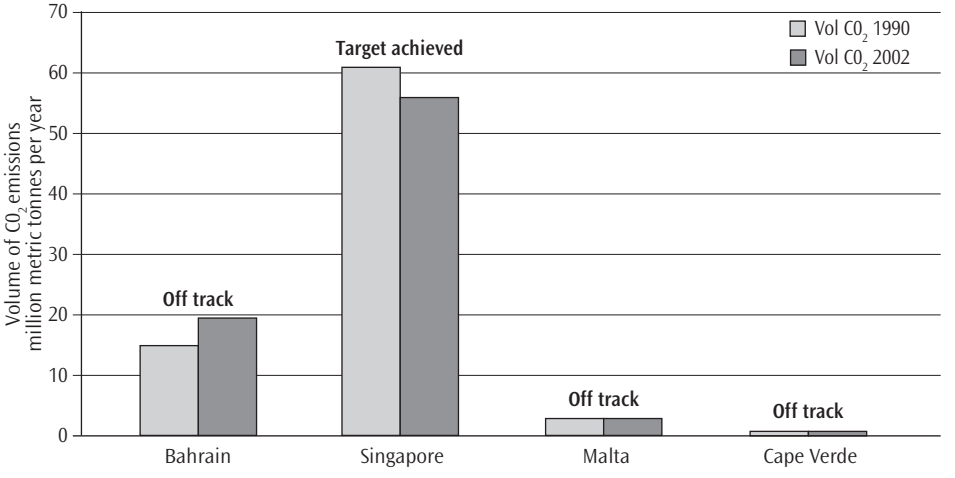
Three of the countries may be judged off-track, as their 2002 levels of CO_2 emissions per capita are higher than the 1990 baseline. But, if we take total emissions per country per year, (which is not an indictor in the MDG system), then the picture changes (Figure 22.5).

Figure 22.4. Progress with MDGs in AIMS region; selected country's CO_2 emissions per head per year: Goal 7 target 9 indicator 28



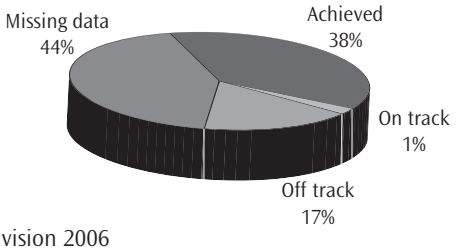
Source: UN Statistics Division 2006

Figure 22.5. Progress with MDGs in selected AIMS countries; total volume of CO_2 emissions 1990 and 2002



Source: UN Statistics Division 2006

Figure 22.6. AIMS Country's 1990–2004 progress with environmental MDG 7



Source: UN Statistics Division 2006

Despite the downward trend, it can be seen that Singapore's levels of CO_2 emissions are nearly three times greater than those of Bahrain and totally overshadow the modest levels recorded for Malta and Cape Verde.

Whilst use of the UN MDG data sets can be illuminating, they are beset with issues of interpretation and relevance for planning. One other major problem for the assessment of progress is missing data. It is evident that taking the MDGs as a whole there are major gaps in the evidence available for judging progress with environmental governance. Missing data have been identified in 29 per cent of MDG indicators for small states[11] in up to 74 per cent of indictors examined by UNEP[12] and in 48 per cent of indicators examined in a study on the AIMS region for the IOC in 2007[13].

Environmental governance practice in SIDS

Action being taken in SIDS to address the issues of environmental governance and management of the commons is diverse and encouraging. Tables 22.1 and 22.2 present summaries identifying examples of critical activities being undertaken in the SIDS AIMS region for better environmental governance to promote greater environmental resilience and economic and social development. The information is derived from country strategic documents and international aid programmes. The activities are classified both in terms of the dimensions of environmental governance adopted by the Yale study on environmental resilience and by the principal aspects of vulnerability affecting SIDS, identified by Roberts (2006). The range and focus of activities offers hope for a better management of the commons. But the information available has substantial gaps especially in providing a firm basis of evidence for assessment of the investment required for scaling up the endeavours for the benefit of all SIDS in the light of results achieved.

Table 22.1. Examples of environmental performance

Dimensions of environmental performance				
Environmental systems	**Environmental stress**	**Human vulnerability**	**Social and institutional capacity**	**Global stewardship**
Sensitive ecosystems: Bahrain: coastal and marine development (IOC, 2004: 113–116).	**Soil degradation: Cape Verde:** Natural resource management to combat desertification and promote new livelihoods (UNDP, 2005: 42).	**Health: Comoros:** Public health programmes to reduce the impact of infectious disease epidemics including malaria and water-borne diseases with projects to improve water collection, treatment and distribution systems (Union of the Comoros, 2005).	**Environmental governance: Bahrain:** Nationally led environmental strategy, with 9 sectoral working groups (MDGR, 2003).	**Greenhouse gases: Mauritius:** Removal of barriers to energy efficiency (UNDP, 2005: 84–85).
Biodiversity: Cape Verde: Fruit bat conservation **Water: Cape Verde:** Agricultural irrigation to implement projects to increase irrigated land areas by at least 40% (FAO, 2005).	**Waste management: Comoros:** Programme to improve the quality of life and hygiene in urban areas (covering pollution, household refuse, insalubrity and neighbourhood disputes systems (Union of the Comoros, 2005).	**Health and economic security: Guinea Bissau:** Mine clearance in Quinta Nanque forest (UNDP, 2005: 68–69)	**Environmental governance: Cape Verde:** Integration of environmental policy with PRSP 2002 (Cape Verde, 2004), and within Medium Term Sectoral Expenditure Framework, including education, water, soil and biodiversity.	**Environmental impacts of trade: Singapore:** Fisheries management to control poaching and sustain endangered species and stock depletion of yellow fin and bigeye tuna, sea cucumber, turtle, shark, lobster.

Environmental systems	Environmental stress	Human vulnerability	Social and institutional capacity	Global stewardship
Biodiversity: Comoros: Marine biodiversity management for poverty relief in 10 village communities (UNDP, 2005: 48–49).	**Pollution, soil degradation: Cyprus:** Protection of the atmosphere, combating deforestation, desertification (UN, 2002).	**Natural disasters: Maldives:** Adaptation to the impact of the 2004/5 Tsunami (UNEP, 2005).	**Environmental governance: Cyprus:** Promotion of agro and eco-tourism projects (UNDP, 2005).	**Environmental impacts of trade: South West Indian Ocean:** Fisheries management in Indian Ocean countries, with tuna tagging and marine area monitoring system (IOC EDF projects see www.coi-ioc.org)
Water: Guinea Bissau: 145 boreholes and water pumping system.	**Waste: Malta:** Priority areas for action include waste management to meet EU waste related objectives and targets.	**Health: Sao Tome & Principe:** Anti-malaria programme, HIV/AIDS programme (IDA et al, 2005).[17]	**Environmental governance: Malta:** Policy development through a Sustainable Development Authority, Parliamentary mechanisms, environmental court, and NSDS (Malta, NCSD, 2006; Aquilina, 2004).	**Greenhouse gases: Sao Tome & Principe:** National communication to the UNFCC, GHG inventory and risk assessment (UNDP, 96–97).
Biodiversity: Maldives: Atoll ecosystem conservation project at Baa Atoll (UNDP, 186–187). With protected areas, and alternative livelihoods.	**Water and waste management services: Sao Tome & Principe** Programmes to improve water supply and sanitation and proper disposal of solid waste (IDA et al., 2005).	**Health: Mauritius:** Eradication of malaria (Roberts, 2004).	**Environmental governance: Mauritius:** Building up sustainable land management capacity (UNDP, 2005 p. 84).	**Greenhouse gases: Guinea Bissau:** Reduction of ozone depleting substances and GHGs; retrofitting refrigerators; recycling old machines; and training of technicians (UNDP, 2005, 68–69).

Environmental systems	Environmental stress	Human vulnerability	Social and institutional capacity	Global stewardship
Water, air, biodiversity and sensitive ecosystems: Malta: priority areas for action include: air quality, nature and biodiversity, groundwater, seawater, land use (Malta NCSD, 2006).	**Waste management: Singapore:** reducing, reusing and recycling waste.	**Health: Cyprus:** Co-operation between Greek and Turkish Cypriot chambers of engineers; programme on improving milk quality, with Madison Dairy Advisory Group; island-wide eradication of brucellosis (UNDP, 2005: 228–229).	**Eco-efficiency: Seychelles:** Renewable energy for remote islands.	**International collaboration: Montreal Protocol: Maldives:** Awareness and incentive programme in refrigeration management plan (UNDP, 2005).
Water: Mauritius: Expanding water supply system: only 57% of population have a 24 hour service and water stress conditions apply (IOC, 2004: 52).		**Safe drinking water: Guinea Bissau:** new hydraulic water pumping systems at village level; 145 boreholes; improving health and liberating time for alternative employment. www.gw.undp.org/environment	**Eco-efficiency: Mauritius:** Sugar bio-energy technology, using sugar cane (bagasse and ethanolproducts) as substitutes for oil-based energy production and transport fuel www.un.intnet.mu/undp/html/Mauritius/energy_env.htm.	**International co-operation on Green House Gases: Refrigeration: Bahrain:** Programme for replacement and retrofitting of equipment and units, testing, trials and training (UNDP, 2005: 122–123).
Biodiversity and sensitive ecosystems: Sao Tome & Principe: Obo nature reserve project, to combat deforestation, to protect endangered species and promote livelihoods (UNDP, 2005: 96–97).	**Cultivation and water systems: Seychelles:** Programme to extend agricultural areas and equip them with roads and water systems (Seychelles Ministry of Agriculture and Marine Resources, 2006).	**Marine biodiversity project Moheli: Comoros:** saving the endangered 'sea-cow' dugong; community based approach to marine resources management and eco-tourism. www.km.undp.org/biodiversite		

Table 22.2. Some examples of interventions in AIMS to overcome environmental vulnerabilities

Factors associated with environmental vulnerability	Interventions undertaken in AIMS countries
Climate change and sea level rise	**Sao Tome & Principe:** National communication to the UNFCC, GHG inventory and risk assessment (UNDP, 2005: 96–97). **Guinea Bissau:** Reduction of ozone-depleting substances and GHGs; retrofitting refrigerators and recycling old machines with training of technicians (UNDP, 2005: 68–69). **Maldives:** Awareness and incentive programme in refrigeration management plan (UNDP, 2005). **Bahrain:** Programme for replacement and retrofitting of equipment and units, testing, trials and training (UNDP, 2005:122–123).
Coastal and marine	**Bahrain:** coastal and marine development (IOC, 2004: 113–116). **Comoros:** Marine biodiversity management for poverty relief in 10 village communities (UNDP, 2005: 48–49). **Singapore:** Fisheries management to control poaching and sustain endangered species and stock depletion of yellow fin and bigeye tuna, sea cucumber, turtle, shark, lobster (Republic of the Seychelles, 2004). **South West Indian Ocean (including Seychelles, Mauritius, Comoros, La Réunion):** Fisheries management in Indian ocean countries, with tuna tagging and marine area monitoring system (IOC, EDF projects, see www.coi-ioc.org).
Desertification	**Cape Verde:** Natural resource management to combat desertification and promote new livelihoods (UNDP, 2005: 42).
Destruction of coral reefs	**Seychelles** working with the International Coral Reef Initiative, http://www.coralreef.gov/international/mainb.html
Land degradation	**Cape Verde:** Agricultural irrigation to implement projects to increase irrigated land areas by at least 40% (FAO, 2005). **Maldives:** Atoll ecosystem conservation project at Baa Atoll (UNDP, 2005: 186–187). With protected areas, and alternative livelihoods. **Sao Tome & Principe:** Obo nature reserve project, to combat deforestation, to protect endangered species and promote livelihoods (UNDP, 2005: 96–97).
Loss of biodiversity	**Cape Verde:** Fruit bat conservation **Malta:** priority areas for action include: air quality, nature and biodiversity, groundwater, seawater, land use (Malta NCSD, 2006).
Natural disasters	**Maldives:** Adaptation to the impact of the 2004/5 Tsunami (UNEP, 2005).

	Mauritius: Early warning systems against cyclones in the Western Indian Ocean (Roberts, 2004).
Pollution	**Cyprus:** Protection of the atmosphere, combating deforestation, desertification (UN, 2002).
Pressure from visitors and tourists	**Cyprus:** Promotion of agro and eco-tourism projects (UNDP, 2005).
Security and health risks	**Comoros:** Public health programmes to reduce impact of infectious disease epidemics including malaria and water-borne diseases with projects to improve water collection, treatment and distribution systems (Union of the Comoros, 2005). **Guinea Bissau:** Mine clearance in Quinta Nanque forest (UNDP, 2005: 68–69). **Sao Tome & Principe** anti-malaria programme, HIV/AIDS programme. **Mauritius:** Eradication of malaria (Roberts, 2004).
Waste management	**Comoros:** Programme to improve the quality of life and hygiene in urban areas (covering pollution, household refuse and neighbourhood disputes (Union of Comoros, 2005). **Malta:** priority areas for action include waste management to meet EU waste-related objectives and targets. **Sao Tome & Principe** Programmes to improve water supply and sanitation and proper disposal of solid waste (IDA et al., 2005). **Singapore:** reducing, reusing and recycling waste (Case Study 1, see Annex 1).
Water stress	**Guinea Bissau:** 145 boreholes and water pumping system. **Mauritius:** Expanding water supply system: only 57% of population have a 24-hour service and water stress conditions apply (IOC, 2004: 52). **Seychelles:** Programme to extend agricultural areas and equip them with roads and water systems (Seychelles Ministry of Agriculture and Marine Resources, 2006). **Cape Verde:** Integration of environmental policy with PRSP 2002 (Cape Verde, 2004) and within Medium Term Sectoral Expenditure Framework, including education, water, soil and biodiversity.
Weak energy use and supply management	**Seychelles:** Renewable energy for remote islands. **Mauritius:** Sugar bio-energy technology, using sugar cane (bagasse and ethanol products) as substitutes for oil-based energy production and transport fuel (www.un.intnet.mu/undp/html/mauritius/energy_env.htm) **Mauritius:** Removal of barriers to energy efficiency (UNDP, 2005: 84–85).
Lack of environmental governance systems	**Malta:** Policy development through a Sustainable Development Authority, Parliamentary mechanisms, environmental court, and NSDS. (Malta NCSD, 2006; Aquilina, 2004) **Mauritius:** Building up sustainable land management capacity (UNDP, 2005).

Conclusion

SIDS suffer from inherent economic and environmental vulnerability as well as from acquired environmental vulnerability associated with the externalities of economic and social development from endogenous and exogenous sources. Those SIDS at an early stage of economic development enjoy higher benefits of social well-being and impose on their natural resources a lower ecological footprint than many more developed SIDS and larger continental states. The misery of population growth is diminishing since Hardin's exploration of the tragedy of the commons and it is concentrated in a minority of states, thus reducing the overall increased pressure on natural resources in SIDS.

Whilst the evidence base for cost-effective intervention is thin, many SIDS that are increasingly dependent on their growing tourist trade are seeking to implement long-term, integrated economic and environmental sustainability programmes, nurture their natural resources and curb the adverse impact of economic development through a variety of technical and behavioural measures. Declining population growth and improved environmental governance may yet provide the fix to Hardin's dilemma as perceived a generation ago. Institutional development for better management of the commons has to be the subject of critical review to provide an effective balance between international, regional and national governance taking into account the specificities of small states and islands. Models from developed countries are not likely to be the best fit (Chang, 2006).

The progress of small and island states will also depend on their influence on international accords to reduce the adverse global environmental impact of population growth and the degradation of natural resources in other larger states, especially those contributing most to climate change and sea level rise, two key risk factors to the economic and environmental resilience for SIDS.

A critical element in tackling Hardin's dilemma is the establishment of an evidence base on the best practices for SIDS in achieving these objectives. Greater south-south co-operation in information exchange between SIDS is also desirable for better governance and more cost-effective technical and behavioural adaptation.

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Notes

1 See Glossary.
2 The 'self-made' states have high vulnerability and high resilience.
3 The elements in the Happy Planet Index (HPI) by country are: (mean life satisfaction score x expectation of life)/ecological footprint. The function is thus per capita lifetime well-being per unit use of natural resources. Progress is achieved by enhancing the value of this function. The ecological footprint is a measure of the per capita use of natural resources; it is a measure of how much land is required to sustain a given population at its present levels of consumption, technical development and resource use efficiency. It derives from a concept developed by William Reese and Mathis Wackernagel at the University of British Columbia. The principal elements are land use to grow food, trees and bio-fuels, areas for ocean fishing and land required to support plant life needed to cope with waste such as carbon emissions from fossil fuels, see www.ecologicalfootprint.org and www.redefiningprogress.org
4 UNICEF database 2007.
5 The Index embraces 16 indicators for 133 countries. They are outcome or environmental state indicators, covering environmental health, air quality, water resources, biodiversity, productive natural resources and sustainable energy. They are grouped into two broad objectives of overall performance: environmental health and ecosystem vitality. The index includes measurable outcomes linked to policy targets but does not include institutional forms, legislative provision, treaty commitments, enforcement facilities or management arrangements.
6 The factors included in the measurement of GDP infer zero rating of all those natural resources and environmental services which do not appear as priced products or services exchanged in the economy.

7 See Meade, J.E. (1961) 'Mauritius – A case study in Malthusian economics', *Economic Journal* Vol. b71 (September) 521–34.
8 UN statistics show that the global annual population growth rates have declined from 2.7 per cent in 1970–1990 to 2.2 per cent in 1990–2003; in the industrial countries, the decline across these two periods has been from 1.1 per cent–0.9 per cent and in the CEE/CIS countries the decline has been from 2.0 per cent –0.2 per cent. In the LDC countries the decline has been from 4.9 per cent –4.4 per cent. See UNICEF (2006).
9 UNICEF (2006).
10 See Schumaker, E.F. (1973) *Small is beautiful, economics as if people mattered*, New York: Harper. Also see www.smallisbeauitful.org
11 Downes A.S. (2005) Progress towards achieving the Millennium Development Goals in the Small States of the Commonwealth, in: Coomaraswarmy I. et al. (2005) *Small States economic review and basic statistics*, pp. 27–39, Commonwealth Secretariat, ISBN 10: 0-85092-831-1.
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Chapter 23

Epilogue: Conclusion and discussion of emerging issues and policy agenda

'Man aspires to the stars. But if he can only get his sewage and refuse distributed and utilized in an orderly fashion, he will be doing well.' Roy Bridger

Post script

This collection of chapters is not intended as the last word in the debate on policy for saving small and island states, but rather as an introduction to the principal issues that are inherent in it and a guide through the expanding literature at the inter-face between theory and practice.

Despite the range of this book and its exposition of the state of the art, it is only too apparent that in trying to save small and island states both the development of theory and the evidence base for intervention is fragmentary and insufficient for comprehensive, effective action. Many of the issues have been clearly identified in international policy reviews and lists of appropriate actions specified. But the process of effective action for sustainable development remains in its infancy. In particular, further studies are needed to explore the interface between policy and implementation and the cost and benefit functions of sustainable development for saving some of the most vulnerable economies and ecologies on the planet.

The implications of population growth in many small and island states needs greater attention in policy development having regard to its impact on the use of natural resources and the changing patterns of consumption which will leave a heavier footprint on their small and fragile environments. Strangely enough, population is excluded from the MDG system of indicators, along with much else that is crucial to the future of SIDS and other small states.

The current global financial and economic crisis will take a further toll by deflecting attention away from the challenges of better environmental governance as the ecologies of these states move ever closer to the limits of their carrying capacity. Environmental tax reform (ETR) is being introduced tentatively and the text calls for tourism, an area which the smart money has attracted, to be carefully assessed in terms of its externalities and devices such as tourism taxation explored. To address the problem of global pollution and global development finance, proposals such as a global carbon tax would need urgent attention. It is nevertheless important to note that such global tax measures require glob-

al co-operation and international political economy factors come to the front seat in any discussions or negotiations on the matter.

It has been the fate of small and island states to be neglected in global forums. But the narrative in this book suggests that it may be from these very states that the best evidence can come of the evolution of survival and alleviating strategies in the face of economic and environmental threats. Darwin did not uncover the roots of the survival of species in his native land. So the benefits of small size and the rapid responsiveness of the ecology and the economies of small island states to incremental global change may well bring these minor league states onto the front of the world stage and help in establishing firmer foundations for the theory and practice of sustainable development. Market and policy failures, however, may be their fate. Like the dodo, some small states may rapidly decline and, with land degradation, sea level rise due to global warming, and climate change, many may become overwhelmed by the externalities of the dominant social paradigm.

The skills for environmental and natural resource analysis are in short supply. More regional and international support is needed to supplement what can be promoted by these small states themselves. The Commonwealth Secretariat and the World Bank are doing much to support the process, but progress with the UN 2005 Mauritius Strategy for SIDS has been tentative at best with much rhetoric but less evidence of systematic programmes and adaptation to a new environmental paradigm.

Two processes are essential for further progress. First, small states must consolidate their commitment not merely through the signing of treaties but with the implementation of programmes for sustainable development with a strong, lively community sector stimulus. Second, they must then carefully evaluate the results by building up the evidence base of what works and at what cost. But in many places this can only be effective with a revived positive role of international and regional bodies in promoting constructive critical review of what achieves the best results in saving small and island states and what are the critical conditionalities. High on the agenda must be: a strengthened policy forum to follow through the strategic accords; a more extensive and accredited evidence base adapted to the varying needs of the countries; development assistance for promoting better practice in policy and action; frank transparent reporting of progress; and a fresh agenda for producing and using relevant indicators of thematic performance and overall progress.

This volume illustrates the gathering capacities of expertise and advice for south-south support. Yet the momentum must be raised and the commitment transformed into rapid and sustained action. Without this, more of these beautiful small and island states will be trapped and engulfed by the pressures of western traditional development, which neglects the proper management of environmental and natural resources as their most critical assets. All this needs sound and realistic management at several levels. Getting safe water[1], sanitation and refuse disposal for all the people would be a good start. Thereafter, the rest of the Agenda for the 21st century could be built on a surer foundation.

Note

1 In 34 SIDS with UN reported data, 10 million people (21 per cent) are without safe water.

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Scenarios for sustainable development[1]: Development v. disaster

Scenarios: a perspective

The theatrical origins of the word scenario (see Box 1) underscore the role of metaphor in using it as a conceptual aid in policy development and planning. Prediction is at the core of the scenario process. But, as had been said:

> 'predictions can be very difficult – especially about the future'.[2]

The scenario process commonly poses a question: If this trend were to continue, what would be the wider future implications? For example, if the population of our country continues to rise, putting increasing pressure on natural resources, what would be the social, economic and environmental implications for us all?

In a scenario, the picture of the future appears as a scene from a play. It is intended to illuminate the present and infer choices that might be made to secure a better future, or in some way to elude the worst consequences of it. A scenario is a loose elaboration of a game theory approach. It explores the expected outcomes of possible responses to current problems. It may be supported by numerical and formal logical analysis, but its principal function is to stimulate thought about broad policy options and the range of possible future circumstances for people and for nations. Scenarios help to paint a picture of tomorrow's world that can stimulate decision-makers today, who may not respond well to a dry diet of numerical models and the forecasts emerging from them. In recent years, scenarios have been used to promote debate about development policy and action to try to avert the risks of predicted social and environmental disaster. They are used variously as a tool in policy-making and planning, as indicated below in recent applications of the method.

In UNEP's 2007 flagship environmental policy assessment, *Global Environment Outlook 4* (GEO 4)[3], UNEP adopts a broad-based scenario approach for envisaging the planet's tomorrow. It offers four distinct policy frameworks. Each gives differing emphasis to the key drivers and the critical uncertainties which are thought to influence the interplay between the natural environment and the processes of economic and social development.

Markets First explores the implications of promoting a lead role for the private sector through international trade, with little or no emphasis on environmental policy and market regulation.

Policy First explores the pathway to the future in which governments at national, regional and international levels take a lead role, with less emphasis on the free play of market forces and greater emphasis on education, health and environmental protection.

Security First, the third UNEP scenario, offers a national rather than a regional or international perspective for policy, with a sharper focus on military intervention and expenditure, giving little attention to social and environmental values, and favouring the pursuit of the interests of select private-sector players.

Sustainability First, the final UNEP scenario explored in GEO 4, is again focused on largely national interests with little involvement by regional or international bodies. It does, however, give great emphasis to health, education and environmental values pursued at national and local levels.

The four UNEP scenarios are played out with support from a variety of computer-based models that explore inter-relationships between factors including population trends, GDP, health and education status, land use, pollution, climate change, consumption patterns, water use, marine eco-systems, and biodiversity. But the emphasis by UNEP is on the contrasting story lines spelt out in the unfolding prose narratives, which try to differentiate the particular implications of the control models for each of the geographical regions of the world.

The objective of the UNEP review is to illustrate the way in which choices made by decision-makers today can influence the patterns of life for the future, despite the common pattern of social and environmental states and trends inherited from the past.

None of the UNEP outcomes predicts a utopia, but each illuminates the risks, trade-offs, synergies and opportunities that may be expected from the choices we make today and their unfolding pattern of implications for our future. It is an heroic and complex attempt, detailed across 50 pages of tightly written text, to present, UNEP claims:

> 'what role society can play today in shaping and sustaining our common future'.
> (UNEP, 2007 p. 400)

Barrow[4] sees scenarios as one tool in the broader set of aids to assessment, prediction and forecasting, essential for the function of the formulation of policies, plans and programmes. It is a function, he warns, traceable to the origins of man, with past associations with sooth saying, witchcraft, magic and superstition. He recognises that we cannot see the future however hard we try, drawing attention to the varied and often surprising patterns of past evolution that defied prediction.

In modern times, Barrow sees forecasting tools, such as scenarios, in use in endeavours as distinct as actuarial practice, military strategic planning, scientific, mathematical and macro-economic modelling and environmental simulations. Barrow draws attention to the gap between what can be assessed from numbers and from game theory, for example, and the subjective pictures of the future that may be derived from expert judgement. He cites as another related tool, the expert consultative process involved in the Delphi technique, which was adopted by the RAND Corporation in forecasting possible outcomes of evolving international relations during the Cold War. The Delphi technique has been sub-

sequently adapted for use in exploring possible futures in health, education, and in environmental systems, and may be found as part of strategic environmental assessment, and in environmental impact assessment.

Barrow concludes that forecasting of future scenarios, however scrupulously conducted with expert advice and a firm numerical basis, '*is seldom accurate and gap free*'. He asserts that, ideally, tools and strategy should be flexible and adaptive. Otherwise the assessments can give a false sense of security. In forecasting, he says, '*The unexpected must be expected*'.

Khor[5], focusing on globalisation, explores through a series of loosely presented scenarios its possible implications for international economic development, finance, governance, trade, competition and development strategy. His principal concern is that in scenarios of the implications of globalisation, the implications for natural resources in developing countries have been neglected. However, he is also concerned that the evidence base is weak for linking environmental damage to economic loss and for demonstrating that environmental protection and eco-friendly technology and practices are themselves economically efficient ways of pursuing development. He sees the strengthening of this evidence base as an essential prerequisite for using the sustainable and human development paradigm as a basis for refining both macroeconomic policies, and the appropriate relationship to establish between the state, markets, people and relevant development styles and models. Thus Khor's position challenges the existence of the very evidence on which the UNEP scenarios appear to be founded.

By contrast Hanley[6], in his exploration of environmental risk, is concerned to match with economic analysis the process of scenario-building adopted by natural scientists in environmental risk analysis. Without this process of examining the costs and benefits of environmental risk reduction, he considers we are in danger, in public decision-making, of throwing out the baby with the bath water. He explores this field using probability analysis, game theory and a variety of approaches to economic evaluation of risk, perception of risk and human behaviour in the face of risk. Scenario-building would greatly benefit from incorporating such concepts into the narrative and the economic and behavioural analysis which should underpin it.

Lomborg[7] presents a sceptic's review of the future implications of global warming and current choices. He challenges the disaster scenarios painted by the Worldwatch Institute, UNDP and others in this field and their claim that global warming is one of the most serious problems facing the world today. Drawing on analyses by Nordhaus and Boyer[8] he addresses the opportunity costs of diverting scarce resources to reducing global warming, in terms of sacrificing the gains from not investing in basic levels of development in education, public health and infrastructure in the poorest countries of the world. Scenarios often present choices in the narrative which lack both an adequate evidence base and appropriate economic analysis to draw out the full implications of the pursuit of one pathway for development rather than another.

The student exercise in scenario development below is offered within this broader context of the basis for decision-making in natural resource analysis.

A class room exercise in using the scenario approach

Objective: Two groups (A & B) are set to explore and identify the critical factors affecting sustainable development at country level and to propose action to achieve defined objectives: Group A's task is to put the country Goodland on a pathway for sustainable development; Group B's task is to put the country Goodland on a pathway to unsustainable development towards that of the failed state of Badland.

Method: The class will be divided into two groups A and B. Both groups will have the current Goodland country profile information (see Annex). Group B will have, in addition, the country profile for Badland.

The two Groups will work separately. Each will identify a co-ordinator and rapporteur to assist their work as a team. The time limits for the review process will be set (for example, the exercise may be introduced on one day with a preliminary discussion session and a report back on another day).

The principal lessons learnt about policy choices in this exercise and the methods adopted for scenario development can be followed through during subsequent sessions of the course.

Group A will have the role of an international group of development experts with the objective of promoting sustainable development in Goodland for the benefit of the public and private sectors and the future of the people. They will examine the country profile, define, in a report, the critical issues, the key development and investment policies and their targets. They will take into account the Key Questions for Review (see Box 2), and use the Policy Development Framework (see Box 3) for recording their decisions and proposed action. They will identify the indicators they will use to track performance and the projections of expected results, taking note of conditional and constraining factors.

Group B will have the role of advisers to an international mafia with the objective of undermining the capacity for sustainable development in Goodland and the promotion of the interests of the criminal businesses of their mafia sponsors. They will start with the Goodland country profile, but will also have comparative material from Badland. They will define, in a report, the critical issues, the key intervention policies, and the targets for moving the country from the current state of Goodland into that of the failed state of Badland. They will take into account the Key Questions for Review (see Box 2) and the Policy Development Framework (see Box 3). They will identify the indicators they will use to track performance and the projections of expected results, taking note of conditional and constraining factors.

Presentation and review of results

Both groups will make a presentation of their results. The class will then review the outcome, in terms of their identification of critical factors for sustainable development of a small island state, or for its decline.

One purpose of this review is to identify strengths and weaknesses in the analysis especial-

ly the gaps in analysis that emerge in the comparison between the policy proposals of the two groups.

For example, Group A may give little weight to investment and support for the factors in the state's survival that Group B selects as the targets to attack.

Group B may neglect the power of the national, regional and international multicultural factors which Group A identifies as essential for progress, and which can also resist and overcome the capacity of malign influences to undermine a state. (See endnotes which may be used to encourage wider discussion within the groups.)

Comment on the exercise

The exercise aims to provide for students an opportunity to discuss and explore:

- the use of MDGs and other indicator systems as tools in policy development;
- the concept of a scenario as an aid to forecasting long-term decision-making;
- the elements in policy and planning relevant to sustainable and unsustainable development;
- the assessment of target values, trends and the factors on which they may depend;
- choices in paradigms for policy development;
- underlying factors affecting country development status and trends; and
- national, regional and international factors in the support for change.

Box 1. What is a scenario?

A scenario is a concept used in policy review and planning in the public and private sectors, as a way for envisaging the future and its implications. It is usually based upon projections from current states and trends of social, economic and environmental circumstances. 'Scenario' is derived from an Italian word for the list of scenes in a play and the entrances and exits of the players.

A scenario may be the output from a series of computer simulations using clearly defined data and mathematical projections, as undertaken for the Club of Rome in the *The limits to Growth* (Meadows D.H. et al., 1972) and *Beyond the Limits* (Meadows D.H. and Meadows D.L., 1992). These scenarios reached a wide audience, provoked great controversy, and became iconic contributions to debates on development policy of those times.

In UNEP's *African Environment Outlook 1* (2002) and *2* (2006) and in the *Global Environment Outlook GEO 4* (2007), the use of scenarios formed a substantial element in the presentation of the future regional and global environmental prospects in the face of a set of broad policy options. The UNEP scenarios, however, were less the product of evidence-based analysis and computer simulation of official data, than in the work of the Club of Rome. The principal aim of UNEP was to alert policy-makers and planners to current trends and to policy options to give greater attention to the impact of development policy on environmental degradation.

The Global Scenario Group has produced a series of scenarios on the issue of planetary sustainability (*1997: Branch points: Global Scenarios and Human Choice; 1998: Bending the*

Curve: Toward Sustainability; 2002: Great Transitions: the Promise and Lure of the Times Ahead). The worst-case scenario in these reviews is a planet with impoverished people, cultures and nature; the best case is the Great Transition towards a future of enriched lives, human solidarity and environmental sustainability. Many of these types of scenario tend to lack a rigorous economics framework and estimates of the costs and benefits of achieving the transition to produce new outcomes.

The Meadows's projections for sustainable development in 1992 included proposals for developing fresh tools for restructuring, including: 'visioning; networking; truth-telling; learning; and loving (sic)'. They concluded then with the warning '... no time to waste. There is just exactly enough energy, enough real material, enough money, enough environmental resilience, and enough human virtue to bring about the revolution to a better world'. Thus, the use of such scenarios goes beyond economic planning and politics into the field of ethics and concepts of the good life.

Box 2. Key questions for review

Group A: The pathway to sustainable development

What are the critical factors that can determine Goodland's progress towards sustainable development?

What are the economic and environmental factors that make the small island state of Goodland vulnerable? How can you promote resilience against these threats?

What are your targets for sustainable development for Goodland and what capacity development and other resources are required for achieving them?

How far does the scope and content of the UN MDGs framework provide a sufficient basis for policy and planning for sustainable development in Goodland? What other factors do you need to take into account?[9]

Who are the key players to be involved in the promotion of sustainable development in Goodland and how will you secure their effective involvement?

What are your policy priorities for securing improvements in sustainable development?

Group B: The pathway to a failed state

What are the critical factors that can undermine the capacity of Goodland for sustainable development and put it on a pathway for decline towards a failed state such as Badland?

What are the economic and environmental factors that can make the small island state of Goodland vulnerable? How can you undermine resilience against these threats?

What are your targets for unsustainable development for Goodland and what development capacities and other resources are needed for achieving them?

How far does the scope and content of the UN MDGs framework provide a sufficient basis for policy and planning for unsustainable development in Goodland? What other factors do you need to take into account?[10]

Who are the key players to be involved in the promotion of unsustainable development in Goodland and how will you secure their effective involvement?

What are your policy priorities for undermining sustainable development in Goodland and putting it on a pathway towards the failed State of Badland?

Box 3. Policy development framework

Country .....
Policy Goal .....
Advisory Group Members .....

Critical issues	Development policies	Interventions/ Investments	Performance indicators	Expected results and targets	Constraints and assumptions

Annex: Supporting material

Groups A and B
Global Bank Goodland country brief

Development history

Goodland gained independence in 1964, after centuries of colonisation by the Dutch (1598), the French (1710), and the British (1810). It has a highly diverse population. Descendants of indentured workers from India, who were brought to work in the sugar-cane fields after the abolition of slavery in 1835, make up about 60 per cent of the population. The rest of the population includes Africans, Creoles, Chinese and Europeans.

Goodland is a development success story. At independence in 1968, the country was poor, with per capita income of about US$260. Today, it is an upper middle-income country, with a 2008 per capita income of US$5,260. In no small measure, this success is attributable to trade preferences in sugar (under the EU sugar protocol) and textiles and clothing (under MFA and later AGOA). But the country's ability to profit from these opportunities testifies to institutional strengths – stable democracy and rule of law; ethnic tolerance; macro-economic stability; equitable social progress; and reliance on private incentives. The country has had a good record in public health and basic education but has been slow to develop effective responses to its now more complex educational, human development and health issues.

Economy

In 2008, GDP growth is projected to accelerate to 3.2 per cent from 2.3 per cent in 2004 as the economy continues to adjust to the erosion of sugar and textiles preferences. Though still respectable by the standards of the region, growth has clearly slowed from the miracle years, with weaker investment and rising unemployment. Goodland is highly vulnerable to changes now taking place in the world trade regime, and the slowdown appears to be an adjustment occurring in anticipation. On one estimate, the ending of MFA in January 2005 and the phasing out of sugar preferences by 2008 could cost Goodland as much as 8–9 per cent of GDP, 20 per cent of exports, and 40 per cent of government revenue. But while these developments add some urgency, Goodland's very success in raising wages and living standards would in any case be undermining competitiveness in labour-intensive sectors such as sugar and mass produced garments.

The challenge which Goodland now faces has not come as a surprise. Over the past decade, the groundwork has been laid to move the economy toward more knowledge and skill intensive activities and higher value added financial and business services. Successive governments have been implementing Goodland's vision for its future, restructuring and downsizing sugar and textiles, putting in place enabling legislation for offshore financial services, and drawing FDI into the IT sector with a state-of-the-art, fiber optic-wired Cyber Tower. Major investments have been undertaken in education, transport, and environmental infrastructure. While the July 2005 election brought a change in government, no fundamental shift in Goodland's development strategy is anticipated.

Despite the steps which have been taken, many challenges remain. Education must be further expanded to bring human capital up to the best practice standards of Singapore or Korea. Stronger university-business ties are needed along with a more entrepreneurial, innovative culture. In light of limited R & D capacity, substantially more FDI must be attracted to gain access to cutting-edge technology and marketing skills. And finally, greater public sector efficiency is needed if the ambitious public investment programme is not to drive fiscal deficits and debt to unsustainable levels. The mid-1990s long-term perspective study, *Vision 2020*, set a goal of sustaining growth in the range of 5–7.5 per cent. Provided such challenges can be overcome, this goal can become a reality. Reform of financial management and financial services is increasing the tax revenue yield, decreasing tax evasion, improving probity in government and promoting civil service reform and results based resource allocation.

Politics

Goodland is a multiparty parliamentary democracy. A general election in July 2005 resulted in the victory of the left-of-centre multi party alliance. Sir V. Goodman is President of the Republic; Mr. A. Fineman, leader of the Labour Party, is Prime Minister.

Development picture/donor co-ordination

Reflecting Goodland's past success and improved access to capital markets, official donor assistance has declined in volume and has become more selective. There is a de facto satisfactory division of labour among donors (e.g. EU, BFDB, UNDP).

The Global Bank Group's role

Global Bank's role in Goodland is evolving, reflecting the country's past success in gain-

ing access to capital markets. Because of its relatively high income, Goodland is one of only a few countries in its region eligible for IBRD loans (most others borrow from the International Development Association, the Global Bank's soft-lending arm for the poorest countries). The Global Bank currently has one active project totalling $12.4 million in the sewerage and sanitation sector. The Bank is currently preparing its new Country Partnership Strategy to frame its support over the coming years.

The Bank also supports the Government of Goodland through analytical and advisory assistance. The Bank has carried out a Country Procurement Assessment Review, a Public Expenditure Review to assess the sustainability of the New Economic Agenda, a Transport Action Plan, and a report on modernisation of the pension system. The Bank has also been supporting the government with a Medium Term Economic Framework (MTEF), a Labour Market Study, and Investment Climate Assessment. A Country Economic Memorandum is underway.

The International Finance Corporation (IFC) has made no new investments since 1996, and the portfolio has steadily decreased as investments have been repaid and/or exited. IFC has an equity investment of $US9 million in a collective investment vehicle. In March 2006, the IFC organised a multi-sector promotion mission, and is positioning itself to play a more active role in supporting South–South investment opportunities as well as private sector involvement in the following sectors: tourism, textile, agri-business, and information and communications technology. IFC is also considering a request from the Joint Economic Council to assist in the establishment of a Credit Bureau to facilitate access to finance for SMEs.

While the Multilateral Investment Guarantee Agency (MIGA) has not insured any projects in Goodland, it has issued four contracts of guarantee to Goodland investors in support of their investment in an agribusiness project in Mistyland. The agency's outstanding gross exposure for this project is US$52.2 million. In the past, Goodland investors have benefited substantially from MIGA coverage of their projects in the region. Goodland is also one of 11 regional countries participating in MIGA's Enterprise Benchmarking Program (EBP), which gauges a country's ability to compete with other potential sites and locations for foreign investment. Goodland is not an active participant in GBI programs, but discussions are underway to help position the country as a global knowledge hub.

The prospects for sustainable development in Goodland are fair. Further progress will depend upon national, regional and international commitment to the conservation of the country's outstanding natural resources. This will require better management of the use of land, keeping tourist development within the carrying capacity of the country and effective solutions to a number of critical stages of further development. These include eliminating the remaining pockets of poverty, malnutrition, alcohol and drug abuse and petty crime.

Unfinished business

Further advances are needed in technical and social research and development (R&D), food security and safety, and better exploitation of renewable energy resources, especially solar power. Re-orientation of the health sector is needed to give more emphasis on health

promotion and the health of the increasingly large population of older people. Reform is necessary to improve the effectiveness and management of medical services and bring them more in line with the principal problems of the country, notably non-communicable disease and mental ill-health.

Other issues yet to be tackled include overcrowding, relief of traffic congestion, land pollution and degradation. This in turn will require further improvements in public education, the standards of public and professional life, and greater probity and accountability in national and local government.

Group B
Extracts from the Global Bank assessment of Badland 2008

Development history

For nearly two decades, Badland has struggled to emerge from a cycle of internal conflicts that have devastated its economy and inflicted severe hardship on its population. Badland is one of the poorest countries in the world and one of the most disadvantaged, as social, economic and environmental indicators reveal:

- GDP per capita of US$361 (2008);
- 146th on the human development index;
- 65 per cent of the population lives under the poverty line;
- life expectancy is 53 years;
- half the population does not have access to clean drinking water;
- half the population is illiterate;
- highest incidence of HIV/AIDS in the region; and
- 97 per cent deforestation.

Despite a remarkable history as the first and only slave colony to gain national independence, Badland's path to development and democracy has been hampered by political instability. After growing at an average annual rate of 2.3 per cent in real terms in the 1970s, real per capita GDP fell an average of 2.4 per cent per year in the 1980s and continued to decline in the 1990s at an average annual rate of 2.6 per cent. A population growth rate of 3.2 per cent a year adds 64,000 a year to the current 2 million population. The early 1990s were marked by a military coup against the president, Jean Paul Le Bruin, and a subsequent international embargo that sought to restore constitutional rule. During this period, industrial activity and exports virtually ceased, tax collection and expenditure control systems collapsed, and maintenance of economic and social infrastructure was all but abandoned.

Global Bank's role

To support a process of national reconciliation and ensure a rapid response to the country's development needs, the Bank identifies four priority areas for action:

1 improving political governance and promoting national dialogue;
2 strengthening economic governance and promoting institutional development;
3 promoting economic recovery; and
4 improving access to basic services.

From 1956 through the mid 1980s, some US$260 million was disbursed for infrastructure projects, rural and urban development, agriculture, forestry and education. From 1987 to 1991, IDA disbursed some US$142 million for projects to support fiscal and trade reforms and projects for basic health services. Results of this investment were poor, arising from mismanagement and lack of transparency and accountability in disbursement of funds. IDA projects, suspended in 1991, were resumed when constitutional order was restored in 1994. From December 1994 to September 1997, IDA disbursed about US$100 million to finance an economic recovery programme, emergency employment creation, road rehabilitation and maintenance, and a forest and parks protection technical assistance project. IDA disbursements to Badland peaked at US$56 million in 1997. From 1997 to August 2000, with no fully constituted Parliament to ratify new credits, IDA disbursements steadily declined, with less than $9 million disbursed in 2000. In September 2001, BADLAND fell into non-accrual with the Global Bank.

Unfinished business

The prospects for sustainable development in Badlands remain bleak, with increasing levels of poverty, crime and degradation of the environment and natural resources. These factors and rampant infectious disease make this small overcrowded island, once of outstanding scenic beauty, unattractive for tourists except those bent on crime, money laundering, human trafficking, drugs and other nefarious activities.

MDG tables

1 Goodland

	1990	2000	2008	Target
Goal 1: Eradicate extreme poverty and hunger.				
MDG Target: halve 1990 level by 2015				
% Population at less than $1 a day PPP	10	7	6	
% Population undernourished	NA	15	12	
Goal 2: Achieve universal primary education.				
MDG Target: 100% by 2015				
% literate females 15–24 yrs	60	65	75	
% literate males 15–24 yrs	75	85	95	
Primary school completion rate (% of relevant age group)	NA	75	85	
Primary school enrolment rate %	80	85	92	
Goal 3: Promote gender equality and empower women.				
% parliamentary seats held by women	7	6	8	
MDG Target: reach 50% by 2015				
Ratio female to male primary enrolment	NA	101	120	
MDG Target: ratio to 100 by 2005				
% women of total employment in non-agricultural sector	20	25	30	
MDG Target: reach 50% by 2015				

Goal 4: Reduce child mortality.			
MDG Target: reduce 1990 mortality by 2/3 by 2015			
Infant mortality rate (deaths in 1st yr per 1000 live births)	20	18	13
Under five mortality rate (deaths under five years per 1000 live births)	23	21	18
Goal 5: Improve maternal health.			
MDG Target: reduce 1990 maternal mortality by 3/4 by 2015			
Maternal mortality rate (maternal deaths per 100,000 live births)	32	25	20
Goal 6: Combat HIV/AIDS, malaria, etc.			
MDG Target: by 2015 reverse increase since 1990			
Prevalence of HIV (% population 15–45 yrs)	NA	1.5	1.8
Incidence TB cases per 100,000 population per year	69	65	64
Incidence of malaria per 100,000 population per year	10	5	1
Goal 7: Ensure environmental sustainability.			
% land area with forest cover:	20	15	NA
MDG Target: reverse loss			
% land area protected: Target: sustain or increase per cent	1	3	4
CO_2 emissions per head of population (metric tonnes)	1	NA	3
MDG Target: halt and reverse increase			
% Population with safe water	85	90	91
MDG Target: by 2015 halve 1990 per cent without safe water			
% Population with safe sanitation	NA	70	90
MDG Target: by 2015 halve 1990 without safe sanitation			
Goal 8: Develop a global partnership for development.			
Aid per head of population (US$)	85	78	26
MDG Target: by 2015 reduce 1990 levels			
Debt service % of exports	7	5	4
MDG Target: by 2015 reduce 1990 levels			
Internet users % total population	NA	2	10
MDG Target: by 2015 increase 1990 levels			
Mobile and mainline telephone subscribers % total population	5	NA	86
MDG Target: by 2015 increase 1990 levels			
Other data			
GDP per capita at PPP $	2,300	4,200	10,800
Population (millions)	1.1	1.2	1.3
Land per head of population (hectare per capita)	18	16	15
Eco footprint (global equivalent no. earth planets at current rate of use of resources)	NA	2.3	2.4
Adult literacy rate % total population 15 yrs and above	79	85	87
HDI rank (GDP, education, expectation of life)	65	60	56
HPI rank (Life satisfaction x expectation of life/ ecological footprint)	50	55	65
Expectation of life at birth (yrs)	65	70	73

NA = data not available

2 Badland

	1990	2000	2008	Target
Goal 1: Eradicate extreme poverty and hunger.				
MDG Target: halve 1990 level by 2015				
% Population at less than $1 a day PPP	30	45	65	
% Population undernourished	65	59	70	
Goal 2: Achieve universal primary education.				
MDG Target: 100% by 2015				
% literate females 15–24 yrs	45	48	48	
% literate males 15–24 yrs	47	47	52	
Primary school completion rate (% of relevant age group)	28	25	20	
Primary school enrolment rate %	35	32	25	
Goal 3: Promote gender equality and empower women.				
% parliamentary seats held by women	4	3	3	
MDG Target: reach 50% by 2015				
Ratio female to male primary enrolment	NA	NA	NA	
MDG Target: ratio to 100 by 2005				
% women of total employment in non-agricultural sector	40	NA	NA	
MDG Target: reach 50% by 2015				
Goal 4: Reduce child mortality.				
MDG Target: reduce 1990 mortality by 2/3 by 2015				
Infant mortality rate (deaths in 1st yr per 1000 live births)	102	94	99	
Under five mortality rate (deaths under five years per 1000 live births)	150	126	130	
Goal 5: Improve maternal health.				
MDG Target: reduce 1990 maternal mortality by 3/4 by 2015				
Maternal mortality rate (maternal deaths per 100,000 live births)	NA	NA	680	
Goal 6: Combat HIV/AIDS, malaria, etc.				
MDG Target: by 2015 reverse increase since 1990				
Prevalence of HIV (% population 15–45 yrs)	NA	NA	5	
Incidence TB cases per 100,000 population per year	470	350	360	
Incidence of malaria per 100,000 population per year	NA	NA	NA	
Goal 7: Ensure environmental sustainability.				
% land area with forest cover	7	4	3	
MDG Target: reverse loss				
% land area protected	NA	NA	0.3	
MDG Target: sustain or increase per cent				
CO_2 emissions per head of population (metric tonnes)	0.1	NA	0.3	
MDG Target: halt and reverse increase				
% Population with safe water	47	46	50	
MDG Target: by 2015 halve 1990 per cent without safe water				

% Population with safe sanitation	24	NA	26
MDG Target: by 2015 halve 1990 per cent without safe sanitation			
Goal 8: Develop a global partnership for development.			
Aid per head of population ($)	24	26	60
MDG Target: by 2015 reduce 1990 level			
Debt service % of exports	9	NA	50
MDG Target: by 2015 reduce 1990 level			
Internet users % total population	NA	NA	7
MDG Target: by 2015 increase 1990 level			
Mobile and mainline telephone subscribers % total population	7	16	NA
MDG Target: by 2015 increase 1990 level			
Other data			
GDP per capita at PPP $	400	380	361
Population (millions)	1.8	2.0	2.1
Land per head of population (hectare per capita)	11	10	9.5
Eco footprint	NA	NA	3.1
Adult literacy rate % total population 15 yrs and above	NA	NA	50
HDI rank	130	140	146
HPI rank	NA	NA	120
Expectation of life at birth (yrs)	49	50	53

NA = data not available

Notes

1 Defined by the UN Bruntland Commission 1987 in *Our Common Future* (Oxford University Press) as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.
2 Attributed to Niels Bohr 1885–1962.
3 UNEP (2007) *Global Environment Outlook 4, Environment for Development*, UNEP, ISBN 978-92-807-2836-1
4 Barrow, C.J. (2006) *Environmental Management for Sustainable Development*, Routledge, ISBN 10: 0-415-36534-1
5 Khor, M. (2006) Globalization, Global Governance and the Dilemmas of Development; Chapter in Chang, H., *Rethinking development economics*, Anthem Press, ISBN 1 84331 1100.
6 Hanley, N. et al. (2001) *An Introduction to Environmental Economics*, Oxford, ISBN 13 978-0-19-877595-9
7 Lomborg, B. (2006) *The Skeptical Environmentalist, measuring the real state of the world.* Cambridge, ISBN 0 521 80447 7, Chapter 24, Global Warming.
8 Nordhaus, W. and Boyer, J. (2000) *Roll the DICE again; economic models of global warming*, Cambridge, Mass: MIT.
9 For example, Group A might be encouraged to consider: state and trends in demography, economic and human development status, protection against disasters and climate change, eco footprint, use of renewable energy, governance, competitiveness, logistical capacity, national, regional and international institutional, professional, and cultural support for information exchange, technical transfer, finance, education, political, economic and social communication, etc.

10 For example, Group B might be encouraged to consider state and trends in inter-state and civil conflict, crime, unemployment, corruption and abuse of power in police, military, courts, elections, and civil services; lack of safe standards and probity in commerce, construction industry; drug and alcohol abuse, prostitution, human trafficking; unwanted fertility, epidemic disease; unsafe water and sanitation, pharmaceutical supplies, black economy, piracy; lack of development of public health, education, medical treatment services, emergency response services, roads, communications, and energy; lack of controls on degradation of land and water resources; decline in protection against disasters and climate change, fraud in governance, and low levels of productivity, competitiveness, logistical capacity, etc.

John L Roberts

Annex B

From Rio to 2015

An overview of select milestones in regional and global policy formation on sustainable development and environmental management

The Prelude: Before Rio 1970s–1980s

1970s

A decade of expert warnings and international treaties recognising the growing threats to the environment from population explosion, poverty and unregulated land use and calling for a global commitment to environmental protection in the interests of human well-being and the conservation of biodiversity.

1972: UN Conference on Human Environment, Stockholm Sweden
Stockholm Declaration contained 26 principles and an Action Plan of 109 recommendations. This provided for a moratorium on whaling; prevention of deliberate oil discharges at sea; report on energy issues; and the creation of the UN Environment Programme (UNEP)[1]. Policy areas covered included renewable and non-renewable resources; the involvement of developing and developed countries; urban planning; and the promotion of human rights. It also asserted the right of people[2] to live in an environment of quality that permits dignity and well-being.

UNEP was established with a mandate for support, co-ordination, advice, developing plans for long-term UN programmes on environment; regular reporting on environment state and trends through the GEO and other regional reports.

Limits to Growth, was published by the Club of Rome providing computer projections setting out a doomsday scenario on the future of the planet Earth. It was compiled by 50 self appointed sages, giving projections for technology development, population growth, nutrition, natural resources and environmental changes. The principal theme was: If current trends continue, the global system will overshoot and collapse by the year 2100. If that is to be avoided, both population and economic growth will have to cease[3].

USA Landsat satellite: started producing images of the world's surface allowing greater monitoring of environmental change; loss of forests, mangrove, wetlands; desertification, etc.

World Heritage Convention agreed at UNESCO: the designation of heritage sites started with the identification of the Galapagos Islands to be protected forever as a world cultural treasure. The definition of heritage covers monuments, groups of building, and sites with works of nature and man, of outstanding universal value from an historical, aesthetic,

scientific, ethnological, or anthropological point of view.
http://whc.unesco.org/archive/convention-en.pdf

1973: Convention on International Trade in Endangered Species (CITES):
This was an international accord to protect both flora and fauna from extinction through commercial exploitation.

1973: RAMSAR Convention[4]
This provided for conservation of wildfowl and their habitats, water quality, food production, wetlands areas and salt water coasts. By 2001, there were over 100 national signatories to the Convention, largely from NGO-led activities covering over 1,000 areas and 90 million hectares.

1974: Cocoyoc, Mexico, Symposium
UNEP and UNCTAD. On economic and social factors leading to environmental degradation.

The principal theme of the symposium was: 'The task of statesmanship is to guide the nations towards a new system more capable of meeting the inner limits of basic human needs for all the world's people and of doing so without violating the outer limits of the planet's resources'.

1977: UN Convention to Combat Desertification
The convention marked a recognition of the mounting problem of desertification across many continents arising from deforestation, soil degradation and climate change; by 2009, 193 countries were party to the convention.
http://www.unccd.int/convention/menu.php.

1979: First World Conference on Climate Change, Geneva
The conference found that CO_2 emissions could have a long-term impact on climate change. It led to the World Climate Programme 1979 and international research and development on climate issues.

1980s

A decade marked by continued international commitment to action on environmental and human welfare in the face of rising poverty, increasing population pressure, negative economic growth per capita, mass migration from wars, growing debt crises, greater urban squalor, poverty and disease, major environmental disasters, more concern on climate change and the depletion of the ozone layer. The end of the Cold War brought an opportunity for using the peace dividend arising in many countries for social and environmental protection. But there was also in this decade increased international concern about reduced security on nuclear weapons and on the safe maintenance of civil nuclear reactors and growing threats of unsafe disposal of nuclear and other hazardous waste.

1982: UN Charter for Nature
The charter asserted the intrinsic value of species and eco-systems: stating that 'the genetic viability of the Earth shall not be compromised'.

1982: United Nations Convention on the Law of the Sea (UNCLOS)
UN Convention on the Law of the Sea proposed the official delineation of marine zones, control of sea pollution, and marine species conservation.

1984: Disasters
Bhopal Union Carbide plant disaster, India. This is still considered one of the worst ever industrial disasters, involving emissions of toxic gas in a densely populated area killing 8,000 people within 72 hours and 25,000 subsequently. Whilst $470 million compensation was paid to victims and their families and special provision made for long term rehabilitation, the disaster raised concern about the need for better international, national and local safety regulation of multinational companies and avoiding the location of hazardous industries in high population areas. http://www.mp.gov.in/bgtrrdmp/relief.htm

Eritrean and Ethiopian Famine. This major famine affected Eritrea and Ethiopia, arising from record low rainfall and the impact of military conflict, with political and economic restructuring reducing social support, food distribution and food security. The crisis produced an estimated 1 million deaths with 8 million people falling into destitution. The international and voluntary effort, especially through Live Aid, produced emergency relief and raised global awareness of poverty and social implications of military conflict in Africa.

Chernobyl nuclear plant explosion. This disaster in Russia caused extensive radioactive fall-out and 300 immediate deaths and probably 2–3,000 other deaths. Internationally, it raised questions about the safety of design and maintenance of nuclear reactors and their future in world energy production.

1987: World Commission on Environment and Development
Known as the Brundtland Commission, it was established in 1983, chaired by Gro Harlem Brundtland, former PM of Norway and subsequently Director General, WHO. It produced the groundbreaking publication *Our Common Future* defining sustainable development as:

'*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*'.

The theme of the report was economic development without depleting natural resources or harming the environment. Topics included in the report were: global warming; loss of the ozone layer; renewable energy; desertification; international institutions poorly equipped to deal with complex issues; and the need for wider participation of public and private sectors and civil society in policy debates on sustainable development.

1989: Basel Convention
This convention set standards for the control of inter-country movement of dangerous waste; its effective date was 1992 and there were 149 signatories to the Convention by 2001.

Montreal Protocol
This protocol was concerned with the implementation of the Vienna Convention on Protecting the Ozone layer. It was eventually signed by 182 countries by 2001.

Rio and beyond 1990–2015

1990s

A decade of increasing commitment to reaching a global consensus on international and local action for sustainable development, through the iconic 1992 Rio Earth Summit. The commitment was made in the face of mass poverty in many countries, continued substantial population increase, growing evidence of hot-spots of environmental degradation and the identification of the neglect of the special vulnerability of small island developing states.

1990: Intergovernmental Panel on Climate Change (IPCC) First assessment report
The panel provided a scientific assessment of climate change; followed in 1995 by second assessment; 2001 Third assessment; and 2007 fourth assessment, together with technical guidelines and summary for policy-makers. See www.ipcc.ch

1991: Global Environment Facility established
The facility is supervised by the World Bank for promoting environmental investment.

1991: Caring for the Earth published
IUCN, UNEP and WWF jointly commit themselves to promoting policy for environmental protection.

1992: Rio de Janeiro UN Conference on Environment and Development (UNCED) 'The Earth Summit'
One hundred heads of state and government and civil society agreed policy statements and institutional frameworks for the pursuit of principles for environment and development, including :

- **Rio Declaration:** a 40 chapter Blueprint for implementing sustainable development (Agenda 21 – the Agenda for the 21st century[5]);
- **Declaration of Forest principles**;
- **UNFCC – Framework** convention on Climate Change;
- **CBD** – Convention on Biodiversity;
- **UNCSD** new mechanism for monitoring progress; Commission for Sustainable Development; and
- Promotion of interests of women, indigenous people, youth, children, NGOs, local government bodies, trade unions and associations, business, farmers, scientific and technical bodies.

1993: World Wide Web
The WWW had just 50 pages in 1993 and covered 50 countries: but new PCs, emails and intranet and internet began to accelerate corporate and global communication. By the year 2006, the World Wide Web had 100 million sites and covered 134 countries. http://www.zakon.org/robert/internet/timeline/

1994: Barbados Programme of Action
This 1994 UN process recognised the vulnerability of Small Island Developing States (SIDS) and their special needs for support for policies and programmes for sustainable

development. The UN recognises 53 countries in this category which includes low-lying coastal countries such as Guinea Bissau.

1995: World Business Council for Sustainable Development
This Council, set up in 1995, embodies the key institutional role of business in securing sustainable development, providing a platform for innovation in environmentally friendly policies and programmes of production and marketing and accounting practice.

1996: Nuclear Test Ban Treaty
This international commitment aimed to stop further testing of nuclear weapons and was signed initially by 71 nations; by 2001, it had been signed by 161 nations with 79 having ratified it. 44 nations, each possessing various degrees of nuclear capability, must ratify the Comprehensive Test Ban Treaty for it to take effect. As of April 2009, nine of these 44 states have not ratified the treaty: China, Egypt, Indonesia, Iran, Israel and the United States have already signed the Treaty, whereas India, North Korea and Pakistan have not yet signed it. http://www.atomicarchive.com/Treaties/Treaty19.shtml

1997: Kyoto Protocol of the UN Framework Convention on Climate Change
This international commitment set targets for GHC reductions. Industrialised countries were required to reduce emissions to 5 per cent below 1990 levels by 2008-12 See: http://unfccc.int/resource/docs/convkp/kpeng.html

1997: *Global Environment Outlook 1* (*GEO-1*), UNEP publication
Global Environment Outlook (*GEO*) is a regular report prepared by UNEP on the state of the global environment, through a consultative and decentralised process. The first edition known as 'GEO-1' was launched in 1997. The *GEO-2* report was launched in 2000, with a focus on the environmental crisis facing humanity in the new millennium. *GEO-3* was published in 2002 providing an overview of major developments between 1972 and 2002. The report presented a global and regional overview under each of eight environmental themes in turn: land, forests, biodiversity, freshwater, coastal and marine areas, atmosphere, urban areas and disasters. *GEO-3* report also broke new ground by using scenario analysis to explore the environmental outlook in an array of alternative futures that provide insight on where events could lead us at various stages between 2002 and 2032. *GEO-4* was published in 2007 and is the latest in this series of UNEP flagship reports, which assesses the current state of the global atmosphere, land, water and biodiversity, describes the changes since 1987, and identifies priorities for action. *GEO-4* also warns that we are living far beyond our means. The human population is now so large that 'the amount of resources needed to sustain it exceeds what is available … humanity's footprint [its environmental demand] is 21.9 hectares per person while the Earth's biological capacity is, on average, only 15.7 ha/person.' *GEO-4* asserts that the well-being of billions of people in the developing world is at risk, because of a failure to remedy the relatively simple problems which have been successfully tackled elsewhere. *GEO-4* recalls the Brundtland Commission's statement that the world does not face separate crises – the 'environmental crisis', 'development crisis', and 'energy crisis' are all one. This crisis includes not just climate change, extinction rates and hunger, but other problems driven by growing human numbers, the rising consumption of the rich and the desperation of the poor.

1999: World Population reaches 6 billion
Population growth continues to put pressure on land use for shelter and food and water supplies. Many SIDS suffering from water scarcity are using water charges, water efficiency schemes and conversion of flood water and used water to meet agricultural and industrial demand.

1999: World Treaty on Human Rights
The treaty includes the following Human rights:

Freedom of association and collective negotiation, freedom from slavery, freedom from child labour, freedom from discrimination at work.

Environmental protection with emphasises on the precautionary principle for environmental protection, promotion of environmental responsibility and diffusion of environmental technology.

2000: UN Agreement on Persistent Organic Pollutants (POPs)
The agreement bans use of POPs which carry health and environmental risks including a ban on 12 pesticides. An exception is made for the use of DDT for control of malaria, although this exception is not universally accepted by aid organisations and the use of DDT remains controversial.

2000: UN Bio-safety Protocol
This protocol adopted the precautionary principle for application to genetically modified crops.

2000: USA refused to ratify the Kyoto Protocol
The USA, one of the largest producers of GHGs, declined to sign the protocol and opted for voluntary reductions and the development of new technology.

2000: Millennium Summit and MDGs
UN heads of government and of state met in a conference to promote sustainable development for the 21st century which gave a sharp focus to poverty, education, disease, climate change, environmental accounting, and a global study of the state of ecosystems. This Summit was seen as a prelude to the 2002 Earth Summit to be held in Johannesburg. It also initiated the UN Millennium Project for implementation of eight defined goals, the Millennium development Goals (MDGs) with measurable targets for implementation by 2015. The Goals covered poverty reduction, education, gender equality, health, environmental sustainability and partnerships for development.

2001: IPCC Third Assessment Report
The report showed a raised estimate of global warming and provided guidelines for action.

9/11: September 11 2001. Terrorist attack on the Twin Towers of the World Trade Centre and the Pentagon. Following the attack which killed thousands of people in New York and destroyed the Trade Centre, the USA and other western nations formed an alliance for retaliation against the alleged sources of attack in Afghanistan and Iraq, seeking but failing to obtain full UN support for a controversial war strategy. The wars shifted the focus of much international strategy and media interest away from sustainable development, poverty relief, environmental protection, the MDGs and peaceful aid programmes.

2002: World Summit on Sustainable Development, Johannesburg
The UN summit set out a global strategy for sustainable development with the participation of 104 world leaders.

2002: European Union ratifies the Kyoto Protocol
EU states agreed to develop national systems of control with EU development of emissions trading. The commitment to this scheme is seen by some in stark contrast to that in countries such as the USA and Australia who continued to challenge the evidence of human factors in global warming.

2002: *Nature* journal reports major impact of industrial fishing
A report in *Nature* cites evidence that industrial marine fishing has killed 90 per cent of the biggest and economically most important fish species.

2003: New Partnership for Africa's Development (NEPAD)
African countries agree to a multi-sectoral partnership of the African Union and an action plan for development with inter-sectoral linkages for economy, environment, science and technology as part of a fresh process for development in Africa and as a means to seek external support.

2003: WHO treaty on tobacco control
WHO calls on countries to sign up to the treaty that aims to make major reductions in tobacco agriculture, processing, marketing and sales in order to reduce the human impact of tobacco through death and disease.

2004: Indian Ocean tsunami December 2004
A tsunami resulting from an earthquake close to the eastern shores of the Indian Ocean killed over 200,000 people and affected 2.4 million people causing massive loss of infrastructure as far as the Maldives, Seychelles and the East African Coast. This natural disaster set in course an international review, led by UNEP, of emergency procedures and early-warning systems to provide protection against sea surges and sea level rise in vulnerable island and coastal states world-wide.

2004: UN Millennium Ecosystem Assessment report
The report declared that: 60 per cent of Earth's ecosystem services (water, soil, nutrients, biodiversity) had been degraded or was being used unsustainably.

2005: UN Mauritius SIDS Conference, Declaration and Strategy
The UN conference held in Mauritius provided international commitment for support to vulnerable small island developing states. Pledges were made by major developed countries for financial and technical support and a follow-up procedure was established through the UN Commission on Sustainable Development (UNCSD) and through subsequent reports to the UN General Assembly.
See http://www.un-ngls.org/orf/sids-mauritiusdeclaration.pdf

2005: Hyogo conference, Kobe, Japan on disaster preparedness
This UN conference produced an agreement to the Hyogo framework for action to enhance early-warning systems and strengthen disaster response, through the UN agency International Strategy for Disaster Reduction (ISDR).

See http://www.unisdr.org/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf

2006: UN General Assembly review on progress with UN 2005 SIDS Mauritius Strategy
The UN received reports from all UN agencies and from three SIDS regional conferences (Caribbean, Pacific and the AIMS[6] region).

2007: International Panel on Climate Change (IPCC) 4th Assessment Report (AR4)
The report provided an assessment of global changes in climate, impact on regions and on SIDS and proposals for mitigating action.
http://ipcc-wg1.ucar.edu/wg1/wg1-report.html

2008: UNEP publishes *Africa, Atlas for our changing environment*
This environmental atlas provided 400 pages of satellite and terrestrial maps, data and statistics on the good and the bad news of the changing environment of Africa, with detailed country profiles. It showed that, from 1950 to 2050, population increase in Africa will have reduced available land from 13.5 hectares per person to 1.5 hectares at current rates of population growth, i.e. 2.3 per cent per year, the highest rate of all world regions.

2008: Global financial and economic crisis
The collapse of financial key institutions in the USA following the unregulated pursuit by them of high-risk loan and investment strategies, had rapid impact on global confidence in banking and investment. This prompted governments and international financial institutions into massive emergency support to avert the collapse of world economy. Some countries used the opportunity to renew their commitment to eco-friendly budgets and government policies to reduce dependence on fossil fuel and to promote efficiency savings at home. International support agencies such as the UN, World Bank and the Commonwealth Secretariat undertook major assessments of the impact on the crisis on regional and national economic, social and environmental policies and the pursuit of the MDGs.

2015: Target date for achievement of Millennium Development Goals
See UNDP, World Bank and UN websites for updated position on progress towards targets.
http://ddp-ext.worldbank.org/ext/ddpreports/ViewSharedReport?&CF =1&REPORT_ID =1336 &REQUEST_TYPE=VIEWADVANCED&HF=N
http://mdgs.un.org/unsd/mdg/Data.aspx

Notes

1 Attributed to Niels Bohr 1885–1962 *Oxford Dictionary of Quotations*, OUP, 2005.
2 UNEP (2007). *Global Environment Outlook 4*, Environment for Development, UNEP, ISBN 978-92-807-2836-1.
3 Barrow C. J. (2006). *Environmental Management for Sustainable Development*, Routledge, ISBN10: 0-415-36534-1.
4 Khor M. (2006). Globalization, Global Governance and the Dilemmas of Development; Chapter in Chang H., *Rethinking development economics*, Anthem Press, ISBN-1-84331-1100.
5 Hanley N. et al (2001). *An Introduction to Environmental Economics*, Oxford, ISBN 13 978-0-19-877595-9.
6 Lomborg B. (2006). *The Skeptical Environmentalist, measuring the real state of the world.* Cambridge ISBN 0-521-80447-7, Chapter 24, Global Warming.

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Annex C

Glossary of key concepts and key players

This glossary provides a basic vocabulary for students of **environmental and natural resource analysis** from an economics perspective. The presentation includes relevant examples of the application of the defined concepts with special reference to **environmental economics** in small and island states. The text includes brief notes on the principal players in this field and sources for further study. Principal cross-references are in **bold**.

Accountability
The process and the measure of the extent of effective and justifiable responsibility in **governance**. The principles on which accountability are commonly based include transparency in reporting; probity and justice in the exercise of power, the use of finance and the implementation of regulations and procedures; and the operation of fair-minded discretion in the means of enforcement.

Adaptation
A change or process by which an organism or species becomes better suited to its **environment** in line with the theory of the survival of the fittest. In disaster management, the term is used metaphorically, in the evolutionary sense, that through adaptation people can modify their capacities and behaviour to increase the chance of survival in the face of specific hazards, such as cyclones, earthquakes or transport accidents, for example. Adaptation can be a process in building **resilience** through developing capacities that can reduce the extent of loss and damage and achieve rapid response, rescue, and recovery. In the climate change literature, adaptation, as against **mitigation**, is a process of adjustment with the objective of living with climate change and modifying plans to take into account new environmental information. (See also **mitigation**.)

Adverse selection
The outcome of offering a contract for services to all-comers, in which those most likely to benefit will apply. So that if, for example, a single rate of car insurance is offered to all, it will attract those who are the worst drivers with the heaviest accident rate. They are likely to benefit most at a common rate for all. In health insurance, those who are well may find it better to seek an insurance policy which rates the premiums in accordance with levels of health and assessed risk. For example, those who are alcohol-free, are non-smokers and are not overweight are likely to find health insurance companies offering

reduced premiums. People who live in places subject to cyclones, floods and earthquakes are best advised to seek insurers offering common priced premiums to all.

Africa
One of the five continents of the world, but variously defined by different organisations even within the UN. Africa, according to the United Nations **Environment** Programme (UNEP), includes 53 countries plus Réunion; WHO separates off part of north Africa into an Eastern Mediterranean region. The SIDS of Cape Verde, Guinea Bissau and Sao Tome and Principe – on the west coast of Africa; and the SIDS of Comoros, Mauritius and Seychelles are officially included in the UNEP region of Africa, but have been commonly marginalised in policy debates and analysis.

Analysis
(From Greek 'to unloose'). To resolve complex matters into simple elements. **Analysis** is distinct from **synthesis** which is the combining of elements to form a connected whole or compound. In philosophy, there are three stages of rational argument in which the final stage of **synthesis** resolves the two previous stages of **analysis:** these two previous stages are thesis *(the arguments for)* and antithesis *(the arguments against).*

Assets
Possessions of value, both real and financial. Real assets include land, buildings and equipment. **Environmental economics** stresses the importance of the value of natural assets and the services they provide, such as forests, water, sea, etc. Traditionally these have not been counted in assessments of national income accounts, such as Gross Domestic Product, but the importance of their sustainability, or substitution, is being increasingly recognised in the face of their non-replacement, over-use and degradation.

Atmosphere
The air and its constituent parts, including pollutants which alter its natural composition. The atmosphere is a complex system of gases which are essential to life for animals and plants. Air quality standards include definitions of the maximum concentrations of specific substances which present threats to life and of which standards may be enforceable by law. The standards commonly cover particulate matter, gases and other substances. Air **pollution** can arise from human activity or from natural disturbances in the atmosphere from dust storms, radon, natural fires and from volcanoes. Many pollutants have an adverse effect on the health of animals and plants.

Behavioural theory
The theory that sees the activity of organisations as a function not merely of market factors but of the complex interplay of the individual goals and activities of the managers and groups involved, their interactions and bargaining power, position and succession. This theory, commonly applied within the sectoral activities of 'the firm', contrasts with classical and neoclassical economic theories which are based on the assumption of the rational economic man and the long-run presumption of profit maximisation as the overriding goal at the levels of the firm, the sector and the national economy.

Behavioural theory has illuminated the process of analysis of political and managerial action but has proved elusive to define in testable form.

The theory is useful in understanding the complex interactions of institutions and other players in the public and private sector with interests in environmental governance and management.

Biodiversity
A measure of the variety of animal and plant species contained within a habitat. Whilst natural factors have determined over millennia the survival of species and their adaptation to changing circumstances, it is common for the variety of species to be reduced with the increasing presence of the human species as a result of predatory action, **pollution** and degradation of the **environment**. Species are scientifically classified according to their prevalence and risk of extinction with some failing, like the Dodo, to survive the impact of man. Conservation is designed to protect species and their habitat through a variety of measures including captive breeding and protected areas.

Capital
One of three factors classically considered to be contributing to productive activity; the others being labour and **natural resources.** It is increasingly recognised that capital includes a variety of elements not merely physical capital. The other elements include human capital, business capital, service infrastructure, natural capital, public institutional capital, knowledge capital. (See Sachs J. (2005) *The End of Poverty,* Penguin Books.)

Carbon footprint (see ecological footprint)

Carbon tax
A tax on the use of fossil fuels (which contain carbon) introduced to reduce the production of carbon dioxide in the atmosphere, which is believed to contribute to global warming, and adverse **climate change.** In some European countries the yield from the tax is used to target energy efficiency for business, or to offset corresponding reductions in taxes on labour, payroll or the insurance costs of business.

Carrying capacity
The optimum size of a population that a habitat can sustainably support. The economist **Thomas Malthus** (1766–1834) considered that whilst population tends to increase geometrically, food production tends to increase arithmetically; thus more people will be condemned to live in misery and poverty; an early application of the carrying capacity concept. The concept is especially relevant to the capacity of environmental services such as water resources, woodlands, arable and pasture land to cope with increasing human and animal use.

Classical economics
A school of thought principally based on the writings of **Adam Smith** (1723–1790) and David Ricardo (1772–1823) which focused on the production and distribution of wealth

from capital, labour and land, through a market system in which the interplay of supply and demand automatically (through the mechanism of **invisible hand**) promoted long term **economic growth**. The classical school was overtaken both by **neoclassical economics** and by the theories of **Karl Marx.** Whilst the concept of the marginal productivity of land was acknowledged in classical economics, later schools of thought gave more emphasis to **externalities,** market failure and environmental impact as essential components of economic analysis of the use of scarce resources.

Climate change
Large-scale alterations in the earth's climate (i.e. the average weather patterns in terms of seasons, temperatures, precipitation, wind direction and speeds, and the type and extent of clouds). The changes in climate are attributed to astronomical changes in solar radiation, long-term changes in the earth's rotation and orbit, to geological factors such as intercontinental plate tectonics and continental drift, as well as to human factors such as air **pollution**. Major changes such as in the Ice Ages are known to have occurred in past millennia; current observations show that systematic changes have been occurring in the past 100 years or more, leading to global warming, which the International Panel on Climate Change (IPCC) have concluded is principally promoted by human activity.

The IPCC Fourth report 2007 sets out the expected global impact as follows: rise in global temperatures of 0.45C to 3.11C, by 2100; increase in highland rain of 10–40 per cent; decrease in lowland rain by 10–30 per cent; more flooding, extreme weather conditions, greater ecosystem stress, threats to health, special threats to Africa and SIDS through water scarcity, food insecurity, increase in disease vectors, risks to endangered species, and sea level rise. The evidence base used by the IPCC is limited by the small number of meteorological monitoring stations outside the western world which affects the specificity of its projections in for example Africa and for SIDS.

Comparative advantage
The advantage gained by a country in international trade if it can produce specific goods or services at a lower resource input cost than other countries. A concept particularly associated with the David Ricardo**.** During colonial times the other continents were seen by Europeans as principally the sources both for exploiting free land by conquest and bilateral trade agreements. This brought to Europe at low prices vast volumes of commodities such as gold, copper, diamonds, timber, fruit and other agricultural products. The colonial system also created markets for manufactured European goods and for specialist services, such as engineering. This tended to bias the development of countries, especially small states and SIDS, to a narrow range of primary goods and related services. Much of their history, since most colonies achieved independence, has been in trying to reduce the adverse economic, social and environmental impacts of exploitation of a narrow range of commodities. A key element in post-colonial policy in **developing countries** has been to reduce imports by the production of substitute goods and services, often through franchise arrangements. (See **natural resource curse**.)

Consumer equilibrium
The point at which a consumer maximises his total **utility** or satisfaction from spending a

limited or fixed income. Neoclassical economics assumes that an individual selects that combination of goods and services in line with his preferences which maximises his total **utility**. Total **utility** is maximised when the individual's marginal **utility** from transferring a unit of expenditure from one item to another is equal.

National accounting practices commonly exclude environmental values. The introduction of **environmental accounting** is a device to ensure that the assessment of consumer equilibrium takes account of non-tradeable environmental use and non-use values. These values are becoming more explicit in stock market transactions and in public company reports in which environmentally-friendly activities are valued. The establishment of markets, for example for carbon trading and road use, are further examples of devices to correct for market failure, which otherwise biases the assessment of consumer equilibrium.

Cost

In economics, cost is a measure of the opportunity lost by preferring one use of scarce resources over another; it thus implies the evaluation of choices: guns or butter; food or drink; war or peace. It thus differs from the accountants' use of the term cost, which is the monetary price paid for goods or services or amount of money spent on producing them. In neoclassical economics, opportunity cost is determined by the consumer's indifference curve and the production possibility boundary between alternative goods and services. In **environmental economics**, specific devices are adopted for the fuller economic evaluation of choices in the use of resources, to account for the impact of trade in goods and services on environmental services and on ecological systems. (See also **opportunity cost**.)

Cost effectiveness

The ratio of effectiveness to cost, expressed in terms of the cost or the price of a given quantity of outputs or outcomes; sometimes the ratio is expressed in terms of the quantity of output for a unit of cost (effectiveness to cost ratio). A cost-effectiveness ratio may be distinguished from a cost-benefit ratio, as in the latter case both the inputs and the outputs are measured in money or cost terms. In coastal protection, for example, cost effectiveness may be expressed as the cost per kilometre of protecting a specific length of coastline (to a defined standard); in water distribution, it may be expressed in the cost of water supply per hundred new customers, or the number of customers served per thousand dollars or rupees spent. In assessing costs, economists will try to apply the concept of **'opportunity costs'** rather than merely the price of the goods or services. Given the budgetary constraints, cost effectiveness can help in choosing an environmental project from competing alternative projects.

Cost function

An equation that shows the elements that determine the cost of producing a given quantity of goods or services in terms of factor inputs and their prices. In forestry management, the cost function of sustaining the forest might be expressed in terms of the cost of capital equipment, labour, and land required per 100 acres of forest. Economists might try to add values for the foregone use of the forest land and timber for other uses such as for arable land agriculture or for timber.

Cost-benefit analysis, Social
An analysis in which the total social costs and total social benefits of a project are set out as a ratio in which both the costs and the benefits are expressed in monetary units. (See also **cost effectiveness**.) In a cost-benefit analysis of control legislation for preserving endangered species, it was found in the USA that to provide a 90 per cent chance of survival of the northern spotted owl would cost $33 billion (1990 values), excluding ecosystem and preservation benefits, the costs largely borne by losses by the producers of wood products. (See: Brown G.M. and Shogren J.F. (1998) *Economics of the Endangered Species Act*, Journal of Economic Perspectives, 12 93) 3–20 summer 1998.)

Critical natural capital
This consists of non-renewable **natural resources** that are necessary elements in sustained development, such as life-sustaining climate, ecological systems, water, land, and biodiversity. Exploitation of **natural resources**, especially through the processes of intensive industrialisation, frontier expansion, and climate change, can lead to degradation of critical **natural resources**, reducing the viability of human and animal habitation. Examples of threats to critical **natural resources** include: desertification, severe industrial air and land **pollution**, water-course and marine **pollution**, and degradation by invasive species of animals and plants. Market and policy failures can result in zero valuing these critical non-renewable resources.

Data (See also **information**.)
Data are numerical records representing properties of observed phenomena relating to their presence or absence or to their quantities or qualities. The word data is from the Latin and is technically the plural of datum; but these days it is commonly treated grammatically as a singular noun taking a singular verb: i.e. *The data comes from* the UN, rather than *the data come from* the UN; but both usages are still to be found in technical texts. The UN agencies are the principal international sources for data on **natural resources** including: The Food and Agriculture Organisation (FAO) which provides through www.Faostat.org a compendium of national data; the United Nations **Environment** Programme (UNEP) through its evolving data portal systems www.unep.org which includes the African **Environment** Information Network (AEIN) and a new website on SIDS. www.sids.unep.org; and the newly established www.AIMSNET.INFO which covers the SIDS AIMS region with hyperlinks to other regional and global sources.

Decision-making
The process of making conclusions or resolutions reached after reviewing choices. Theories of decision-making may be based on mathematical or behavioural models in which four broad aspects are considered:

- those factors (and people) that may be affected by the decision (costs and benefits) of the expected outcomes;
- those factors bringing about the current status or trends observed;
- the objectives or criteria to be used in the assessment; and
- the assumptions and risks associated with the circumstances and outcomes.

Demand
The need or desire for a product backed by the money to purchase it. In economics, effective demand is the willingness *and* the ability to pay and not just the want or need for the product.

In **environmental economics**, the concept of willingness to pay has been used extensively to assess environmental values. One example is in the assessment of the price local residents would be willing to pay to provide a pilot escort system in the Prince William Sound in South East Alaska to avoid further oil spills from tankers, following the Exxon Valdez disaster of 1989. In this way, willingness to pay is a measure of price and also an indicator of demand for that environmental resource.

Demographic transition (See also **epidemiological transition**, **economic transition**)
The change in the dynamics of a population, observed during the process of development, affecting the numbers of births, deaths and population growth over a period of time. Least developed countries have high birth rates and death rates and low population growth. Initial economic and social development is associated with a decline in the death rate, but with little reduction in the birth rate, thus giving rise to a major increase in the population growth rate. As development becomes established so the birth rate and the population growth rate eventually decline. Within many countries this pattern is uneven. Economic change brings with it rural poverty, associated with population increase. This, and other factors, promote a drift to urban areas and pressure on land and social services through informal squatter housing in the urban periphery. SIDS, as a whole, span the range of development transitions, from Guinea Bissau amongst the least developed to Malta and Singapore amongst the most developed.

The demography of many African and Asian countries is being further modified by the impact of HIV/AIDS, which affects both adults and children. It is reducing the survival of young adults and children, and leaving increasing numbers of orphans, whilst having less effect on older people. These changes are increasing the dependency ratio of the populations affected, with fewer working people alive.

Developing countries
Those countries in which the level of resources and income and their management has been inadequate to generate savings necessary for substantial investment programmes for social and economic progress. Such countries are typically characterised by a large agricultural sector in which the majority of people live at or near subsistence levels. Such countries may export raw materials (agricultural and mineral) for use by other countries but commonly gain or deploy insufficient funds from this trade to invest in internal development.

Development
The process of increasing productive capacity to achieve economic and social progress. **Meadows and Meadows** make the distinction between '**To grow** (which) means to increase in size and **to develop** (which) means to bring to a fuller, greater, or better state'. (Meadows D.H. and Meadows D.L. et al. (1992) *Beyond the Limits*, Earthscan, London).

In **neoclassical economics** the concept tends to be focused on economic and social development with little attention given to the adverse impact this may have on the **environment** and the value of **natural resources**. The Meadows's contribution to the debate on development was to give special emphasis to the use of environmental resources in the first review commissioned by the Club of Rome *Limits to Growth* (1972). This promoted in its wake the international recognition of environmental capital as a source of wealth and the rate at which it was being consumed and not renewed. (See also **sustainable development**.)

Development economics

The branch of economics concerned with how developing countries apply their resources to achieve economic growth. In neoliberal economics, development has come to mean the capacity of a national economy, whose initial economic condition has been more or less static for a long time, to generate and sustain an annual increase in its gross national income (GNI) at rates of 5 per cent to 7 per cent or more. This GNI growth would either 'trickle down' to people in the form of jobs and other economic opportunities, or create the necessary conditions for wider distribution of the economic and social benefits of growth. This view in policies, promoted by John Williamson, adopted by the IMF and the World Bank under the Washington Consensus, has been challenged by evidence that shows that whilst many developing countries have achieved high rates of growth, the standard of living of many people in them remained for the most part unchanged. This resulting inequity was typified by Hans Singer, a fierce critic of the neoliberal theories, as 'the lion's share going to the lions'.

By contrast, development can be seen as a process of involving changes in social structures, popular attitudes, and national institutions, as well as the acceleration of economic growth, the reduction of inequality and the eradication of poverty. From this perspective, three objectives of development are: to increase the availability and widen the distribution of basic life sustaining goods such as food, shelter, health and protection; to raise standards of living; and to expand the range of economic and social choices available to individuals and nations. The adoption of such objectives by policy-makers leads to policies that provide greater access by people to food, health, shelter, social protection, education and jobs. Thus development economics becomes focused on the choices in the use of scarce resources to achieve these ends. (See also **Development, Development theory, and Sustainable development**.)

Recent work re-appraising the theory and practice of development economics has distinguished between the models relevant to developed countries and those more applicable to developing countries. Arthur Lewis, Nobel Prize winning economist from Saint Lucia, strongly argued for a special approach to development for developing countries which would acknowledge the value of their cultures. He argued for greater emphasis on building an enabling environment for growth through infrastructure. Both Reinert and Chang draw attention to the adverse affect on developing countries of the frontier expansion model of past European colonial policy with its exploitation of their natural resources and the risk that the new welfare colonialism of aid support and the failure of the WTO negotiations can put poor countries permanently 'on the dole', thus failing to integrate them into the global economy. Peet decries the failure of the policies and governance of the IMF,

World Bank and WTO effectively to address the critical development issues including inequality and environmental protection. (See: Lewis, A. (1955) *The Theory of Economic Growth*, Homewood, Illinois; Jomo K.S. (2005) *The Pioneers of Development Economics*, Zed books London and New York; Todaro, Michael P. and Smith, Stephen C. (2009) *Economic development* (10th edition), Pearson Education: London; Reinert, E.S. (2007) *How rich countries got rich ... and why poor countries stay poor*, Constable and Robinson London; Chang, H-J. (2007) *Rethinking development economics*, Anthem Press, London; Peet, R. (2009) *Unholy trinity, the IMF, World Bank and WTO*, Zed books, London, New York.)

Development theory
That field of social and economic theory concerned with the factors that contribute to the improvement and sustainability of well-being of people in developing countries. Theories of development have substantially changed in the last fifty years, in the recognition that the best interests of the subject countries in 'the Third World' may not be to 'catch-up' with the Western countries in the 'first world' or to model their policies on those of the then Soviet block, 'the second world'. It has been increasingly recognised in this field that outcomes are closely related to the contribution of environmental factors, the management of **natural resources**, the quality of governance and the avoidance of counterproductive macro-economic policies conditional on aid programmes. Research increasingly shows the important distinction between national growth and the economic and social benefits of that growth between different sections of society, where despite national development, inequalities are widening in many countries in terms of disparate opportunities in education, health and standards of living within societies.

Diminishing returns
The economic law that posits that as equal quantities of one variable input factor of production are increased in production activity, the quantities of all other factors remaining constant, a point will be reached beyond which the marginal physical product of the variable factor will decline. This is called diminishing returns to a factor. When all factors of production are variable, diminishing returns to scale occurs provided all factors are increased in the same proportion. In environmental management, it is recognised that a population of animals that can be sustained with additions in food, in one defined habitat, is limited by its carrying capacity, after which point the marginal additional population will decline for each unit addition in food.

Disaster, natural
A significant impact on the **environment** from natural causes, a natural disaster can adversely affect normal human activities and cause sudden loss. It often exceeds the capacity of the local community resources effectively to respond in the rescue and rehabilitation of people and systems affected. Examples of disasters include the tsunami of 2004/5 in the Indian Ocean causing widespread loss of life and damage to many communities from Sri Lanka to the Maldives and the Seychelles; Hurricane Katrina which in 2005 devastated New Orleans in the USA and adjacent communities and territories; forest fires in Greece in 2007, which caused death and injury to resident population and

widespread property damage. Disasters also include man-made events such as marine oil-spills, industrial fires, meltdown of nuclear reactors, shipwrecks and airplane crashes.

Disaster risk management
The process of policy development and decision-making to lessen the risks of disasters and their impact on people and on the **environment.** This may be based upon a conceptual framework of those elements considered most critical in producing adverse impacts of disasters and the most cost-effective measures for prevention, preparedness, adaptation and **mitigation** of the consequences. The UNISDR provides advice and support for disaster risk management. For the complete UN/ISDR 2008 guideline on building national resilience to disasters, see: http://www.unisdr.org/eng/about_isdr/isdr-publications/16-Towards-National-Resilience/Towards-National-Resilience.pdf:

Discounting
An accounting device to bring into comparison the cost or yield of projects spread over variable periods of time. This form of calculation of costs and benefits is commonly adopted in appraisal of projects. The method of discounting recognises that the value of benefits delivered now is greater than the same benefits delivered in the future, and that future costs are, similarly, of less importance than present costs of equal weight. In the field of environmental protection, for example, if a nuclear installation would have to be safely dismantled in 200 years time at a current cost of $300 billion, that cost in 200 years time discounted to the present at 5 per cent would be $0.017 billion now. This encourages us to build now and impose that cost on future generations without necessarily setting aside that discounted amount in current savings. The practice of discounting is controversial as it tends to appear that discounting operates to the disadvantage of future generations.

Dominant social paradigm (DSP)
A conceptual framework for economic and social development which underpins the industrial age. With this framework of thought, attributed to Pirages and Ehrlich (Pirages, D.C., and P.R. Ehrlich (1974). *Ark II: Social Response to Environmental Imperatives*. New York: Viking Press), economic growth and population growth are unchallenged norms, whilst the continuing exploitation of natural resources is of little account, despite increasing evidence of damage to the environment and the consequential adverse impact on human welfare. (See also **New environmental paradigm**.)

Dose-response relationship
The change in an outcome variable (response) associated with a specific level of introduction of an intervention (the dose). The metaphor which is applied to interventions to 'treat' environmental problems, is derived from clinical science which identifies the specific measures of outcome from the administration of specific levels of treatment, such as the dose of a drug, and its effect on blood pressure. Biological and ecological systems are complex, however, and other inter-related factors may affect the validity of any interpretation of simple one-on-one relationships in any case of treatment.

Ecological economics
Inter-disciplinary scientific study, involving ecologists, economists and other natural and social scientists, concerned with the complex inter-relationships between ecology and human activity. In particular, the studies have focused on ecological functioning, degradation and resilience and the implications for human welfare. Ecological functioning systems studied include regulation functions (such as climate regulation), production (such as oxygen, food, water), carrier functions (such as habitat, forestry, agriculture and aquaculture), and information functions (such as education and scientific research). This discipline is especially relevant to the needs of SIDS on account of their fragile ecological systems. It differs from '**environmental economics**' in so far as it involves the joint participation of many science disciplines.

Ecological footprint
A measure of the per capita use of **natural resources**, assessed by how much land is used to sustain a given population at its current levels of consumption, technical development and resource use efficiency. Carbon and water footprints are other widely used concepts in this context. They all derive from an idea developed by William Reese and Mathis Wackernagel at the University of British Columbia. The principal elements in the assessment are land to grow food, trees and bio-fuels, areas for ocean fishing and land required to support plant life needed to cope with waste such as carbon emissions from fossil fuels. The carbon footprint is a subset of the ecological footprint. Carbon footprint is the total set of GHG (greenhouse gas) emissions caused directly and indirectly by an individual, organization, event or product (see www.ecologicalfootprint.org).

Economics
From the Greek for a *'house steward'*. The study of scarcity (and abundance) of resources, and the choices in their use and distribution. Classical economics in the late eighteenth and early nineteenth centuries was concerned with the sources of wealth in the world, in which capital, labour and **environmental and natural resources** were separately identified. In the eighteenth and nineteenth centuries, economics tended to focus on capital and labour as the principal components determining wealth and development. Neoclassical economics laid more emphasis on the efficiency of the market system with minimal regulation from government sources. **Natural resources** in the production function appeared inexhaustible as they were continually being found in vast quantities in newly-explored continents. Since the second half of the twentieth century economists have become more concerned about both the external impact of the production of goods and services on **natural resources** and the rate of consumption, degradation and exhaustion of primary **natural resources** such as land, air, water, forests, fisheries, and fuel (wood, coal, oil). Small states whose economies depend greatly on the nature and extent of **natural resources** have become the focus of global concern, fresh frameworks for economic assessment and of initiatives to conserve and make better use of the **environment** as a source of wealth and a sector for employment (in food, tourism, pharmacological sectors for example).

Economic development
A process of economic transition and structural change of the economy (usually involving

a shift from agriculture to the industrial production of goods and services) which increases national income. Capital accumulation and investment are key components of economic development as they increase productive capacity, productivity and via the multiplier effect aggregate demand. National measures of economic development, such as growth in GDP per capita, ignore the distribution of both the benefits and costs of development between regions and people, and the cost of the **externalities** of economic development. Some costs of economic development are often hidden and can include, in many countries, low or zero valuation of human rights, the exploitation of vulnerable groups such as women, children, ethnic minorities and migrant workers, excessive hours of work and 'sweated labour', low pay and high unemployment, gaps in social security and labour protection, degradation of **natural resources**, intensive and unplanned urbanisation, dependence on non-renewable energy sources and inequality in the distribution of the growing wealth. Some economists have given special attention to many of these factors notably **Karl Marx**, the German economist in the nineteenth century, and **Gunnar Myrdal**, a Swedish Nobel prize winner in the twentieth century.

Economic growth
The growth of the real output of an economy over time. **Economic growth** is a function of growth of capital, labour, **natural resources**, allocative and technical efficiency, and the level of aggregate demand. **Economic growth** is usually measured by the **gross domestic product** and divided by the total population (GDP per capita); this allows for fluctuations in both the product and the population served. Different models of the critical factors in determining **economic growth** have been proposed, including those of **Domar, Harrod, Solow and Romer.** In assessing the importance of measures of **economic growth**, it is important to recognise that GDP includes only those outputs that are traded. All other goods and services are zero valued including many of the **natural resources** such as seas, lagoons, rivers and lakes, mountains, air and primary uncut forest, which may constitute the principal sources of wealth in small states and in SIDS.

Economic systems
Interconnected strategic and operational elements that provide mechanisms for dealing with the problems of scarcity and choice in the use of resources for promoting wealth and welfare in societies. The principal economic systems are commonly recognised as the market system; the centrally planned system; and the mixed economy, which has elements of the market and the planned system within it. These traditional economic systems tend to neglect the value of **natural resources**, since they normally zero value those **natural resources** that are not used, not included in plans and not traded. **Environmental and natural resource economics** provide methods for correcting such limitations in the traditional economic systems.

Economic theory
The presentation and development of a testable model of the way an economy functions, the relationship of the specific model to other models and the expected outcomes of the interplay between variables.

Economic transition
The transition from an economy dominated by subsistence agriculture to one with a wide range of activities. The transition normally includes the promotion of intensive mechanised agriculture, mining and manufacturing industry, and services (such as tourism, financial services and social services). This transition is associated with **demographi**c and **epidemiological** transitions. The process transition of an economy produces new stresses on **natural resources** and promotes a reduction in natural forests, and the degradation and **pollution** of land, water and air. It is often associated with unplanned urban development, the intrusion of infrastructure into rural areas, including electrical and communication pylons, roads, railways, sea and airports, together with energy production and waste disposal systems. In SIDS, these can become dominating features of what was otherwise landscape of outstanding natural beauty and a principal attraction for the key service industry of tourism. How far economic transition of SIDS can be accomplished within an island's ecological carrying capacity, without critical loss of the natural heritage and its non-use value as a setting for tourism, is a challenge for policy-makers and planners that is yet to be fully addressed.

Economies of scale
The effect of a reduction in the average and marginal costs of each item produced as the scale of production is increased. At some critical point in the increase of scale of the production function, however, average and marginal costs may rise when extra costs of management, maintenance and increased costs of capital equipment and infrastructure may be incurred. Traditional approaches to accounting do not include **externalities** and other 'economic' perspectives of cost in the assessment of economies of scale in the production function. **Environmental economics** provides concepts and methods of calculation for overcoming these limitations, including the valuation of environmental impact and the **opportunity costs** of natural capital. A characteristic of small states and SIDS is their limitation on achieving economies of scale across a wide range of goods and services, which contributes to their vulnerability, due to the small size of their local markets and the high transport costs attached to exports.

Ecosystem
The system of interdependence of living organisms and their natural **environment**, in which nutrients and matter move continually between the integral components in patterns that can be defined, often in cyclical pathways.

Ecological economics has especially focused on the ways in which human development affects the functioning of ecosystems and how ill-identified or ill-managed **externalities** adversely affect the sustainable delivery of essential **environmental goods and services**.

Efficiency
The micro level efficiency is the ratio of factor outputs of goods and services to the factor inputs measured in physical or in monetary terms. (See **Parkinson's Law** and X-inefficiency.) At the level of the market, optimal efficiency has been attained when it is not possible to reallocate resources to make one person 'better off' without making another

person 'worse off'. Classical economists assumed that in a perfect market the 'market mechanism' of the 'invisible hand' ensured that long run efficiency of allocation of resources was achieved. A distinction is commonly made between allocative efficiency and technical efficiency. The former is concerned with the best allocation of resources; the latter with the best use of resources once allocated. Welfare economists recognise that market failure is a common factor and that the principle of distributive justice is seldom achieved without external intervention especially with regard to the allocation of social products (sometimes called merit goods or public goods) such as education, health services, security and environmental services such as water, clean air and waste disposal. In these cases, the link between consumption, payment and ability to pay is often indirect or obscured. (See **public goods**.)

Elasticity of demand
The responsiveness of demand for a product or service when one of the principal determinants of demand is changed, such as price or income. Elasticity is presented as a ratio of demand over the dependent variable (price, income, etc). The demand for basic requisites for human life such as food, housing, water and public transport, tend to be inelastic with respect to price, the same applies to common drugs of addiction such as tobacco and alcohol. In these cases, if price increases by say 10 per cent, the demand will fall by less than say 5 per cent. Luxury goods and services such as private transport, eating out and foreign holidays, tend to be elastic with respect to price. In these cases, if the price rises by say 10 per cent, one can expect a similar fall in demand, other things being equal. (See also the **Veblen effect**.)

Emissions trading
Emissions trading (or emission trading) is an administrative approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. It is sometimes called cap and trade.

Environment
The external conditions that affect the life of organisms (persons, other animals, plants, etc.). These conditions include the non-living features and the relationships between living organisms and the ecosystems in which they exist. The concept of **Environment** may also be applied to the internal conditions within an organism which affect its life and which may be affected by external conditions. In economics literature, there are five factors of production: land, capital, labour, organisation and entrepreneur. Environment can be defined as land, as natural capital or as a combination of land and natural capital. Land is defined to include surface of land, anything residing below land and anything coming to land surface from above. Soil, surface-water and underground water, sunrays, rainfall, atmosphere and climate are different forms of land and are examples of environmental goods. Minerals and oil are exhaustible **natural resources**, and forest, bio-diversity and river water, underground water and ocean water are examples of non-exhaustible **natural resources**. The latter can be replenished under given conditions. All types of environmental goods and services are also called natural capital. (See Nath's chapter: *Concepts and public policy issues in environmental and natural resources analysis.*)

Environmental accounting
A system of accounting for the value and price of non-market goods and services. This includes many **natural resources** and environmental goods and services, which are not traditionally valued in accounts, if they are not directly traded in the market. Such methods start with a recognition that standard methods of accounting do not adequately include the value of depletion of **natural resources**, although depreciation of other capital resources are accounted for; nor do they include the external impact on the **environment** of the production, distribution, sale and use of other goods and services. Environmental accounting attempts to remedy these omissions and provides an assessment of how far the use and consumption of **natural resources** is sustainable. Merely accounting for loss of non-renewable **natural resources** is not considered by environmental accountants as sufficient as a policy tool. The cost of substitution has to be considered. Methods adopted to correct for these accounting issues include: adjustment of net cost and income to account for use of **natural resources**, and the **externalities** of trade upon them, and evaluation of **natural resources** as assets taking into account their direct use, indirect use, non-use values and intrinsic use values. (See Madhoo's chapter: *Valuation of non-market goods and services.*) It is a fashion these days to call environmental accounting 'green accounting'.

Environmental economics
That part of the study of public economics focused on scarcity and choice in the use of **natural resources** for securing human welfare. Major concerns of such studies include: the impact on the **environment** of the production, distribution and use of goods and services (as in the economics of **pollution** control and energy production); and the development and use of economic and other policy instruments for correcting **market failure**. This aspect of economics gives special attention to the use of **natural resources** as public assets which contribute to human welfare. The growing interest in environmental and natural resource economics is reflected in the *Journal of Environmental Economics and Management* (since 1974). The discipline has followed the lead in **welfare economics** given by **Pigou** and **Hotelling** through their analysis of **externalities.** Another area of interest has been the application of **cost-benefit analysis** to environmental concerns. Central themes of the discipline have been the extension of economics to environmental issues, the development of pricing of environmental assets and the evaluation of the impact of changes in **technology**. In **developing countries** there has been a special focus in these studies on **property rights**, social welfare, population displacement, **governance**, **information** and issues of the distribution of costs. A further area of study has been that of financial incentives for protecting the **environment**, compensation for loss of environmental resources, pricing the provision of environmental services such as water, sanitation, communications and waste disposal. The discipline has contributed greatly to the recognition of the neglect of valuation of **natural resources** as **natural capital**. This has placed natural resource valuation as a key element in the assessment of progress in development and human welfare. Concern for the rate of consumption of non-renewable **natural resources** has promoted fresh debates on the approaches to measuring progress in **development**, moving away from **GDP** to new indices which incorporate impact on the **environment** and a human welfare function. (See for example, **Happy Planet Index**.)

Environmental goods and services
Things derived from nature which ensure life support and which people prefer more of rather than less, such as clean air, animals, grazing land, fruits, sunshine, shade and water; whilst air **pollution**, water **pollution** and hazards, such as sea level rise, are bad. Environmental goods and services depend upon the proper functioning of the ecosystem and the continuous interactions within it between organisms, including man, and the physical, biological and chemical environments. Some environmental goods and services may be considered as capital (i.e. a stock of assets) such as land, seas, and even trees; whilst others can be considered as non-capital environmental products or services such as fruits, grass, fish, and fowl. Pearce and Barbier (2006, op.cit.), classify environmental goods and services into the support for four types of **ecosystem** functions:

- regulation functions (e.g. biodiversity control, climate regulation, storage and recycling of waste, continuous nursery and feeding habitat, watershed regulation);
- production functions (e.g. oxygen, food, drinking water, materials for physical construction, energy and fuel, medicinal uses, genetic resources, ornamental);
- carrier functions (e.g. habitat, agriculture and forestry, industry, recreation, conservation); and
- information functions (e.g. providing scientific, aesthetic and cultural benefits).

The balance between environment goods and bads determines the sustainability and efficiency of these environmental functions essential for ecological survival.

United Nations Environment Programme (2005) has developed the following classification of goods and services in order to facilitate preferential treatment of goods and services in international trade.

- Goods destined to be used in environment remediation or clean up (e.g. oil spill remediation equipment), prevention of environmental damage in industrial processes (e.g. air pollution control, waste management, energy savings), or equipment for environmental monitoring and analysis.
- Technologies and products that, in their use, are more environmentally friendly than the norm. This includes consumer goods such as electric cars and producer goods such as wind turbines and technology for cleaner burning of coal.
- Goods and services that have been produced in environmentally-friendly ways (e.g. organic produce, recycled paper).

(See Nath's chapter: *Concepts and Public Policy Issues in Environmental and Natural Resource Analysis.*)

Environmental impact assessment (EIA)
An evaluation using a standard defined methodological framework to identify the expected impact on a particular **environment** by the introduction of a new process or infrastructure, to assess the extent to which it may adversely affect the existing ecosystem and to recommend either interdiction or mitigating action that could be taken to reduce the anticipated damage. (See also Strategic Environmental Impact Assessment in Madhoo's chapter, *Impact Assessment and Biodiversity Conservation: An Application of EIA and SEIA.*)

Environmental Kuznets Curve (EKC)
The EKC hypothesis is that the relationship between income per capita and environmental emissions has an inverted U-shape. In other words, at relatively low levels of income, emissions increase with income, but after some 'turning point' emissions decrease with income. The econometric methodologies used to empirically test the existence of EKC are subject to severe limitations and hence the existence of a U-shaped relationship remains controversial. Moreover, evidence suggests that the existence of an EKC appears to vary according to the pollutant.

Environmental performance
An assessment of the outcome of environmental management. A national level index developed jointly by Yale and Columbia universities in the USA, it combines reducing environmental stress on human health, promoting ecosystem vitality, and sound management of **natural resources** using 16 indicators across 133 countries and a proximity to target methodology. A pilot study was published in 2006. (See www.yale.edu/epi)

Environmental tax
Taxation is one of a number of **policy instruments** designed to achieve environmental improvements or the reduction of **pollution** and degradation. Taxation has been used in relation to a number of environmental protection issues including: energy tax, to reduce energy consumption; motor vehicle tax to discourage the use of high fuel consumption vehicles and to pay for the cost of road maintenance and development; congestion tax to reduce use of roads in high-use areas such as cities; reduced taxes and exemptions for environmentally-friendly products and services. Many countries are now initiating environmental tax reform (ETR) which aims to shift tax away from environmentally and socially-friendly activities whilst placing more tax on **pollution** and environmentally damaging activities. Examples include: Denmark's carbon tax with reduction in employer and income tax; energy tax with reduction in employer social security levy; Norway's eco-taxes with reduced environmentally harmful subsidies and payroll tax. (See also **Pigouvian tax**.)

Epidemiological transition
The transition, associated with development, of the pattern of diseases and death in a population. **Developing countries** have an epidemiological pattern of early death and disability, dominated by infectious diseases, infant death and maternal risk. Developed countries have a pattern of longer life resulting from the mastery of infectious disease, through public health measures and other aspects of social development (such as food security, decent housing and education). In developed countries that have passed through this epidemiological transition, people live longer and the pattern of diseases shifts to non-communicable diseases (such as heart disease and cancers) and to accidents and traumatic injury, as the dominant causes of death and disability.

Equilibrium
A state of balance. In the case of market prices it is achieved at the price where the quantity demanded of a good or a service is equal to the quantity supplied. Environmental

equilibrium is achieved where the supply of environmental services that is sustained, renewed or replaced is equal to that which is consumed.

Equity
Fairness and justice in the distribution of costs and benefits in human society and the mechanisms for adjudicating on claims. In **environmental economics**, inter-generational equity is a key concern in which the claims of future generations to enjoy the opportunities offered by plentiful **natural resources** are given due weight in assessing the costs and benefits of development policies. Intra-generational equity is achieved when these resources are fairly available to different social and income groups of the same generation.

Externalities
Cost and **benefit** factors which are not included in prices but which have an effect on human welfare. **Pollution** is a prime example of an external cost imposed on society by the production, distribution, and use or disposal of other goods and services. Other examples of external costs are accidents and injuries in work. Examples of external benefits are the use and non-use values of public and private parkland and protected environments. Training of workers in one firm or country who then become available to be used by another is an example of an external benefit not included in the cost or price paid. Depending on the benefits and costs, these externalities are called positive or negative externalities. Recognition of **externalities** is an important element in the adaptation of **economics** as a discipline in providing advice and support to **small states**, where their **natural resources** and the health of their populations are critical resources for **development**.

Fiscal policy
Government commitment to action on gathering income, and managing expenditure and debt as tools in macro-economic **policy** to influence economic activity, including production, consumption, employment, prices, trade, savings and investment.

The word fiscal derives from the Latin words (*fiscus*, *fiscalis*) for the public treasury of ancient Rome or the emperor's privy purse. Fiscal policy may operate through government commitments to expenditure, changes in liability to taxation and taxation rates, and the application of taxation, trade tariffs and economic incentives to affect the demand and supply of different types of goods and services.

Fiscal policy at national level is commonly reviewed and amended annually through the national Budget process. Following the global economic and financial crisis of 2008/9, many governments and international financial institutions have introduced supplementary fiscal stimulus packages before their annual Budgets. These have included emergency measures of taxation, subsidies, loans, public works and government management of elements of the financial sector, to respond to the collapse of banking and capital markets. In some cases these measures have included 'green taxation' to steer economies towards development that is more sustainable with respect to its impact on **natural resources**. (See also **Taxation, Green taxes,** and **Sustainable development**.)

Forest
A land area of more than 0.5 hectares with trees higher than 5 metres, with foliage cover of more than 10 per cent, excluding land that is predominantly used for agricultural purposes or for urban land-use. Forests can be naturally occurring or planted or both.

Free trade
International trade operating free of constraints such as tariffs, subsidies, quotas, and exchange controls. In the late eighteenth century and in the nineteenth century in Europe, free trade was a policy, indeed a 'political movement' in opposition to the previously existing mercantilism, a wide-spread eighteenth century system of trade controls and protectionism designed to produce balance of trade surpluses to increase money supply and thus stimulate the economy.

Free trade is now a policy, in principle, promoted by GATT, WTO and the regional 'free trade areas' such as European Union, EFTA and NAFTA, but closer examination shows that even within these areas many trade constraints operate to the disadvantage of external competitors. In response to the 2008–2009 global financial and economic crisis, many voices have been advocating the rejection of free trade and a reversion to protectionism verging on the mercantilism of the eighteenth century. For **small states and SIDS** the recognition of their special and differential interests in adapting global free trade principles to the specificities of their development needs to be a key element in their dealings with WTO, GATT, UNCTAD and the EU to overcome the constraints of the un-level playing field of international commerce. (See Box 17 Chapter 8, p. 292, *The COMESA countries and the un-level playing field in African Environment Outlook 2,* Progress Press, Malta for UNEP, 2006 http://www.unep.org/dew/africa)

Frontier expansion model
A model encompassing the process of the opening of new land frontiers through trade and colonisation to promote **economic growth**. This process was a dominant feature of **economic growth** for European countries in the period 1870–1913. The European countries imported scarce **natural resources** (such as cotton, wool, other agricultural products and minerals) for use in industrial production and then exported manufactured goods (such as ships, steel, pottery, engineering products, railways and transport, electrical systems and components, household goods), and also services (such as education, health and engineering design) to assist the development of the colonies. But the impact of these polices on **developing countries** was in many cases unfavourable due to:

a lack of re-investment of income;
b low productivity of land after exploitation for the natural resources;
c lack of spill-over from technologies used in natural resource exploitation to other sectors of the economy;
d market and policy failure, corruption, the use of military power to impose exploitation of natural resources, and
e lack of commitment to sustainable development through regulation and re-investment.

Policy reform can however overcome this vicious circle by exposing such forms of exploitation, through greater transparency in policy-making and better governance.

Game theory

Use of logical analysis methods for exploring the outcomes of the interaction of competing players. The theory is loosely based upon deductive methods used in playing card games, chess and other games of chance and interactive play. The common feature is that the success of the pursuit of an objective by one player is constrained by the responses of other players. The theory had its early development in the 1940s and 1950s by a mathematician, von Neumann, and an economist, Morgenstern. It has had early applications in marketing and other aspects of management and in both positive (what decision-makers do) and normative (what decision-makers ought to do) perspectives. Around 1950, John **Nash** developed a definition of an 'optimum' strategy for multi-player games where no such optimum was previously defined, known as the **Nash** equilibrium. This concept was further refined by Reinhardt Selten. These men were awarded The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel in 1994 for their work on game theory, along with John Harsanyi who developed the analysis of games of incomplete information. (See also **Nash** Equilibrium.) More recently game theory has been applied to **environmental economics**, especially in the management of fisheries and common land, by adaptation of the classic game theory concepts of interactive assessment of pay-off developed by A.W. Tucker (1950) in the 'prisoners' dilemma'. Examples of the application of this approach in **environmental economics** include: the management of emissions to reduce acid rain; the management of road congestion; farmers' use of common grazing; and fishermen who share the use of marine areas. The theory covers both competitive and cooperative games in which the common theme is to arrive at the best pay-off for the parties involved, which may be equivalent to a **Pareto** equilibrium. (See Hanley, N. et al. (2001) *Introduction to environmental economics,* Oxford University Press.)

Gross domestic product (GDP) (and real GDP)

Gross domestic product (GDP) is the aggregate monetary value of all goods and services produced in an economy in a given period, normally a year. The measurement can be made in terms of incomes, expenditures or added values. GDP excludes income from abroad and capital consumption. GDP normally takes no account of the value of **natural resources** consumed, expended or increased except those that appear in the income and expenditure accounts. Real GDP is a statement of GDP over a period of time to allow secular comparison taking into account inflation. **Environmental accounts** are now commonly being developed to adjust standard national accounts to reflect the use and value of **natural resources** and environmental services. National income accounts which capture the environmental and natural resource costs are known as green national income accounts.

GDP at purchasing power parity (PPP)

Purchasing power parity (PPP) figures are produced to adjust national figures in international monetary comparisons taking into account the differences in the cost of living in different countries that are not accounted for by exchange rate values of the national

currencies. The figures are based upon the local cost of a standard 'basket of goods and services'. In Mauritius in 2004, 2.7 times the number of goods and services could be purchased in Mauritius for each dollar when exchanged at the then existing rate for rupees. The difference partly reflects lower local prices of labour, housing, locally produced food, drink and textiles. It is also a function of the mechanism for determining local exchange rates. PPP has many limitations, especially as a surrogate measure for quality of life, not least because the quality of goods and services in the baskets may vary from country to country, and other factors may affect quality of life assessments such as security, schooling, health services, **pollution**, governance and the perceived quality of the physical and social **environment**, etc. Exchange rate values are also affected by the fact that currencies are traded for other reasons than to buy and sell goods and services; they may be traded in terms of their value as capital assets unrelated to their value in terms of consumer goods and services.

Globalisation

Globalisation is a term used in many different ways to express the idea that the rate of change in common aspects of our ways of life has rapidly increased, spreading a conformity world-wide in terms of economic, social, religious, cultural and political characteristics. The process is seen to be promoted by international public and private institutions. Some people consider this a boon, others a burden. This conflict of views has given rise to pro- and anti-globalisation movements. One key issue is the distribution of the gains and losses. People in many developing countries have expressed concern that they will remain poor whilst the richer countries and multinational companies will get richer. The rapid spread of dominant social, economic, religious, cultural and political systems has been a common feature of human history from the time of the Pharaohs, the Greeks, Romans, European Christian, Turkish Muslim and Soviet empires. The designation of globalisation today to refer to more recent trends in the spread of cultures has been influenced by the perceived power of mass media communication (telegraph, radio, cinema, TV, computer, internet). A large body of literature has been developed around the term, with much controversy about its meaning, its significance and how to identify and measure its spread and impact (for example, see Held, D. and Mcgraw, A. (2002) *Making sense of Globalization* Ch 1 in *Globalization/Anti-globalization*, Cambridge: Polity). Others have been more focused on its implications for sustainable development, international social justice, and the reform of development theory and practice (see Stiglitz, J. (2006) *Making Globalization work*, Allen Lane).

Global public goods (see also **Public goods**)

Gross national product (GNP)

The total money value of all final goods and services produced in an economy over a defined period (usually one year) plus net property income from abroad. It is distinguished from **gross domestic product** (GDP) by the inclusion of income from abroad. In many small states income from abroad through remittances can be a substantial proportion of national income making a large difference between GDP and GNP figures for such countries.

Goals, aims, objectives, activities (see also **Logical framework**)
Identified points of aspiration or desired achievements or outcomes of action, normally distinguished by increasing levels of specificity, with goals being general, aims and objectives being more specific, and activities being the action taken for their pursuit. These concepts are a common feature of rational planning which tries to define aspirations within a tightly presented framework. The underlying assumption of such systems is that change can be planned mechanically and that progress is a process of rational management in closed systems, with predictable linear progress though milestones of change. Examples of the use of the goals and logical framework systems for planning are in the UN system of the **Millennium Development Goals** and in standard EU procedures for programme and project planning. The logical framework approach is derived from the application of 'Systems Theory' to management, which has more recently been radically adapted in the light of approaches derived from 'Chaos Theory' and the concepts of complex adaptive systems. This more recent behavioural approach to planning and management recognises that organisations are sensitive to initial conditions and subject to unpredictable external forces, through which their sustainability is best protected by nurtured instability and continuing dynamic adaptive capacity. This adaptive **management** approach assumes that the future is unpredictable and the relationship between elements in a system are short-range, that any observation of a system is subjective and the people involved in and affected by any system have different mental models of it. This makes the pursuit of goals derived from a shared vision a complex, if not impossible and fruitless, undertaking.

Governance
A term used in economics and political science to cover the **management** process of states, corporate bodies, companies, assemblies, judicial bodies, etc. The term embraces common concepts such as openness, participation, accountability, transparency, probity, **effectiveness** and coherence. Various comparative measures of governance are available to show the relative levels of governance in different countries. The term is applied to the management of the **environment**.

Government failure
Where governments fail to act to correct for market failure or fail effectively to implement sound laws. Markets fail due to the presence of public goods and monopolistic tendencies. Environmental issues are strewn with examples of government failure, as a result of delayed or ineffective formulation of environmental protection laws and policies, or inadequate enforcement of them. This failure may result from legislative or bureaucratic incompetence, or from conflicting commercial pressures and political favouritism or direct corruption. The failures may involve a variety of areas of intervention including legislation, government expenditure, fiscal policy, exchange rate mechanisms, trade and capital controls, price controls, taxes, subsidies and lack of administrative probity. Such failure occurs technically where the private costs which result in adverse environmental degradation do not adequately reflect the full social cost of that damage.

Greenhouse gases (GHG)
A gas which, like a pane of glass in a greenhouse, absorbs solar rays, warming the earth's lower atmosphere and surface and thus, it is believed, contributing to climate change. Such gases include carbon dioxide, methane, nitrous oxide, chlorofluorocarbons and ozone. Burning fossil fuels such as wood, coal and oil in industrial and domestic processes and transport is thought to raise the temperature of the lower atmosphere and to contribute to the melting of the polar ice-caps, raising the level of the sea and increasing the frequency and intensity of extreme events such as cyclones and storms, floods and droughts. GHGs are also thought to be affecting the loss of the ozone layer that protects the penetration of ultra violet radiation through the lower atmosphere which can cause mutations in the genetic material of plants and animals.

Green taxes
Taxes whose objective is to promote environmentally-friendly behaviour by consumers and producers or to implement the 'polluter pays principle'. Examples include: carbon tax, landfill and energy taxes. The development of a package of 'green taxes' is referred to as environmental tax reform (ETR).

Habitat
The place where a population of organisms occurs and are sustained naturally. The sum of the environmental elements which constitute an interdependent community of living organisms and the natural home of animals and plants.

Happy Planet Index
A method of comparing relative human progress and its impact on the **environment**, developed by the New Economic Foundation (NEF) in the UK. The NEF presents national human welfare as assessed by the index function: mean National Life Satisfaction X mean National Expectation of Life/mean National Ecological Footprint. In this the SIDS come out well showing higher efficiency in producing human welfare per unit use of environmental resources than many more developed and larger countries. (See Marks N. et al. (2006) *Happy Planet Index, NEP*, http://happyplanetindex.org)

Hazard
An identified object, activity or event which could give rise to injury or damage to people or the **environment**. Hazards may arise from natural phenomena such as submerged rocks or icebergs at sea, volcanoes and avalanches, or from human activities, such as dangerous sports or industrial processes, from built infrastructure such as high-power electricity pylons and deep mines and quarries. Hazards may be classified in terms of their location, level of risk, and the frequency and extent of causing loss and damage.

Hedonic pricing method (HPM)
A method of pricing of goods or services using surrogate markets to estimate the values of non-marketed items. For example, the environmental value of houses in 'quieter' sites, overlooking parkland with low noise levels, good air quality, etc. may be assessed by comparison with prices of houses in different areas. The assumption is that people's values

for certain qualities can be inferred from what they are prepared to pay for them. The method of assessment using house prices for valuing environmental assets assumes perfect information, the analytical capacity to allow for other values, the stability of the housing market and zero valuing of benefits to people other than the house buyers.

Human capital
That aspect of **capital** that consists of knowledge and know-how, which is increased by education and training. Human capital is the stock of productive skills and technical knowledge in labour. It can be increased by investment in education, training and even health care. The term derives from **Karl Marx's** concept of labour power and the distinction made by **A.C. Pigou** between investment in material and in human capital. It has the characteristic of being expandable by experience, transportable through communication, but not transferable in terms of ownership like land and fixed capital. Many early theorists refer to it as labour, but in recent years it has become a specific aspect of the study of capital, notably through the work of the 1992 Nobel prize winner in economics Gary Becker through his perspectives linking sociology and economics. *'The Economic Way of Looking at Behaviour'* (Gary Becker, Nobel lecture 1992).

Human development index
A composite statistical index developed for the United Nations Development Programme (UNDP) which combines national **indicators** on income, education and health for the assessment of relative levels of human development as a measure of social and economic progress. The SIDS appear across the whole range of the classes of the index which is presented in annual Human Development Reports as both an index number and a rank order divided into three broad classes: high, medium and low human development. See www.undp.org

Increasing returns to scale
The increasingly greater rate of growth of an output associated with increasing level of input. To be more precise, if all inputs are increased by 10 per cent and output increases by more than 10 per cent, then it is a case of increasing returns to scale. It is often observed that this pattern of increasing returns to scale occurs during a particular phase of industrial or environmental production. In other phases, the returns to scale may be constant, diminishing or even negative. In environmental studies the carrying capacity of a habitat may determine the pattern of returns to scale of input factors; desertification and total loss of endemic species may be the final stage of over-exploitation of natural habitat.

Index number
A single value of a variable that allows comparison over time or between entities (such as countries or companies). An index is commonly a summary composite variable derived from a number of different variables such as in the retail price index (RPI) (combining the prices of a defined set of goods and services), the Human Development Index (HDI) (combining levels of education, income and health), the **Environmental Performance Index** (EPI) (combining different aspects of environmental governance), or **the Happy Planet Index** (HPI) (combining length and satisfaction with life and the **ecological footprint** of

populations). The elements in a composite index have defined weights whose values may be based on the results of social and market surveys of behaviour or opinion.

Indicative planning
A method of planning based upon the defining of objectives and the design of programmes to achieve these objectives, using performance indicators as measures of commitment and achievement. In a centrally planned economy, indicative planning replaces the market mechanism; in a mixed economy, indicative planning may supplement the market mechanism and be focused on overcoming specific aspects of market failure, such as support for underdeveloped regions (as in the EU), for environmental protection, for poverty relief and for minority groups. In the public sector, indicative planning may be the principal mechanism for planning in health, education, physical infrastructure and local community services (police, waste management, roads, etc.).

Indicators
Measures of quantities and qualities used for evaluation of states and trends in phenomena. In planning and evaluation, indicators in use are commonly divided into three groups: inputs to processes; service levels; and outputs and outcomes. The **Millennium Development Goals** (MDGs) system adopted by the UN includes 48 indicators for assessing the progress towards the achievement of 8 Goals. The indicators in the MDG system have target levels against which progress can be assessed. The UN, through its agencies, compile data on a variety of environmental features using national indicators collected by all countries in accordance with standard methods. FAO and UNEP are the principal sources for international comparative data on environmental indicators; the Commonwealth Secretariat compiles data on 60 small states and SIDS, with indicators covering population, economy, demand, trade, commodities, exports, agriculture, public finance, exchange rates, money supply, labour, demography, health, education, gender, transport and communications. The World Resources Institute, supported by UNDP, UNEP and the World Bank, maintains a regular biennial review of trends in environmental and related data and an analysis of environmental governance. (See www.wri.org for online version.)

Information
What is understood by a particular sequence of symbols. Sometimes defined as 'useful' data, or 'objective oriented' data, that is data for decision-making. The distinction between data and information is in the use to which it is put. (See also **data**.)

Information asymmetry
Where the actors in a market have different levels of **information** about the market, some more, some less, some better in quality, and others worse. This is a feature of imperfect markets. An essential condition of the perfect market is complete information amongst all the actors. In the absence of complete information it is common for actors in a market to engage specialist agents, or to undertake training to acquire specialist skills, or to use special tools, to overcome these information gaps. These devices allow the actors to operate more efficiently and also to compensate for market failure. Examples of imperfect markets with information asymmetry abound, but they include medicine, equities and futures.

The development of general education, encyclopaedias, the media, the telescope, the internet and mobile phones have all contributed to reducing information asymmetry. The invention of the telescope allowed buyers to identify ships safely approaching port as they were bidding for the merchandise the ships were carrying. Independent fishermen using mobile phones can now take their catch to those markets offering the best prices. Consumers, before making a purchase, can use the internet to check availability, prices and reviews by consumers' associations with their independent assessments of quality of goods and services. Patients, before going for a consultation, can use the internet to check their likely diagnosis and even the success rates achieved by a specific surgeon or hospital. Increasingly the internet and other media are overcoming the information isolation of SIDS in global markets.

Intangibles
Variables within economic assessment that can be identified as relevant and maybe important in appraisal but are difficult to quantify and value, such as scenic impact, risk of injury, and nuisances like noise and odour.

Interface
The linked surfaces between two elements in a system which may give rise to specific interactions. In governance there is an interface between policy and its implementation. At this interface there exist many conflicting and often powerful vested interests and pressure groups which may promote the policy or deflect it from its intended course.

Invisible hand
The image used by **Adam Smith** (author of the classic 1776 text *An Inquiry into the Nature and the Causes of the Wealth of Nations*) to characterise the mechanism by which market forces co-ordinate the actions of buyers and sellers in the market with the effect, he claimed, of maximising individual welfare and overall economic efficiency. Smith postulated that an individual, by pursuing his own good, tends to promote the good of the community, as those actions which are profitable for him will also be the most beneficial and efficient for the community. But the problems arising from market failure, especially in the field of child labour, health and safety, cartels, and the **environment** (see **Tragedy of the Commons**) have, since Smith's time, given rise to specific controls on the free market to protect human welfare and the **environment**. Examples of government intervention are manifold and include legislation against child labour, excessive hours of work, health and safety at work, minimum wages and physical planning. These illustrate the practical limits of the free market theory. Some of these issues were anticipated by Smith who recognised the need for government intervention. They have continued to be a focus for political debate and economic theory. (See Foley, D.K. (2006) *Adams fallacy, a guide to economic theology,* Belknap Harvard.)

Land
Those parts of the earth's surface, normally exposed above water and sea levels, providing opportunities for **habitat** for animal and plant life (see also **Environment**). **Africa** is the second largest land mass in the world with a total of over 3,000 million hectares, 3 times the

size of the USA. It contains 53 sovereign states, Sudan being the largest and Seychelles the smallest. Mauritius is the most densely populated state in Africa with 583 people per 100 hectares. Africa is rich in **natural resources** including forests, arable land, mountains, coastal and freshwater systems. Its mineral resources include gold, diamonds and copper, cobalt, and platinum. Desert and semi-desert zones cover 66 per cent of the African land area. Loss of forest cover, land degradation and desertification are major problems in land management in Africa, arising from population growth, cropland expansion, urban expansion, chemical contamination and war. Integrated policies for promoting improvements in land use for the protection of biodiversity and human well-being are explored in the UNEP core publications *Global Environment Outlook* and the *African Environment Outlook* which have special sections on SIDS. (See S. Nath Chapter, *Concepts and Public Policy Issues in Environmental and Natural Resource Analysis.*)

Limits to growth model
The model adopted by Donella Meadows in *The Limits to Growth* 1972 by the think tank the 'Club of Rome' to draw attention to the rate of use of global **natural resources**, the environmental impact and the implications of economic and population growth. Using a series of computer simulations on then current data and trends, the study concluded that if the growth trends continued unchanged *'in population, industrialization, **pollution**, food production and resource depletion, the limits to growth on this planet will be reached within 100 years'*. The publication was followed up with the 1992 re-assessment, *Beyond the Limits*, (Earthscan), which re-examined the doomsday scenario but set out the principles on which sustainable development might be technically and economically feasible, with an easing of population and **economic growth** and a sharp increase in the efficiency in use of energy and **natural resources**.

Logical framework (see also **Goals, aims and objectives**.)
A form of design of work programmes and their presentation, for the purposes of planning, and of programme and project management. The logical framework relates items of expenditure to activities linked to targets on measurable indicators, which are then used for monitoring progress towards the achievement of specific goals, aims and objectives, through specific activities. The process has been popular in US and in European planning within the management of programmes in the EU and elsewhere. The form used for presentation normally is a table in which the rows are the events that take place as a programme is implemented, that is via goals, purposes, outputs and activities. The columns of the table identify information about the events in each row, namely:

- narrative description;
- objectively verifiable indicators;
- means of verification; and
- assumptions.

The framework depicts the argument that if these assumptions hold, then these outputs will be delivered, and this purpose and goal will be achieved. Normally, the framework is linked to estimates of costs and timescales.

The process has many adherents but also critics who focus on a number of weaknesses including its inflexibility as a management tool where initial situations change and projects develop in unexpected and maybe more fruitful ways; the impact of external events and factors excluded from the initial deterministic framework; unrealistic timescales and prices; weaknesses in the evidence linking inputs to outputs; and the frequent dependence of the achievement of specific outputs on external multiple factors not included in the project, or the assumptions. The use of the framework for evaluation has similar weaknesses tending towards its use for audit rather than for learning about better programme processes and better management. The logical framework fits best where the evidence base for an intervention is well established and the assumptions on which performance is based are subject to direct control. Much of the work in environmental management is at present at the margin of science and more in the field of research and development, for which the established forms of logical frameworks are least likely to be appropriate to obtain useful results.

Management

The process of being in charge of an undertaking and controlling the use of resources for defined ends. It can include policy development, planning, resource mobilisation, resource allocation, control of supply, production, marketing, sales, distribution, employment, capital investment, maintenance, public relations, finance, monitoring, evaluation and performance appraisal, customer and public relations and succession. In the twentieth century, management as a process of professional activity was promoted by three broad global transitions in institutional arrangements. In the private sector, ownership became separated from management and a new managerial class emerged distinct in the social structure from the classes of workers and capitalists. Second, in the public sector, procedure-based administration of services was increasingly transmuted into objectives-oriented management, with defined goals, monitored by targets and fuelled by performance-related pay and appointment and promotion on merit. Universities supported this through their masters programmes and new business schools. Thirdly, in national and international NGOs, especially in the UN and intergovernmental organisations, new protocols for service provision were emerging based on defined goals, with activities and budgets set within a **logical framework** for achievement. Management of **natural resources** are now being fundamentally influenced by these global trends in the oversight of programmes concerned with the principal areas of concern (**land, water, fuel and energy, coastal and marine, biodiversity, and environmental conservation**). These have become increasingly developed areas of professional management and economic and scientific enquiry world-wide as part of the process of global economic and social development. The professional, evidence-based management of **natural resources** is becoming a vital component in national and international governance. (See also **goals, aims, objectives; managerial theories**.)

Managerial theories

Theories devised to explain the behaviour of companies which do not conform to **classical economic theory** since they do not evidently pursue the long term end of profit maximisation, through the process of optimally combining quantities of factor inputs to produce goods and services. The principal alternative management theories are:

- the Marxist theory that the capitalist system in the long run leads to bankruptcy of firms, the impoverishment of labour, the collapse of the state and the essential conditions for social revolution;
- the corporate managerial theory in which the separation of management from ownership leads to the substitution of managerial-linked objectives such as maximising sales or managerial income instead of the maximisation of the profits of the firm; and
- the behavioural theories of the firm in which the long-term behaviour of the firm is a function of its complex social organisation, conflicts and inconsistencies arising from the functioning of the social groups within and related to the firm.

The application of managerial theory to environmental governance is in its infancy. Much effort has been given to the identification of outputs and outcomes (such as through the development of performance indicators, the monitoring of **climate change** and the development of specific economic and regulatory instruments); less attention has been given to the institutional framework for management, the public private sector interface, the study of management behaviour and the micro economics of production functions for environmental goods and services.

Marginal analysis
The examination of the quantitative implications of the increase or decrease of one unit of a specific variable such as an input or an output on other variables. The changing slope of the relationship between two variables such as cost and output can be of critical importance in determining the optimum volume of production. In **environmental economics,** it also has relevance in assessing the critical point in monitoring environmental trends, where the carrying capacity of an ecology in supporting a species is reaching its limit and where the rate of renewal of the ecology and the reproduction of the species begins to slow and then declines. Marginal analysis, for example, can be of use in the monitoring of fish stocks in relation to volume of fishing, and in the monitoring of tourist arrivals in relation to volume of tourists in situ. It has been found that social attitudes of support for the protection of an endangered species, expressed as the marginal willingness to pay for protection of that species, vary inversely with the number of that species alive.

Marginal cost
An increase in total cost due to production of an additional unit of output. Since most economic decisions are taken at the margin, marginal analysis and the concept of marginal cost are extremely useful tools in all branches of economics.

Market
The mechanism of exchange between buyers and sellers of goods and services. The theory of markets recognises different markets according to their characteristics of organisation and structure. The market for environmental services is increasingly recognised as a special field of study and management and as a condition for sustainable development. The environmental market includes: the operation of utilities such as water, sanitation, and power; the provision of environmental governance through conservation, protection and

regulation; the monitoring of environmental trends; the implementation of environmental laws; environmental research and development; the institutional organisation of the market in terms of the public private split; the role of NGOs; trading in environmental goods and services (such as carbon, waste, transport systems); and **environmental accounting**.

Market failure
An outcome of the operation of the market revealing long run sub-optimal performance or persistent bias in any of its principal functions. The failures may arise from lack of productive efficiency, allocative efficiency, technical progressiveness or product performance. Market failure may result from flaws in performance arising from weaknesses in **market structure** or market conduct. Markets fail in the presence of **externalities** and information asymmetry and in the provision of public goods and goods produced under conditions of decreasing cost (water and electricity, for instance).

Market performance
The efficiency of a market in maximising human welfare. The dimensions of efficiency of performance may include: production, distribution, resource allocation, technology, and product quality in relation to price. The performance of the market for environmental services can be evaluated by the same criteria as used for any other market, but more emphasis may be given to the intergenerational sustainability of the market and the extent to which environmental values are adequately included in the assessment of the output of goods and services and the use and renewal or substitution of natural capital.

Market structure
The organisation of the market defined in terms which are thought to affect its conduct and performance. The principal structural characteristics may include: the concentration of sellers and buyers and their relative size; the conditions of entry and barriers to entry; the differentiation of the products for sale, and the extent of vertical integration and diversification. It is expected that market structure interacts with market conduct and performance and with public policy which may, in turn, aim to control all or any of these other aspects the market.

Environmental services and resources are subject to their own market conditions and are affected by the market for other goods and services and the public policies which engage them. In recent years there has been a shift in the delivery of many environmental services, such as water, sanitation, waste management and energy production from the public to the private sector and the break-up of public sector monopoly supply. This has had mixed results in terms of performance. But it has been accompanied by the extension of the principle and practice of 'the market regulator' with the aim of promoting efficiency and protecting consumer interests and value for money.

The markets for other goods and services have also been affected by firms adopting more environmentally-friendly policies, by public policy requirements and by shareholders seeking 'green' shares as part of 'ethicals' trading. ('Ethicals' were formerly largely restricted to shares in companies that excluded alcohol, tobacco and arms trading). Many companies now publish environmental accounts which identify the payments they have

been required to make as penalties for environmental infringements and the investments they have made for environmental protection.

Millennium Development Goals (MDGs)
Strategic Goals agreed through the UN in 2000 for achievement of greater global development. The MDGs have associated indicators and targets for each country to achieve by a target date, for most Goals by 2015, against a 1990 baseline. The eight Millennium Development Goals relate to poverty reduction, education, gender equality, child health, maternal health, control of major diseases, environmental sustainability and partnerships for development. Their pursuit is being integrated into the design of National Strategies for Sustainable Development and Poverty Reduction Strategy Papers. The environmental targets and indicators include forest cover, protected areas, energy use, CO_2 emissions, safe water, sanitation provision, and reduction of slum property and insecure housing tenure. The environmental issues concerned with coastal and marine management, biodiversity, waste management, and natural disasters, all of critical importance to SIDS, are not included in MDGs. The MDG system is coming under increasingly critical review as a tool for policy, planning and management. (See for example *Nature* (2007) Millennium Development Holes, 446, 347 March editorial: *'The MDGs could be buried in the history's graveyard alongside other well-intentioned but failed development efforts …'*) (See Roberts J.L. Chapter, *Making Sense of Millennium Development Goals: Implications for Environmental Governance.*)

Mineralogical threshold
The point at which the energy cost of extracting minerals (metals, stones and oil) steeply rises as the concentration of those minerals in any site decreases through exploitation. With the increase in energy use there can be a corresponding increase in adverse environmental impact depending on the source of the energy. Policy intervention may be necessary to address situations where the market does not account for environmental damages.

Mitigation
Mitigation and adaptation are two foundational concepts that have emerged in climate change literature. Mitigation of climate change involves taking actions to reduce greenhouse gas emissions and to enhance carbon sinks. This is distinct from **adaptation** which involves taking action to minimize the effects of climate change. Scientific consensus is leading to increased efforts to develop new technologies and sciences and carefully manage others, in an attempt to mitigate climate change. Carbon capture and storage (CCS) is a plan to mitigate climate change by capturing carbon dioxide (CO_2) from large point sources such as power plants and subsequently storing it away safely, instead of releasing it into the atmosphere. (See also chapter by Munro: *Climate Change Policy and SIDS.*)

Moral hazard
The risk that the removal of prices at the point of consumption may promote changes in consumer behaviour and over-use of products and services. For example, 'free' access to parkland, beaches, roads, seaways, cities, and health services may promote patterns of use, especially over-use by some, which neglects the adverse impact on the quality of

those services, and the opportunity of access by others whose marginal benefit from the use may be greater. The introduction of road charges in congested cities, health charges in overcrowded health services and excess elements in insurance policies, are policy instruments directed at reducing the adverse social and economic impact of the moral hazards of such goods and services otherwise offered free at the point of use. Even in the Soviet Union, which created 'free' public transport, a small user charge was introduced to limit excessive use.

Multinational firm

A business (firm) that produces and sells in more than one country. The incentives for multinational business arise from firms having specific advantages (such as monopoly from patents or unique protected products); locational advantages (through local production and distribution and responsiveness to changes in demand and taste); country specific advantages (whereby businesses adjust production and distribution systems to avoid tariff quotas and other regulations and to take advantage of cheaper labour and local skills and other financial advantages such as grants and tax write-offs). Those concerned with environmental protection may encounter special problems in regulating the activities of multinational firms whose headquarters may be beyond local jurisdiction or where particularly hazardous production systems may be located in countries with less restrictive, environmental control systems. Examples of such difficulties occur with marine and fisheries management and the regulation of disposal of hazardous waste. Some multinational companies, however, promote best practice in their international activities and have become pioneers in environmental accounting and health and safety management. They are increasingly involved in global negotiations on sustainable development policy and programmes with international and intergovernmental organisations.

Multiplier

The multiplier is classically linked to the observation in macroeconomics that a small change in national expenditure may lead to a larger change in national income. The process however is cumulative and interactive. The concept may also be applied to changes in environmental conditions where a small change in **pollution** levels may lead to a much larger change in biodiversity. Evidence from the creation of marine-protected areas, for example, shows that the reduction in fishing and **pollution** can lead to a very rapid and large change in fish stocks and this then spreads to provide a beneficial impact on non-protected areas.

Municipal solid waste

The 1992 Earth Summit defined a waste management hierarchy from the most desirable to the least desirable: source reduction; re-use; recycling; waste to energy (incineration), and land-fill. This is based on engineering principles largely relevant to the safe disposal of hazardous waste. Economic analysis (within the EU) suggests that such a hierarchy, taking into account total external and private costs, should be: recycling; landfill; incineration; and composting (for agricultural use). The position of each element in the hierarchy is subject to variation in costs and benefits and depends on the methods of collection, especially the transport costs and the composition of waste.

Nash equilibrium

In game theory, **Nash** equilibrium (named after John Forbes Nash) is a solution concept of a game involving two or more players, in which each player is assumed to know the equilibrium strategies of the other players, and no player has anything to gain by changing only his or her own strategy unilaterally. If each player has chosen a strategy and no player can benefit by changing his or her strategy while the other players keep theirs unchanged, then the current set of strategy choices and the corresponding payoffs constitute a **Nash** equilibrium. **Nash** strategy describes a more restrictive game situation than dominant strategy. A strategy is dominant if, regardless of what any other players do, the strategy earns a player a larger payoff than any other. Hence, a strategy is dominant if it is always better than any other strategy, for any profile of other players' actions. (See chapter by Gangopadhyay and Gangopadhyay on *Intellectual Property Rights and Anti-competitive Behaviour: Major Deterrents to Economy and Ecology of SIDS.*)

National income

The total money value of goods and services produced over a period of time (usually one year) less capital consumption. Traditionally, the loss of the capital value of non tradeable **natural resources** is not included in accounts of national income. In **environmental economics**, methods of accounting can be used to value **natural resources**, the extent of replacement of renewable capital such as woodland, fish stocks, water resources and the substitution of non-renewable stocks such as oil and coal with other facilities such as hydro-electrical systems, wind power, solar energy, etc.

National plans

Integrated, definitive proposals at country level for determining economic and social development over a defined time-period, usually five years. Institutionally, they can give rise to national planning departments whose remit is complementary to that of Ministries of Finance, the latter being more concerned with short-term fiscal policies and expenditure programmes. In many countries the two functions are combined in one ministry. The UN has promoted both National Strategies for Sustainable Development and Poverty Reduction Strategies, which have a similar purpose and format to traditional national plans with elaboration of targets for a range of national indicators of performance. Central planning, as an integrated system for sector-wide national plans, has tended to fall into disuse following the demise of the Soviet Union and the discredited process of false reporting of performance it engendered. There is a continuing debate about the accuracy and value of data on environmental quality and about the assessment of the costs and benefits of environmental protection to enhance national and global plans for **sustainable development**.

Natural capital

In classical economics, wealth was seen to be determined by three elements of production, capital, labour and land. **Natural resources** included land, basic raw materials such as water, cotton, wool and wood and commodities such as iron, copper and gold. More recently, through the emerging concept of 'productive power' associated with Friederich List, a

nineteenth century German political scientist, three kinds of capital were seen to contribute to productive power: natural capital (**natural resources**), material capital (machinery and equipment) and mental or human capital. The designation of **natural resources** as 'capital' has important implications for their management and treatment in economics. Like other capital they need maintenance and replacement. Their accumulation or protection represents foregone consumption and this needs to be accounted for in any valuation. (See Hamilton, K. and Rashid, Hassan (2006) *Measuring Development Prospects by 'Greening' the National Accounts:* in Lopez, R. and Toman, M.A., *Economic Development and Environmental Sustainability,* Oxford University Press, ISBN 0-19-929799.) Classical economics tended to treat **natural resources** as inexhaustible and non-degradable with no **externalities** as a consequence of their use. **Environmental economics** recognises that **natural resources** may be renewable or non-renewable and subject to **pollution** affecting their use. (See also **Natural resources**.)

Natural resources

These include land, basic raw materials and commodities such as oil, iron ore, trees, plants, etc. As part of natural resources, the importance of the productive capacity of environmental services such as that provided by water, wetlands, climate and biodiversity is increasingly recognised. Natural resources can be classified as renewable and non-renewable, actual and potential, biotic and abiotic natural capital. The rate of sustainable use of natural resources is a function of the replacement and substitution rate and the amount of standing stock. The stock of a natural resource is a known quantity whereas reserves may be an estimate in the form of geological evidence. Natural resources can become a 'curse' where access and distribution are dominated by corrupt practices and by increasing conflict and social inequality in wealth and power. (See **Natural resource curse**.) Many developed and developing countries, especially small states, are facing pressure on and even exhaustion of their natural resources. They then become more dependent on external sources or on substitution by manufactured goods, such as man-made fibres, plastics, recycled water, etc. Conservation of natural resources is a major focus of natural capitalism, environmentalism, the ecology movement and political 'green parties'. Edward Barbier is associated with the development of the theory of the natural capital basis of economic development in poor and middle income countries, in which he presents the following propositions:

- Low and middle income countries have natural resource dependent economies.
- Such resource dependence is associated with poor economic performance.
- Development in such countries is associated with increased land conversion and stress on available water resources.
- In such countries a significant share of the population is concentrated on fragile lands.
- This combination of pressures gives rise to the need for frontier expansion into more fragile land areas and the greater degradation of natural resources with lower income yield (the vicious circle of the frontier expansion hypothesis). All these issues are of critical importance to small states and SIDS as they move through the stages of demographic, economic, epidemiological and social transition.

- New concepts in development policy which address the social and economic implications of this theory include:
  - land reform;
  - the dismantling of fiscal policies that have promoted the adverse environmental effects of unsustainable exploitation of natural resources such as woodlands, wetlands and marine areas; and
  - the exposure of political and commercial corruption that has traded quick financial returns on natural resource harvesting against the long term impact of natural resources depletion and degradation. (See Barbier, E.B.: chapter 'Natural capital, resource dependency and poverty in developing countries', in: Lopez, R. and Toman, M. (2006) *Economic Development and Environmental Sustainability*, Oxford.)

Natural resource curse

The adverse effect on economic growth, political and social relations that can arise from any large supply of scarce and thus high value natural resources, such as farmland, oil, natural gas, gold, diamonds, poppies (for heroine), cacao (for cocaine) and even water. This 'curse' can sometimes result in extreme and long-lasting economic decline and wide-scale poverty alongside small numbers of very rich people, continuing levels of conflict, violent disputes, civil war, secession or invasion and conquest movements to control the access to the benefits of the valued resource. The concept is attributed to Richard M. Auty in**:** *Sustaining Development in Mineral Economies: the Resource Curse Thesis*, Routledge, London and New York. (See also: Stiglitz, J. (2006) *Lifting the Resource Curse,* chapter 5, in: *Making Globalization Work*, Allen lane, Penguin Books, London.) The history of colonialism has been replete with the unfolding tragedy of this 'curse' which has in many countries spilled over into the post-colonial era through corruption and conflict over the share-out of the riches. Currently, countries affected by the 'curse' include the oil-rich Eastern Region (Biafra) and its conflict with federal Nigeria, oil-rich Shiite and Kurdish areas of Iraq, North Sudan without oil and oil-rich southern Sudan, Sierra Leone and Mozambique (over diamonds), and the Congolese province of Katanga (rich in cobalt, copper tin, radium, uranium and diamonds) in conflict with the rest of the Congo.

Resource-rich **developing countries** are also subject to exploitation by multinational companies. The multinationals are specialised in extracting **natural resources** at low prices through contractual arrangements that impose adverse conditions on the countries concerned. Thus, the host countries have little or no access to the 'rents', surplus or profits, resulting from any increases in world prices for the **natural resources** extracted.

Stiglitz, J. (2006 op.cit.) makes proposals to resolve these problems including: transparency in extraction contracts; reduction in arms sales in such conflict areas; certification of the source of **natural resources** to advise buyers; targeted financial assistance to aid local development; international contracting standards to protect developing countries; limitations on environmental damage in extraction contracts; and better enforcement of international law and standards. Increasingly, host countries are renegotiating extraction contracts under the threat of nationalisation of the industries concerned. (See also Humphreys, M., Sachs, J.D. and Stiglitz, J.E. (2007) *Escaping the resource Curse*, Columbia University Press.)

The natural resource curse is also explained in terms of the 'Dutch Disease'. Netherlands witnessed the discovery of off-shore oil and gas in the late 1950s and early 1960s. This resulted in an upswing in exports of natural gas which led to appreciation of the Dutch guilder. This development hurt other exports for a while and acted as a threat of de-industrialisation, with adverse macroeconomic effects. The problem proved short-lived, but the name 'the Dutch Disease' stuck.

Neo-classical economics

The neo or 'new' classical economics derives principally from the writings of Alfred Marshall and others working in late nineteenth century Europe. Fresh concepts were developed such as 'marginal analysis' derived from the application of calculus to economic data, and a new focus on the choices in the allocation of resources to alternative ends. The use of geometrical diagrams to illustrate the implications of algebraic formulae was an essential feature of Marshall's contribution to teaching in economic theory and its practical application to management both in macro and in micro-economics, respectively. The neo-classical school of thought developed principles from their application of the analysis to corporate decision-making. These principles associated with Marshall include 'diminishing marginal **utility**', 'economies of scale', 'elasticity of demand', the 'life cycle of the firm' and the methods of comparative static equilibrium analysis, which are continuing as central features of the inheritance from this school. The crux of neo-classical economics is: lack of government regulation, free trade, and efficient markets due to the 'invisible hand'. Marshall's contribution to **development economics** is less well known. He wrote; 'the growth of mankind in numbers, in health and strength, in knowledge, ability and richness of character, is the end of all our studies.' (*Principles of Economics* first published in 1890.) Marshall's framework of analysis can be applied to **environmental economics**, especially in the management of environmental services.

New environmental paradigm (NEP)

A conceptual framework for economic and social development, underpinning the movement for sustainable development. With this framework of thought, attributed to Dunlop and Van Liere (Dunlap, R.E.; Van Liere, K.D. 1978. *The new environmental paradigm*. Journal of Environmental Education. 9: 10–19), the value of natural resources and their conservation is seen as a necessary condition for **sustainable development**.

New growth theory

In economics, **new growth theory** or **endogenous growth theory** was developed in the 1980s as a response to criticism of the neo-classical growth model which posits that the long-run rate of growth is exogenously determined by either assuming a savings rate (the Harrod-Domar model) or a rate of technical progress (Solow model). Endogenous growth theory tries to overcome this shortcoming by building macroeconomic models out of microeconomic foundations. Households are assumed to maximise **utility** subject to budget constraints while firms maximise profits. Crucial importance is usually given to the production of new technologies and human capital. The engine for growth can be as simple as a constant return to scale production function (the AK model) or more complicated set ups with spillover effects, increasing numbers of goods, increasing qualities, etc.

Endogenous growth theory demonstrates that policy measures can have an impact on the long-run growth rate of an economy. For example, subsidies on research and development or education increase the growth rate in some endogenous growth models by increasing the incentive to innovate. Some contend that new growth theory has proven no more successful than exogenous growth theory in explaining the income divergence between the developing and developed worlds (despite usually being more complex). (http://en.wikipedia.org/wiki/Endogenous_growth_theory)

New International Economic Order
A policy adopted by the UN in 1974, which set out principles for promoting support for improvements in developing countries. The policy included support for access of primary products, special trade concessions for manufactured goods, transfer for economic aid, and an increase in economic co-operation from **developing countries** to developed country markets. This policy has been pursued largely through UNCTAD, but has met with mixed results. The process is now being overtaken by WTO policies and the ending of preferential treatment for many low and middle-income countries. The impact of the erosion and loss of preferential trade arrangements is hitting small states and SIDS hard and over a short period of time. Many are trying to renegotiate special and differential treatment. This is a principle that has been endorsed by the UN including through the UN SIDS Mauritius Strategy of 2005. (See www.sidsnet.org/docshare/other/20050201154324-Mauritius)

Normative economics (see also positive economics)
The study of what ought to be in economics programmes, based upon value judgements about the ideal state of the world. In the field of environmental economics, a normative view might be expressed by designating an optimal (norm) amount of road tax that would minimise pollution and increase social welfare. In other words, road taxes should be introduced to ensure that the land value of roads and the externalities of road use are introduced into the market for road use. Normative economics is distinct from 'positive economics' in which the question of road taxes would be considered in terms of the specific yield from, or estimated yield from, road tax and its actual impact on road use, travel times, choice of alternative means of transport, etc. Normative economics includes those approaches to **welfare economics** whose focus is how economic activity should be organised to maximise human welfare. **Environmental economics** can be pursued from a normative or a positive perspective depending on the purpose of the study. It is important to ensure a clear distinction between the two, although any method of measurement contains value judgements, often concealed. At the simplest level, value judgements are inherent in any use of numbers; for example, to say a family consists of five people, a factory produces five tonnes of waste or a country has five million square kilometres of land, implies that each member or unit counted is equal to each other unit despite the difference in individuals, the composition of waste, and the variation in the quality, use and non-use value of each unit of land.

Opportunity cost
Sometimes called the 'economic cost', it is the sacrifice made in using scarce resources to produce one good or service expressed in terms of the alternatives forgone. An example of opportunity cost assessment in **environmental economics** would be in the cost of building

a road. This can be expressed in terms of the contract price or in economic terms as the loss of agricultural land, of habitat, of biodiversity and of other environmental services entailed from both the use of the land on which the road is built and the **natural resources** extracted for use as materials for building the road. In addition, the opportunity cost involves the economic costs of the labour and the capital in designing and building the road which are thus lost for alternative uses such as providing environmental protection.

Optimising resource use (See also **Bentham, Pareto and Kaldor**.)
Seeking the highest value in social welfare through major economic and social objectives such as full employment, macro-economic stability in prices, **economic growth** and balance of trade. The optimising approach may not lead to sustainable development, unless proper account is taken of the state and use of **natural resources** as part of natural capital now and into the future. These are increasingly seen as essential factors in the production of goods and services and in non-use values in any society.

Ozone layer
A layer of ozone gas in the upper atmosphere of the planet Earth. Ozone is a highly reactive gas formed by the recombination of oxygen with ultraviolet radiation from the sun. The ozone layer protects the earth from the adverse effect of ultraviolet rays from the sun on animal and plant life. In the lower atmosphere **pollution** can damage the ozone layer by the build up of chlorofluorocarbons (CFCs). Scientific observations suggest that the earth's ozone layer has been increasingly damaged and within 50 years could cause substantial **climate change** with, in particular, melting of the Arctic ice caps. (See also **Climate change, Greenhouse Gases**, **Public goods**.)

Paradox of value
The notion that the value of a good or service is determined by its scarcity rather than its usefulness. The classical contrast is between diamonds and water. Diamonds (except for industrial diamonds) are of little practical use but, because of scarcity and demand for decoration, they are expensive; water is of indispensable use and yet in many countries where it is plentiful it is provided at a low price. In recent decades, with water scarcity arising from greater agricultural, industrial and domestic demand, the marginal **utility** of water and its price has continued to rise. This has also been affected by rising marginal costs of extraction, treatment and distribution as remoter areas are covered and the greater per capita demand affects the market.

Pareto optimality
The maximisation of the economic welfare of a population which satisfies the following criteria: that, as a result of a change in resource use, the welfare of a person cannot be raised by changing the distribution of benefits, without reducing the welfare of any other person. This principle derives from a concept of ordinal **utility** developed by Vilfredo **Pareto** an Italian engineer and economist. The criteria have the merit that they avoid the need for interpersonal aggregation of welfare. In many cases, however, these criteria are so difficult to meet that in practice a complementary concept developed by Nicholas **Kaldor** and John **Hicks** is adopted. In this modified Pareto assessment, a choice in the

deployment of resources can be considered beneficial, if, after the change, the gainers can compensate the losers and still be better off. This divides the assessment process into two parts: a) the assessment of costs and benefits or efficiency gains and losses; and b) their distribution. This modified view has been further developed by Paul **Samuelson,** with the construction of a social welfare function, but Kenneth **Arrow** has challenged the validity of the social ordering method on which it depends.

Parkinson's law
The stylised or satirical notion derived from the sayings of Professor C. **Northcote Parkinson** that 'work expands to occupy the time available for doing it'. This notion is also recognised in the concept of X-inefficiency, that is the gap between the actual and the minimum supply cost for a good or service. This gap arises in many large mature organisations, in the public and the private sectors, which are not subject to competition and whose supply costs are raised by inefficient factors such as restrictive labour practices, staffing unrelated to output and workload, the monopoly position of certain supply systems, and bureaucratic practices. These factors are common in large historic private businesses (such as western motor car manufacturing, traditional sea-ports) and in state-run organisations, such as state railways, the civil service, state utilities and other monopolies such as state transport, water, telephone and electricity companies, schools and health services. Supply side inefficiency was a commonplace in the Soviet centralised economic system which lacked any competitive elements. The use of work-study, other systems of work measurement, and contracting-out within the public and the private sectors can increase productivity and reduce supply costs. The application of management sciences is beginning to penetrate into the management of environmental services, especially through competitive bidding and the evaluation of contracted services required in international aid programmes.

Perfect competition
A stylised market in which there are many sellers and many buyers, non-differentiated products, free entry and exit to the market and complete knowledge of the market by buyers and sellers. Theory asserts that such a market would produce more efficient performance than any other, such that market output is optimised with minimum supply costs and suppliers receiving an acceptable return on their outlays (including capital, labour and **natural resources**). Such markets scarcely exist, since all the conditions seldom apply. But the model serves to identify critical factors in the imperfections of existing markets. The absence of perfect competition and the recognition of market imperfections and market failure frequently define the point of entry for government intervention. This is especially so in the market for land and **natural resources**. There, the interests of 'buyers' are inadequately represented and the knowledge of their willingness to pay is obscured. However, government intervention does not necessarily, resolve the problem and planners and managers must anticipate the risk of policy failure, where intervention may not provide effective or cost-effective correction to the recognised failures of the market.

Pigouvian tax
Taxes and subsidies to remedy market failure and its impact on resource allocation, where prices failed to reflect the social as well as the private values for goods and services. In

environmental economics literature, such taxes are extensively employed to charge for negative **externalities** created by polluters. (See Chapters in the book by Madhoo: *Environmental policy instruments and governance* and by Nath and Schroeder: *Tax instruments for Environmental Management in Tourist Destinations*.)

Photosynthesis
The process by which green plants use sunlight to convert nutrients from the soil, carbon dioxide from the air and water to produce glucose, whilst releasing oxygen as a beneficial by-product for the respiration of plants and animals. This process is adversely affected by air **pollution** and especially by damage to the **ozone layer** in the upper atmosphere which inhibits ultra-violet radiation from the sun penetrating into the earth's atmosphere.

Planning (See also **National plan**)
A process of preparing and presenting a detailed proposal for doing something over a period of time with defined resources in relation to anticipated events. The process can be applied both in the public and the private sectors, at national, community, family or personal levels. It is consistent with many theories of economic systems. The time scale can be short, medium or long term and may include various levels of intention and aspiration expressed in terms of aims, goals, objectives, targets and outputs and outcomes. There are many applications for planning in environmental management especially in relation to the protection of endangered species, the provision of water and sanitation systems, the control of air **pollution** and global warming, the management of settlements and the systems of regulation of industry to avoid adverse environmental impact. Planning has been seen to be a necessary process for protection against market failure. Experience has shown, however, the gross errors that planning can give rise to through policy failure both under centralised planning systems and in the mixed market economies.
(See also **Logical framework** and **Programme, planning, budgeting** (**PPB**))

Policy
A formal declaration of a commitment made by a government or a corporate body for the pursuit of a general or specific objective. Examples of policy objectives in the field of **natural resources** management include: reducing greenhouse gas emissions; conserving endangered species; providing safe water and sanitation for all; and promoting the use of renewable sources of energy. Policy statements may, but do not always, define the means for their achievement, nor the timescale. Policies can be classified in a number of different ways. For example, they can be classified by the sectors to which they apply (education, finance, commercial, environmental) or the function they entail (distributive, regulatory, organisational).

Policy analysis
Policy analysis is the review of existing or prospective policy to evaluate its structure, logic, inter-relationship with other policies and potential for fulfilment. It differs from programme evaluation in that its focus is on the nature, scope and content of the policy and is not restricted to its measured performance. The analysis commonly examines the institutional context and the process of development of the policy. This may include identification of problems to be addressed and the method used in developing and formulating the policy.

These methods can include consultation, political debate, expert evidence, legislative process, method of enactment and enforcement, public opinion survey, etc; evaluation of expected outcomes, cost-benefit analysis, pilot studies, comparative analysis, needs assessment, feasibility assessment, etc. Policy analysis may be set out in reports which identify the strengths and weaknesses of the policies themselves, their viability, the support they have and the processes from which they have emerged. It may also review the capacities and conflicting interests of policy-makers and the impact this may have on policy formation and its implementation. (See also **Behavioural theory**.)

Policy failure

Policy failure occurs where a government or other corporate body has intervened to correct for market failure, but where the intervention is ineffective, inefficient or inequitable. In the field of environmental policy, policy failure may arise through the failure of governments or corporate bodies to provide adequate measures, such as through regulations or economic instruments, which achieve efficient and sustainable management of natural capital. The failure may arise from the absence of intervention, the inadequacy of the regulatory instruments, or through flaws in implementation arising from inadequate funding, inefficient management or corruption. For example, the government may provide for an environmental impact assessment of proposed industrial initiatives, but the EIA may fail to identify serious adverse environmental impact and allow the initiative to go ahead irrespective of the adverse environmental implications.

Policy instruments

A tool used for implementing policy. At macro economic level this may be a monetary or fiscal tool, such as reduction of money supply, the use of a tax, or price or quantity controls on goods or services; in administration, this might include legislation with legally enforceable penalties or restrictions on action, such as penalties for environmental damage, planning regulations requiring set-back, waste controls or ecological protection of endangered species (broadly known as command and control measures). Policy instruments may also include education, training, R & D and institutional development to influence proper information gathering and use, attitudinal changes, supplier and consumer behaviour and capacity building for promoting technical skills. Market-based instruments can include product and emissions charges, deposit–refund schemes, subsidies, performance bonds, emissions trading, product recycling standards, and debt-for-nature swaps.

Policy instruments have been developed in the field of **natural resources** management principally to correct for global and local market failure. But some policy instruments may have adverse side-effects where the impact of the intervention is worse than the problems addressed. They may also be adopted at local level through by-laws or by corporations for advancing their policy objectives, such as the introduction of environmental accounting to assess environmentally friendly policies and practices and to promote greater transparency of the environmental impact of operations in response to or anticipation of shareholder concerns. (See Pearce, D. (1997) *Integrating the Economy and the Environment, policy and practice*, Commonwealth Secretariat, London; and Hargroves K.C. et al. (2006) *The Natural Advantage of Nations*, Chapter 11, The Role of Government, Earthscan, London, ISBN 10: 1-84407-340-8)

Political economy
The term political economy reflects the belief that politics and economics are inseparable, and that political factors are crucial in determining economic outcomes. Political economy literature is divided into positive and normative political economy.

Positive political economy The relatively recent approaches to political economy – sometimes referred to as the new political economy – borrow economic approaches for modelling incentives as a way of understanding the political and economic forces that shape public policy. An example of positive political economy would be investigating the role of interest groups in explaining environmental policy. Therefore, new political economy models can help us understand how environmental and natural resource regulations come about.

Normative political economy identifies 'good' policy outcomes (consistent with a particular value system) and investigates how, given the existing political constraints, these good policy outcomes can be realised, such as designing a carbon tax on Pigouvian principles in order to capture negative **externalities**.

Polluter pays principle
The principle was initially seen as a post-**pollution** payment punishment, that is whoever pollutes should pay the cost of cleaning up the **pollution** caused and any other damage. This has proved difficult to apply except in cases of single source **pollution** such as a major oil spill from a tanker or damage following a nuclear power station accident. The principle, however, can be implemented from within companies as an ex-ante prevention programme. Many companies (such as 3M – in their **Pollution** Prevention Pays; and Texaco in their WOW – Wipe out Waste) have been finding that reducing **pollution** can increase efficiency and have internalised the process by investing in **pollution** control. Shareholders of public companies are increasingly insisting on environmental audits to reveal in annual accounts the balance between company payments for infringements of **pollution** control and company investment in preventing **pollution** as part of ethical business and trading.

Pollution
Contamination of natural resources and systems with poisonous or harmful substances causing changes in the physical, chemical and biological strata detectable in impaired performance, reduced growth, lowered renewal capacity and ultimately the eradication of organisms and entire species. **Pollution** is one aspect of the **externalities** of human activity in agricultural, industrial and service sectors. Intervention to control **pollution** has been a common aspect of state activity through education, training and regulation. Modern approaches to corporate management accept responsibility for pre-emptive action to reduce **pollution**, to avoid contraventions of **pollution** law and seek ways to achieve productive gains in the process. Examples are in recycling materials, reducing emissions from engines with compensating efficiency gains, re-using waste material such as sugar bagasse for fertiliser or energy production, and reducing packaging. The adoption of the '**polluter pays principle**' puts the burden of the cost of the **externalities** of pro-

duction on the producer rather than the community. The **Coase** theorem offers a basis for private negotiated settlement to reduce **pollution** where specific productive activities are adversely affected by local single point identifiable emissions. The Coase theorem may work when the number of affected parties is small and transaction cost is zero. Otherwise, government regulation is warranted and command-and-control and market-based instruments are employed.

Pollution haven
A location to which, in the absence of effective **pollution** control systems, polluters migrate to avoid the costs of regulation. Typically this process is a threat to **developing countries** that lack the regulatory capacity required for **pollution** control or who may be tempted to accept the price for taking the trade. The result may be no net reduction of global **pollution** but merely a migration of it from rich to poor countries. The **pollution** haven effect may be so strong that it promotes the migration both of polluting substances and investment capital, with the re-location of polluting industries moving from countries with strong controls to others with weak. (See Copeland, B.R. and Gulati (2006) *Trade and the environment in developing countries*, In Lopez, R. and Toman, M.A. op.cit) A similar trend may occur within countries where the **pollution** is concentrated in areas where poor people live and who have little political power to protest.

Population trap
Where the population growth rate exceeds the **economic growth** rate and thus **economic growth** per capita remains constant or declines. It is a common feature of **developing countries** when, in the first stage of demographic transition, the death rate declines but the birth rate does not decline in proportion. Population growth may also be affected by increasing length of life and by immigration, especially where countries with marked **economic growth** attract migrants from less developed countries, fleeing from poverty, conflict, corruption and poor governance. Africa abounds with conditions which produce population traps, putting a heavy pressure on land and **natural resources** and promoting poverty, land degradation, and conflict for scarce **natural resources**.

Porter hypothesis
Hypothesis of P.R. Porter (1990) 'America's Green Strategy' *Scientific American* 264:168, that tighter environmental standards only slightly affect production costs, as they trigger innovations that may increase a firm's competitiveness and outweigh short-run costs to firms of complying with the regulations. This hypothesis has been supported by some empirical evidence and is used by policy-makers to justify intervention but it may also provide a supporting case for protectionism and curbs on competitive imports.

Portfolio of investments
A collection of financial securities (stocks, shares and bonds) with the aim of spreading risk, by putting together some which offer high short-term income and others longer term capital gain. The concept can be applied metaphorically to environmental initiatives, some with short-term gain and low cost (quick fixes such as pit latrines and filtering of

water supplies), and others more costly and with longer term benefits such as early warning systems for tsunamis.

Positive economics
The study of the choices people make in the use of resources, the interactions of these choices, and the general laws that can be derived from such studies. (See also **normative economics**.)

Poverty
Poverty exists where households cannot meet their basic needs for survival. The concept is not confined to money income but includes the lack of basic services and facilities such food, water, sanitation, shelter, clothing, health care, education and security. The World Bank has used per capita income of US$1 dollar a day ($365 a year) assessed at **purchasing power parity** (PPP) as a measure of extreme poverty; and $2 a day ($730 a year) as a measure of moderate poverty. In high income countries, lack of access to cultural goods and services such as entertainment, recreation, quality education and other prerequisites for upward social mobility are identified as elements in relative poverty (see Sachs, J.D. (2005) *The End of Poverty,* Penguin books). Poverty is linked to environmental degradation through contamination of water supplies, unplanned urbanisation in squatter areas, deforestation for expanding cultivated land for food and the use of wood for cooking, heating and habitations. Theoretical models explaining the links between poverty and environmental degradation include the frontier model in which population growth rates, debt crisis and GNP per capita are critical factors in promoting unsustainable use of natural resources.

Prisoners' dilemma
Co-operation is usually analysed in game theory by means of a non-zero-sum game called the 'Prisoner's dilemma' (Axelrod, 1984). The two players in the game can choose between two moves, either 'co-operate' or 'defect'. The idea is that each player gains when both co-operate, but if only one of them co-operates, the other one, who defects, will gain more. If both defect, both lose (or gain very little) but not as much as the 'cheated' co-operator whose co-operation is not returned.

Product life cycle
The core concept of the theory that seeks to explain changes in international trade over time. The life cycle of a product is considered to have four phases:

1. innovation and development of a new product;
2. production and penetration into existing markets at home and abroad, displacing existing products;
3. diversification of production with competing producers and displacement of the original country's market share; and
4. migration of production to countries with lower production costs when the original innovators shift to other products as they lose market share.

The concept may be applied to the life cycle of environmental products, services and policies. North-South and South-South transfer of technology is a key process in the management of environmental technology. Some aspects of the life-cycle process can be recognised in health and safety, emissions control, energy production, water and sanitation services, ecological tourism, marine management and nature protection, etc. In the process of transfer from the original market to another, the specificities of the new market have to be assessed (reviewing market structure and performance), especially the differences arising from the stages reached in economic, epidemiological and social transition of the new host countries. The risk for developing countries is that they are encouraged to adopt environmental policies and processes from the North, but this process of migration is not most effective or efficient in their new specific environments.

Production function

Production function describes the underlying technology, that is, the physical quantities of in-put factors necessary for the production of a defined quantity and quality of output of goods or services, with specified technology. In environmental management, the production function consists of capital, human and **natural resources** required for achieving the objective in accordance with a specified technology (or means). For example, for saving an endangered species in a sanctuary, the technology includes the physical capital of sanctuary buildings and equipment, skilled staff, nutrition for the species, land and other **natural resources** to provide a habitat for breeding. These are the resources required for producing the product of conservation of a species. The environmental impact of the process of production also needs to be assessed having regard to the complexity of the ecological process and the inherent capacity for unexpected outcomes. (See for example: Fuggle, R.F. (2004) 'Lake Victoria: a case study of complex interrelationships' in Nightingale, D. et al. (eds) (2004) *African Environmental Outlook*, case studies, Earthprint for UNEP ISBN 92-807-2365-0).

Productivity

The ratio of outputs to inputs in a production process. These ratios can be calculated in marginal, average and total terms. For example, total factor productivity is a ratio of total value of output to total value of inputs. Sources of increases in productivity may be through improvement in any of the factors of production capital, labour, and **natural resources**. Additionally, productivity may be increased by fresh applications of science and knowledge bringing about greater productivity through changes in technology. Improvements in technology for producing energy from renewable resources have resulted in reduction in cost per kilowatt hour of over 90 per cent in the past twenty years. (See 'Energy', Ch. 11, in Lomborg, B. (2006) *The sceptical environmentalist, measuring the real state of the world*, Cambridge UP.)

Profit

The difference between total income and total cost. If negative, the result is termed 'loss'. In economic terms the calculation of income and cost goes beyond that normally entered by accountants in the books of a firm. The economic calculation should include the 'costs' of capital, labour and **natural resources** not put to other uses, and the **externalities** in

terms of the impact on the **environment** and on health and safety. The economic cost may also include an element for risk-bearing by investors. The adoption by many companies of environmental accounts provides a bridge between the 'cost accountants' assessment of profit and the assessment from a broader economic and community perspective. The development of the concept of business sustainability is attracting the attention of members of the International Chambers of Commerce as an alternative model to profit maximisation. (See the management helix for the sustainable organisation, Chapter 10 in Hargroves, K.C. and Smith, M.H. (2006) *The Natural Advantage of Nations*, Earthscan; www.naturaledgeproject.net)

Programme, planning, budgeting (PPB)
A planning framework which became popular in the 1970s and 1980s in public sector financial management and resource allocation. In PPB, the budget lines are defined in terms of programmes with measurable outputs (such as number of households with waste collection services), rather than budget lines defined in terms of inputs (number of waste collection operatives). The programme statements include objectives, activities for achieving objectives, resources required for the delivery of specific levels of service, and the expected outputs. The framework can also be used within the private sector. The approach can be equally applied in the development of environmental services, but it ultimately depends upon an established evidence base of the linkage between outputs and inputs which tends to be lacking, except in specialised areas such as energy production, water services, forestry and some aspects of protection of biodiversity. It is the nature of many problems in **natural resources** that they are complex and the results of intervention uncertain. So-called rational planning tends to be based on the model of the relationship between mankind and nature as one of conquest and control, rather than one of respecting ecological limits, managing problems, expecting surprises and adapting to them. (See Funtowicz, S. and Ravetz, J. (2002) *Environmental policy under conditions of complexity*, Post-Normal Science, EC-JRC/ISIS, Ispra, Italy/RMC Ltd London.)

Property rights
A moral or legal entitlement to have or to do something with land, open access resource or other assets including securities, intellectual items such as ideas, artistic products, books, films, stories, recipes, designs, patents, etc. Deeds, securities certificates, registered patents and copyrights identify the rightful owner of the assets and laws define the terms under which licences may be granted for use of the assets, with breaches being subject to legal penalties. The assets themselves may be bought and sold and inherited. (See the Gangopadhyays' chapter: 'Intellectual Property Rights and Anti-competitive Behaviour: Major Deterrents to Economy and Ecology of SIDS'.)

Protectionism
A policy adopted by governments involving the use tariffs, quotas and other trade barriers to shield their local industries from external competition. This has been a key element in development policy for assisting infant industries to thrive and to respond to overcome those elements which contribute to vulnerability, such as small size (lack of economies of scale) and remoteness (high transport costs for exports). Similar controls may be used to shield a

country from importing products that may damage the **environment**, either in the country of origin or once imported. For example, they may include controls on importing vehicles that do not meet local emission standards, banning the import of dangerous waste, or excluding the import of timber except from certified renewable forest sources. It has become a controversial issue as some countries turn to protectionism in response to the global economic and financial crisis of 2008–9. WTO rules oppose protectionism in general but allow some controls on environmental grounds where there is evidence to support them.

PSIR analysis
A framework for policy analysis adopted by UNEP in its assessments of environmental outlook for the world, which includes examination of Pressures, States, Impacts and Reponses in environmental policy and management. The DPSIR framework adds Drivers to the basic PSIR framework. The Opportunities framework adds Opportunities to the PSIR framework. The Drivers are the factors which promote pressure, such as population growth, consumption of goods and services and technological developments. The Opportunities explore the potential for promoting sustainable development by building on best use of **natural resources** to overcome poverty, to promote employment, to reduce vulnerability, to reinforce sustainable **environment** and to promote human well-being. An economic perspective is now embraced within this framework covering environmental use and non-use values, and current and future conditions; this further development of the framework for policy analysis is called Integrated Environmental Assessments and Reporting (IEAR). (See http://www.unep.org/geo)

Public finance
Income and expenditure of public bodies. Traditionally concerned with income and tax, the field has been extended now (since **J.M. Keynes**) to include government intervention in promoting economic and social progress. This commonly includes securing economic stability, growth, employment, reducing inflation, attracting investment, and providing services to overcome market failure (such as education and health services). It also includes developing essential infrastructure and 'utilities' such as roads, gas, water, electricity, postal services, and emergency services. Public finance is applied to the development of regulatory measures covering the private sector (such as factory inspection, health and safety). In most countries it includes police, prison services and other security services, some of which are privatised. More recently public finance has been increasingly directed to protect the **environment** (**pollution** control, national parks and protected areas) using a variety of economic instruments (subsidies, incentives, trading systems). Public finance is also directed to the implementation of international treaties at national level (law of the seas, Kyoto Protocol on global warming and greenhouse gas emissions, controls on desertification) and R & D in these fields.

Public goods
Sometimes called 'merit goods' or 'social goods', are goods and services provided by community action (by the state or public financed organisations) for the benefit of most or all of the population served (such as national defence, radio and TV, roads, police, education, low income housing and health services). They are commonly paid for out of general pub-

lic funds and not by the users at the point of use of the services. Thus, there is generally no link between the consumption of these goods and services and the payments made for them, unlike goods in the private sector. In principle, a public good is one where a person cannot be excluded from its provision (non-excludable) and where the consumption of it by one person does not reduce its availability to anyone else (i.e. it is a 'non-rival' good). A distinction is made by economists between 'pure' and 'impure' public goods. 'Pure' public goods are those to which use is 'non-excludable' and 'non rival'. Examples are the climate we have, the ozone layer, and the high seas, for the benefits of these are without rival, they belong to all and none are excluded. By contrast 'impure' public goods may be either partially non-excludable or partially non-rival. Examples of 'impure' public goods are the natural elements of common land, private parks, rivers and coastlines. They are 'impure' because they have rival consumers, or they may be operated to exclude some people from benefiting wholly from them.

The concept of benefit area can be invoked to classify public goods into local, national and global public goods. The benefit emanating from a public good provided by a local community government may be contained within the geographical boundary of that locality and hence such public goods are called local public goods. Similarly, the benefits of national defence will be nation-wide and benefits of international peace will be global, so these public goods are called national and global public goods, respectively. (See Nath's Chapter 1 on **concepts**.)

In theory, open access to goods and services presents the moral hazard of unregulated demand, overuse of services, supply of ineffective services, queues and pressure for immediate rather than longer-term benefits. This is the *Tragedy of the Commons,* identified by Garrett Hardin in 1968 in which the users do not take into account the effect of their use on others, now, or in the future. The effect can be found in over-fishing and over use of common land and forests, where the interest of other users, especially future generations is commonly subordinated to current selfish over-exploitation. (See the chapter by Madhoo: 'An illustration of the tragedy of the commons: The demise of the Aral Sea'.)

The optimal level of provision of public goods, the Lindahl equilibrium, is where the marginal social benefit equals the marginal social cost. The existence of 'free riders' who may benefit from or degrade a public good, like air quality, without paying for it, results in the market failure of a sub-optimal provision. This provides a case for external intervention either through private 'club' provision or through corporate, voluntary or government intervention. Philanthropic action has commonly promoted government action to follow the lead, for example in the provision of public parks, recreational facilities, education, health and social services, environmental research and the protection of habitat for conserving biodiversity. The creation of markets for environmental protection is currently the subject of extensive activity with some successes and failures (e.g. emissions trading, the EU Common Agricultural Policy). Self governance may also play an effective part in negotiations between competing parties in a **property rights**' dispute.

Quality of life

A measure of the value placed upon the way of life of a person or population. A concept

closely linked to 'well-being' and to 'happiness' which has attracted a variety of approaches to definition and to measurement. One approach has been through subjective 'life satisfaction' surveys in which each person is asked 'how satisfied are you with your life in general?' and they are asked to assign a score to the value. This has been used by the New Economics Foundation as part of their study for the inter-country **Happy Planet Index** (HPI). An alternative approach has been adopted by the Economist Intelligence Unit which presents inter-country quality of life scores derived from a composite index of elements including material well-being, health, family life, job security, social and community activity, political freedom and security, and gender equality. The 2005 UN Millennium Ecosystem Assessment defined well-being in terms of security, basic material for the good life, health, social relations and freedom of choices and action.

The composite approach to the assessment of quality of life has limitations in terms of the quality of data from the different countries, the variation of values within countries, the value judgements imbedded in the choice of indicators and the weights given to them in the final index. Moreover, the use of mean values for countries obscures the distribution of values which for people with socialist views may present the most important aspect of well-being for a country. From an environmental perspective, the HPI purports to show the efficiency with which life satisfaction and length of life are extracted in a population per unit use of **natural resources** (the ecological footprint). From the 2005 NEF study, many SIDS emerge as the most efficient in this function, with the people of Vanuatu in the Pacific being the top of the league and many of the large developed countries such as the USA, France and the UK being near the bottom.

Rate of interest (discount rate)
The level of payment, usually expressed as a percentage per year, made by borrowers to lenders for the use of money. It represents a benefit to lenders for forgoing current consumption and for the risk of loaning money which may not be repaid. The rate of interest may be used also as a device for discounting the value of future benefits and costs in project assessment, on the grounds that benefits now are more valuable than in the future and the loss of the interest attained from investment is the opportunity cost of delay in receiving the benefit. The use of interest rates in discounting is a common practice in the assessment of the value of environmental and other public and private sector projects. High rates of interest used in discounting, however, may be considered to undervalue the benefits of a project accruing to future generations or the costs to them of future outlays. For example, nuclear energy provides current high benefits, but the disposal of waste from nuclear energy projects in the distant future, say 200 years time, involves deferred future high costs, which today appear modest when discounted at normal rates of interest but place a burden of risk on future generations.

Regression analysis
A statistical analysis which estimates the equation that best fits a set of observations of two related variables, which may be represented on a scatter diagram. For a linear equation the form is $C = a + bY$, where coefficients of the equation a and b are based on paired observations of the two variables C and Y (simple regression equation). The equation can

then be used to estimate the value of C with respect to any value of Y. The slope b of the regression line indicates the rate of change in the dependent variable (C) associated with one unit change in the independent variable (Y). This simple linear regression model can be generalised by including more independent or explanatory variables on the right hand side (multiple regression equation). Now the coefficients on each explanatory variable will indicate the partial effect of that explanatory variable on the dependent variable while keeping other explanatory variables constant. In these formulations it is assumed that the interrelationships between dependent and explanatory variable(s) are linear. A linear equation implies that the rate of change between the variables remains constant. In many economic circumstances, as with **diminishing returns to scale**, the rate of change in the dependent variable varies at different points on the range of the independent variable. This has great importance both in economics and in environmental phenomena, where at a certain point in the value of a dependent variable, the rate of change increases sharply with respect to the independent variable, having reached what is called the 'tipping point'. In ecology, this is observed when a specific habitat reaches its **carrying capacity** and is unable to sustain itself, experiencing unabated decline or degradation. This occurs to air quality when exposed to excessive pollutants or arable land regeneration when overgrazed. Another example of a non-linear relationship is the Environmental Kuznets Curve. For such cases, non-linear regression equations are used.

Research and development (R & D)

R & D is the process of scientific study seeking to produce innovation in products or services and to apply the results to economic purposes. It is conducted both in specialised public funded centres, most notably in universities and public institutes, and in the private sector, linked to specific industries. It is a fundamental tool in economic development process. In environmental management, it is focused on the technologies for sustaining and improving environmental services. It is also used for reducing adverse impacts on **natural resources** of industrial and other human activities and on early detection and effective intervention to reduce the adverse human and ecological impact of environmental disasters. One specific environmental application of R & D is in improving the efficiency of energy production from non-renewable sources such as coal and oil and in substituting increasingly efficient means of using renewable sources such as biomass, wind, solar, geothermal and nuclear fission.

Resilience

The capacity to recover from shocks (from the Latin 'to leap back'). It has been explored from an economics perspective with respect to small states by Briguglio and colleagues (2006, *Building the economic resilience of small states,* University of Malta and the Commonwealth Secretariat). They defined economic resilience in three dimensions as the ability of an economy: a) to recover quickly; b) to withstand shocks; and c) to avoid shocks. In constructing an index of resilience, they included the following variables: macroeconomic stability (covering fiscal deficit, inflation and unemployment, external debt); microeconomic market efficiency (covering regulation of credit, labour and business); good governance; (covering judicial independence, impartiality of the courts, the protection of intellectual **property rights**, military interface in the rule of law, political sys-

tem and the integrity of the legal system); social development (covering education and health). The concept of resilience in this approach is seen as a nurtured capacity, whilst vulnerability is considered inherent. Environmental resilience is similarly the capacity to respond to ecological shocks. Professor Albert Binger, formerly of the West Indies University Department of Environment and Development (WSSD 2002) has argued that SIDS are inherently vulnerable in so far as they depend upon the unsustainable use of non-renewable **natural resources** and are exposed to natural disasters; their resilience depends upon developing alternative economic structures which reduce their exploitation of non-renewable **natural resources** and invest in environmental regeneration. The development of tourism can offer this alternative but can also have an adverse impact on the **natural resources** the tourists come to enjoy. (See Nath and Schroeder's Chapter, *Tax instruments for Environmental Management in Tourist Destinations*.)

Risk, non-financial

The probability of damage or loss resulting from the impact of hazards on human life and the **environment**. The UN agency concerned with disaster risk management strategy (UNISDR) defines risk by the equation: Risk = Hazards x vulnerability/capacity for effective response. (See Roberts, J.L. Chapter: *Disaster risk reduction: Practical adaptive options.*)

Risk analysis

Risk analysis is concerned with the assessment of the nature and extent of risk, the probability that an adverse event might occur, the factors that affect that chance and its environmental and human consequences. The function of risk analysis is to identify the nature of risks, their economic, social and environmental impact, people's perception of risk, how society can manage risk and the role of analytical techniques such as economics in illuminating such questions. There are four components to risk assessment and its analysis, hazard identification, dose-response estimate, exposure assessment, and risk characterisation; the latter includes safe exposure levels, acceptable risk level, uncertainty and data limitations. The process of risk analysis reviews the technical features of hazards (location, intensity, frequency and probability), the physical and social extent of vulnerability and the capacity for prevention, **mitigation** and rehabilitation in relation to expected impact.

Scenarios

Used in planning in the public and private sectors as a method for envisaging the future and its implications for policy based upon projections from current trends. 'Scenario' is derived from an Italian word for the list of scenes in a play and the entrances and exits of the players. In planning, it is used to list the expected future unfolding events and states of markets and resources. A scenario may be the output from a series of computer simulations using clearly defined data and mathematical projections, as undertaken for the Club of Rome in the *The Limits to Growth* (Meadows, D.H. et al. 1972) and *Beyond the Limits* (Meadows D.H. and Meadows D.L. 1992), which reached a wide audience, provoked great controversy, and made iconic contributions to debates on development policy of those times.

In UNEP's *African Environment Outlook 1* (2002) and *2* (2006) the use of scenarios formed a substantial element in the presentation of the future regional environmental prospects in the face of a set of broad policy options. The UNEP scenarios, however, were less the product of evidence-based analysis and computer simulation of official data than was the work of the Club of Rome. The principal aim of UNEP was to alert policy-makers and planners to current trends and policy options to give greater attention to the impact of development policy on environmental degradation. The Global Scenario Group has produced a series of scenarios on the issue of planetary sustainability (1997: *Branch points: Global Scenarios and Human Choice*; 1998: *Bending the Curve: Toward Sustainability*; 2002: *Great Transitions: the Promise and Lure of the Times Ahead*). The worst-case scenario in these reviews is a planet with impoverished people, cultures and nature; the best case is the Great Transition towards a future of enriched lives, human solidarity and environmental sustainability. Many of these types of scenarios tend to lack a rigorous economic framework and estimates of the costs of achieving the transition to produce new outcomes. The Meadows's projections for sustainable development in 1992 included proposals for developing fresh tools for restructuring including: 'visioning; networking; truth-telling; learning; and loving'. They concluded then with the warning '… no time to waste. There is just exactly enough energy, enough real material, enough money, enough environmental resilience, and enough human virtue to bring about the revolution to a better world'. Thus, the use of such scenarios merges beyond economic planning and politics into the field of ethics and concepts of the good life.

Small island developing states (SIDS)

The term small island developing states is mostly used in the United Nations system in relation to the Barbados Programme of Action and the 10-year follow-up Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of SIDS.

Fifty-one countries are classified as SIDS by the UN. This SIDS group is not homogeneous. A common feature is their environmental susceptibility.

Small states

In the World Bank and The Commonwealth Secretariat, the term used is small state. Small states are defined as sovereign developing states with populations of less than 1.5 million. Small states are characterised by a high degree of economic openness, due to their heavy dependence on exports and imports, which renders them highly exposed to changing conditions in the rest of the world. Thus, they are likely to suffer from global crises. Exposure to external conditions exists in all countries, but in the case of small states such vulnerability is more intense, and is often manifested by high levels of fluctuations in GDP, import costs and export earnings.

The seminal April 2000 Commonwealth Secretariat–World Bank Joint Task Force Report on small states: 'Small states meeting the challenges of the global economy', started a new international partnership on small states, where a number of international partners (IMF, World Bank, ComSec) agreed on a framework to assist small states and initiated the 'small states forum' which meets during the IMF–World Bank Annual meetings.

There are 45 small states. All these countries follow the definition of 1.5 million. However, the Commonwealth includes larger states in its reviews such as Botswana, Lesotho, Namibia, Jamaica, and Papua New Guinea, because they share many of the characteristics of smaller states.

Social attitudes
The mental state of a population in relation to general or specific matters. The concept commonly embraces three components: cognitive (knowledge and beliefs), affective (liking, preferences), and behavioural (action, tendency, purchase intentions, willingness to pay and willingness to accept compensation). In **environmental economics**, social attitudes to natural and environmental resources are a key element in the assessment of opportunity costs – the notion that the value of something is dependent on what we are willing to give up for it.

Standard cost
An estimate of the expected cost of production using normally efficient methods of production and normal prices of materials. A standard cost may be used in an estimate of expected production costs or the prices of contracted work as a bench-mark. The establishment of standard costs in certain aspects of environmental services is common. It is used in assessing expected costs of extending water supply, renewable energy production, waste management and carbon trading. The practice is less well developed in other areas including beach management, fisheries protection, and natural disaster protection. The method is one element in the establishment of a production function for the delivery of environmental goods and services. For example Ellis, G. and Fisher, A. (1987) 'Valuing the **environment** as an input', *Journal of Environmental Management*, 25: 149–156, demonstrated the 'cost' of increasing the yield from crab fisheries in terms of the increase in protected wetlands and the number of traps set.

Standard of living
A measure of the value of quality of life of an individual, family or community. A common unit of measure is monetary income adjusted for purchasing power. This approach to measurement does not include those values that derive from non-traded goods and services such as the quality of environmental services enjoyed, which may include housing location, travel time, air quality, noise exposure, scenery, ecology, etc. Some of these values may be reflected, however, in house prices and the willingness to pay for environmental benefits. These may all be included in assessment of the standard of living.

Statistics
The theory and methods of collecting, tabulating and analysing data. A key function in government and business for planning and for assessing the state and trends in trade and political, economic, social and other aspects of community life. Statistics are commonly classified into different specialised fields including trade, health, population and vital statistics. The World Resources Institute, sponsored jointly by UNDP, UNEP and the World Bank, publishes a biennial report and set of environmental and related statistics on the

global **environment** with case studies of current issues and interventions. (See www.wristore.com)

Supply side economics
The aspect of economics concerned with productive capacity, efficiency, output and sales. Special focus has been given to the inhibiting impact on supply of market interventions by trade unions and governments in influencing the determination of terms and conditions of employment, wages, welfare and social security provisions which increase the production costs to the firm. The supply side dimension of economic appraisal tends to ignore human and environmental **externalities**, market failure and the existence of a market in such social values. Industries dominated by supply side economics include: the arms trade, 'big' tobacco, alcohol, other drugs of addiction and European agriculture under the Common Agricultural Policy.

Surplus value
An excess of income from a factor in production over and above its supply price. **Karl Marx** identified surplus value as 'exploitation of labour', calling for capitalists to pay workers the full value of their outputs. He saw wage exploitation of workers as one of the defining features of capitalism and the principal element in the dialectical conflict between capital and labour, and the source of the pressure for a 'workers revolution'. **Marshall** identified the surplus as a quasi rent for the use of capital. The concept of surplus value is a key element in **environmental economics** where the **externalities** of production may not be included in the supply price. For example, the price of timber may not include the loss of forest cover with timber harvesting.

Sustainable development
Defined by the UN Bruntland Commission 1987 in *Our Common Future* (Oxford University Press) as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. This concept avoids the false conflict between human progress and environmental loss and is sometimes referred to as ecological modernisation. In economic terms the concept of a sustainable economy is one where physical capital, labour, natural resource endowments and technology lead to constant or increasing economic opportunities now and in the future, so that potential human welfare does not decline. This approach allows allocative and technical efficiency to exist with sustainable development. In terms of the sustained availability of **natural resources**, there are two views in **environmental economics**. One view depends on the concept of 'strong sustainability' which requires any used natural resource to be replaced over time. The other depends on the concept of 'weak sustainability' which accepts substitution through new technical transformation of any non-renewable natural resource. Thus, if the same level of energy production from oil can be achieved through wind power, this is, other things being equal, an acceptable substitute under the concept of weak sustainability, but not under that of strong sustainability, since the former oil resources have been depleted and cannot be replaced.

A complication in the measurement of sustained total capital is population change. This

raises the question of whether we should be sustaining total capital or total capital per head of population. It has been postulated that economies naturally generate their own (endogenous) capacity for sustaining growth. This is possible through technical progress which allows for a reduction in the adverse impact on the environment as the economy grows through the substitution of capital and labour for the use of natural resources (the phenomenon of 'Environmental Kuznetz' curve). Evidence to support the theories of endogenous growth and the Kuznetz transformation is fragmentary but, if true, it could produce a self-sustaining potential for economic growth and a declining degradation of natural resources. Pearce and Barbier (2006, *Blueprint for a sustainable economy*, Earthscan) have argued that we cannot rely on the invisible hand of the market mechanism, un-aided, to provide the basis for sustainable development; new economic tools and regulations are necessary to correct for market and policy failure. Solow, R. (1992, 'Sustainability: an economist's perspective', in Stavins, R.N. (2005) *Economics of the Environment*, Norton) has suggested that one economic rule to promote intergenerational justice in sustainable policy is that the return on the use of any non-renewable **natural resources** should be re-invested into capital formation.

Taxation

Government receipts from imposition of charges on income of persons and corporations (direct tax) and on trade in goods and services (indirect tax). Taxes are used for pursuing a variety of government objectives, including: to raise government income, to alter the distribution of wealth, to control the level and distribution of spending, to control the level of imports and exports and for the pursuit of social and environmental ends (e.g. funding of health services, the arts, protection of the **environment**, etc.). Taxation has been used in many countries for environmental protection. (See also **Pigouvian tax/Green taxes**.) The objectives of such taxes have been to encourage technological innovation, to promote changes in supplier and consumer behaviour, and to achieve environmental goals in a cost effective manner. The use of taxation as an economic instrument has been largely focused on single point **pollution** reduction. Taxation has been used to reduce emissions in energy production or in energy use and on sources of water **pollution**. Environmental tax reform (ETR) aims to shift tax penalties away from environmentally and socially-sound practices (taxes on employment) and place it on polluting and environmentally-damaging practices (carbon taxes, car tax related to engine size or emissions). Property tax can be used to recoup costs of the **externalities** of tourism. (See Nath and Schroeder chapter: *Tax instruments for Environmental management in Tourist Destinations.*)

Technical efficiency

The level of output achieved as a ratio of the factor inputs, for example the number of pink pigeons produced per acre of managed protected habitat. In this example the factor inputs in protected habitat may include capital equipment and buildings, labour and land. The efficiency ratio may be affected by external and internal inhibiting factors in the production function. The external inhibiting factors may include: adverse climate, predators, and disease. The internal inhibiting factors may include: equipment maintenance, profes-

sional and managerial skill, and the suitability of habitat. Technical efficiency is usually measured in terms of total factor productivity. (See **Productivity**.)

Technology
The methods used to produce goods and services, including the specific use of capital, labour and **natural resources** in different proportions. The pattern of technology use is affected by both supply-side and demand-side practices. In energy production, the technology involved adopts widely different methods of production each with its own level of environmental impact, depending on the fuel used and the method of energy production and emission control adopted. Apart from switching to renewable sources of energy production such as hydro-electricity, wind and wave power, low emission technology is now increasingly applied in energy production from fossil fuels such as coal and oil. The technology of the demand-side in the energy market also has an impact on emissions. Total emissions are affected by the extent of recycling, by lower energy use methods in the construction industry, by greater domestic energy efficiency practices, such as thermal insulation, by longer life lighting, and by greater use of public transport promoted through road use charges.

Theory of consumer behaviour
Theory which addresses the issue of how consumers allocate their resources between alternative goods, services, savings and investment. The impacts – both economic and non-economic (such as psychological) – on the consumer are analysed. In environmental policy, a new focus has been given to sustainable consumption recognising the global growth in population, the disparity between rich and poor, the unsustainable consumption of **natural resources** such as water, food and fossil fuels and the impact of such consumption on environmental degradation. (See Meadows and Meadows (1992), *Beyond the Limits*; Hargroves, K.C. and Smith, M.H. (2006) *The Natural Advantage of Nations*.)

Theory of markets
Theory which addresses how scarce factors of production are allocated to products and services in the market place. This process determines prices and volumes of outputs and also the prices and allocation of the factors of production (capital, labour and **natural resources**). **Environmental economics** addresses the issue of the market for environmental goods and services. In doing so, it examines the impact on **natural resources** of the market for other goods and services. A key concern in **environmental economics** is that certain **natural resources** are un-priced or under-priced in market transactions. This leads to the unsustainable use of such resources. **Environmental economics** exposes the failure of the theory of markets adequately to take account of the scarcity and vulnerability of **natural resources**.

Trade integration
The reduction of barriers to trade between countries and regions with the objective of achieving international economic and social advantage. Common stages involving increasing levels of integration include the establishment of:

a a free trade area;
b a customs union;
c a common market;
d an economic union; and
e a monetary union.

The USA is an example of an economic and monetary union of federated states; the EU is a common market with differences in fiscal and monetary policies between member states; EFTA is a free trade area; and COMESA is establishing a customs union. Environmental restrictions on trade in the EU are binding on all EU countries and affect the EU position in WTO negotiations, including such matters as recycling, packaging, emissions standards, eco-labelling and carbon trading.

Tragedy of the Commons
Derived from an iconic paper in 1968 by **Garrett Hardin**, this metaphor identifies the disastrous end result of unrestrained freedom in the use of common pool resources such as common land and the sea, in which people become trapped by their own competitive impulses and ultimately destroy the use of the common inheritance. The common resource can only be sustained by agreed regulation which limits the freedoms previously enjoyed. Examples are to be found in the use of common grazing, forest land and marine resources. In these cases, as demand increases with population growth, so the **carrying capacity** is reached and limitations have to be placed on use, through some regulatory control such as through price, rationing by volume, or the introduction of new forms of **property rights**.

Utility
The value that a person gets from the consumption of a good or service. Some economists such as Jeremy Bentham and other Utilitarians considered that utility was measurable on a cardinal scale and additive across populations allowing the calculation of 'the greatest happiness of the greatest number'. Others, in the neo-classical school, consider that **utility**, measurable on a cardinal scale, is neither possible, nor necessary, since each person's marginal utility varies inversely in relation to units of consumption of any good or service. As against cardinal measurement, it was argued that ordinal ranking serves the purpose better, that is to arrange goods and services in order of preferences. **Environmental economics** has further developed the concept recognising the existence of willingness to pay (WTP) for non use values (**utility** without consumption).

Vulnerability
Literally, the extent of exposure to attacks or harm (from the Latin word 'to wound'). Social, economic and environmental vulnerability is the inherent condition of being exposed and susceptible to loss and damage from conflict, social, economic, natural and other hazards. The level of exposure can be affected by isolation and the location, frequency and extent of hazards. The economic and environmental risks arising from vulnerability may be increased by the frequency and severity of hazards and relieved by developing resilience through prevention, mitigation and other adaptive capacities that can reduce

the extent of loss and damage. Economic vulnerability, especially in small states, arises from extreme dependence on exports and imports, high dependence on capital inflows, and, in some cases, lack of natural resources.

The issue of small states vulnerability was given formal expression within the Commonwealth at the 1977 Commonwealth Finance Ministers' Meeting in Barbados. In response, the Secretariat prepared a programme designed to assist in overcoming 'the disadvantages of small size, isolation and scarce resources which severely limit the capacity of such countries to achieve their development objectives or to pursue their national interests in a wider international context'. This was endorsed by Commonwealth Heads of Government at their 1979 Meeting in Lusaka and reaffirmed at their 1981 meeting.

In 1983, with the political repercussions of the US invasion of Grenada still resonant, Commonwealth leaders, at their New Delhi meeting, felt that the problems of small states 'deserved consideration on a wider basis, including that of national security'. A Commonwealth Consultative Group was commissioned to examine the special needs of small states for economic development including issues relating to national security. The report – *Vulnerability: Small States in the Global Society* – was published in 1985. The report was the first to note that small states are 'inherently vulnerable to external interference'. The report outlined measures that can be used to reduce vulnerability such as underpinning economic growth and diplomacy and foreign policy management.

Following this publication, the Ministerial Group on Small States was formed to discuss issues of importance to small states. In 1995, ministers recognised that the international context faced by small states had changed dramatically since the Cold War ended. The Secretary-General constituted a Commonwealth advisory group of eminent persons led by Dame Eugenia Charles of Dominica. Their report – *A Future for Small States*: *Overcoming vulnerability* – was published in 1997.

(See also Briguglio, L. et al. (2006), *Building the resilience of small states*; Islands and Small States Institute of the University of Malta and the Commonwealth Secretariat, London, ISBN 99909-49-23-9 who define economic vulnerability as 'exposure to external shocks arising from intrinsic features of the economy, measured by economic openness, export concentration, and dependence on strategic imports'.

Washington Consensus

A set of policies developed in 1989 by John Williamson, for the Institute for International Economics, to promote economic development in Latin America. These policies were subsequently adopted by proponents of neo-liberal economic **globalisation** and later opposed by the anti-**globalisation** movement. The policies covered ten major areas of economic reform, including fiscal discipline, redirection of public spending to education, health and infrastructure, tax reform to reduce the burden on high income earners, market determination of interest rates, competitive exchange rates, trade liberalisation, openness to FDI, privatisation of state enterprises and legal security for **property rights**. The set of neo-liberal economic policies were criticised by Hans Singer (with colleagues), in *The Economic North-South Divide* (2001) as ones likely to promote rising inequality in **developing countries** and greater poverty. Singer opposed the **Washington Consensus** and called for a new

approach and 'economics as if people mattered'. International bodies now refer to a post-**Washington Consensus** which includes support for the global **environment** and the relief of poverty especially in the least developed countries.

Water
A naturally-occurring liquid substance combining hydrogen and oxygen, essential for animal and plant life on earth derived from oceans through evaporation and atmospheric precipitation and found in marine and fresh water courses. Water is both essential for sustaining life through ingestion and a natural habitat for animals and plants. The circulation of the earth's water driven by solar energy and affected by differences in seawater density is determined by temperature and salt content of the oceans. Inland fresh water systems are major contributors to water distribution, energy production, irrigation of land for agriculture, and for transport. Human pressures on water through overexploitation and **pollution** adversely affect the sustainability of animal and plant life. These pressures are degrading inland ecosystems in rivers, streams and floodplains; in lakes and reservoirs, marshes, wetlands, oases and aquifers. They also adversely affect coastal and marine systems, including mangrove forests, coral reefs, estuaries and mudflats, sea-grass and algae beds, and fish ecosystems. Management of water systems is concerned with provision of water for drinking, and for other purposes, taking into account both supply and demand aspects and the protection of water supplies in the face of adverse natural and man-made pressures.

Welfare economics
A normative school of economics concerned with how economic activity ought to be carried out to maximise economic welfare of the society. The school embraces the work of Vilfredo **Pareto**, Nicholas **Kaldor** and John **Hicks**. It may be claimed that health, environmental and **ecological economics** have developed from this school via the route of public economics.

Key figures in development policy and environmental and natural resource analysis

Bentham, Jeremy, 1748–1832
British political economist, scholar and pamphleteer, he was the founding father of the word 'utility', a notion congruent with the modernist concept of private happiness, and for promoting the idea of 'the greatest happiness of the greatest number' as a standard for assessing the impact of political policies. His concerns for economic and social progress and equality of opportunity persuaded him to favour death duties to establish redistribution of wealth without undermining current incentives for the rich. He founded and endowed University College London, leaving in his will his embalmed body to be dressed in his own clothes and exhibited for posterity in a glass case in the entrance hall of the College. It is moved into the Board room for governors' meetings.

Burnham, James, 1905–1987
Noted for '*The Managerial Revolution*' (1942), which was a rejoinder to the Marxist theory

of the dialectic process giving rise to a workers' revolution. Burnham predicted that a new elite would gain power, and that managers and technocrats would not own but would run the capitalist businesses, the army and government, especially in the USA, Germany and Japan. This reflected the fundamental changes in the market structure emerging in the twentieth century and the behavioural approach to the positive theories of management and of economics.

Coase, Ronald, 1910–
A British-born, Nobel Prize-winning economist, he devised a theorem (1960) for resolving competing claims in **property rights** to achieve a Pareto equilibrium. The theorem states that if transaction costs are zero parties affected by an externality will agree on an allocation of resources that is both Pareto optimal and independent of any prior assignment of **property rights**. For example, fishermen adversely affected by a farm's **pollution** of a river can negotiate to pay the farmer an amount to reduce the **pollution** up to the increased value of the fish caught. Professor Coase is currently Clifton R. Musser Professor Emeritus of Economics at the University of Chicago Law School.

Daly, Herman, 1938–
Former Senior Economist in the **Environment** Department of the World Bank, and editor of the *Journal of Ecological Economics*. Noted for his 1977 *'Steady State Economics'* and 1996 *'Beyond Growth'*. He proposed the Utopian target of zero population growth as a necessary condition for sustainable development (SD). This was included in a set of other necessary conditions for SD which included: ensure harvest rates are equal to or lower than growth rates; ensure investment from income from non-renewable resources goes into renewable substitutes; keep the time period of emissions less than assimilative capacity; and put global limits on aggregate emissions, energy use, resource use and population growth.

Domar, Evsey, 1914–1997
Polish-born economist, professor at MIT USA, who collaborated with Sir Roy **Harrod** in developing the Harrod–Domar model of **economic growth**. Also an expert on Soviet economics during the Cold War.

Hardin, Garrett, 1915–2003
Biologist who wrote *'The Tragedy of the Commons'* in 1968, using the example of overgrazing of common land as the inescapable result of the free market. Opposed to the notion of 'the invisible hand' guiding the free market to the optimum economic position for all, he was a key contributor to thought on environmental policy and regulatory management.

Harrod, Sir Roy, 1900–1978
A British economist jointly credited with the 'Harrod–Domar **economic growth** model' which introduced the concepts of warranted growth and actual growth, taking into account changes in savings and the size of the labour force and productivity. He was noted for stimulating thought about the nature and determinants of growth and refinements of Keynes's notion of economic equilibrium. From an environmental perspective, it has to be recognised that whilst he accepted the importance of improvements in physical capital

through savings and investment, he did not address issues of the special constraints of developing and small states, nor the impact of **economic growth**, measured in terms of income, on the depletion of natural capital, nor the **externalities** of **economic growth** on health and the **environment**.

Hicks, John, 1904–1989
Key contributor to the theory of **welfare economics** and, with Nicholas Kaldor, introduced the complementary notion of compensation to be used with the Pareto principle of welfare gain. The concept of the potential Pareto improvement (PPI) states that any economic change is beneficial to welfare, if the 'gainers' could compensate the 'losers' and still be better off. This concept embraces both the assessment of efficiency gain and its distribution. This conceptual development may be seen as foreshadowing cost-benefit analysis and environmental impact assessment in which the loss of natural capital and its services can be assessed against economic gains from physical capital investment and labour productivity.

Hotelling, Harold, 1895–1973
In *The Economics of Exhaustible Resources* (1931) Hotelling proposed a rule (known as Hotelling's rule) that **natural resources** should be treated as capital and then the optimal rate of extraction would be where the return is equal to the interest rate for capital, that is the opportunity cost of capital. This notion is a key element in the development of natural resource analysis while analysing exhaustible / non-renewable **natural resources**.

Huntingdon, Samuel, 1927–2008
A Harvard Professor of mathematics, noted for his 1996 *Clash of Civilizations and the Remaking of the World Order*, he predicted that future conflict would not be between nation states but between cultures. 'The fault lines between civilizations will be the battle lines of the future.' Seen by some critics as the political justification for US intervention in foreign lands, especially in Islamic countries, and an excessive simplification of the white Anglo-Saxon Protestant influence on Western thought and politics. Under President Nixon he was an adviser who proposed bombing Vietnamese villages to drive peasants into the towns. Amartya Sen's rejoinder in 2006 *Identity and Violence, the Illusion of Destiny*, should be taken as an antidote and Omae Kenechi's *The End of the Nation State* an alternative exploration of the idea of the impact of globalization on national identity and sovereignty.

Jevons, W. Stanley, 1835–82
A key contributor to the development of **neo-classical economics** and the marginal analysis framework. Also noted for his analysis of the impact of economic activity on non-renewable **natural resources**, such as coal. In *The Coal Question,* he examined the implications of limited resource stocks as a constraint to sustained economic development.

Keynes, John Maynard, 1883–1946
Noted principally for his 1936 publication on *The General Theory of Employment, Interest and Money*, which addressed the policy and theoretical implications of the 1930s economic depression in Europe and the USA. His theory and policy proposals challenged the classical

theories of the operation of the market economy and the neo-classical, micro-economic theories of the firm. He dismissed the notion of the self-correcting capacity of the market to respond to critical falls in demand, mass unemployment and hyperinflation. He argued for government intervention through fiscal policy, public works and deficit funding to redress market failure, stimulate employment and aggregate demand. Keynes promoted new departures in fiscal policy by his notion of the multiplier effect, which stimulates demand many times greater than the initial level of investment. Keynes is acknowledged as a forerunner of **development economics**, through ideas inherent in the Bretton Woods developments of the IMF and the World Bank. He is also noted for his influence on other economists such as Joan Robinson and James Meade. They adapted his theories to the specificities of rural economies of developing countries. His influence can also be traced in the ideas of Nicholas Kaldor and John Hicks who extended his theories into supply-side **economic growth** and **welfare economics**.

Kuznetz, Simon, 1901–1985

A macro economist and Nobel Prize winner noted for his contribution to the measurement and compilation of data on national income, its distribution between rich and poor and its value in the assessment of **economic growth**. He proposed the notion that there exists an inverted 'U' shape relationship between the equality of income distribution and income levels. This idea has been adapted into the field of **environmental economics** in the Environmental Kuznetz curve. (See *World Development Report 1992,* the World Bank) which claims that a similar inverted curve relationship exists between income levels and environmental quality. The effect in an expanding economy is in stages. At first, as income increases so does environmental **pollution**. Then, with further increases in income, **pollution** reaches a peak. In the later stages of increases in national income, **pollution** declines as new technology intervenes to increase efficiency and to reduce degradation of the **environment**. This process is stimulated by a growing demand for a cleaner **environment**, which imposes regulations for constraint on environmental depletion. With each stage of **economic growth**, structural change in the economy reduces the level of dependence on **natural resources** and industrialised production, and there is a shift towards the development of non-industrial services. This is sometimes referred to as 'buying your way out of environmental degradation'. This structural change in a developed country may serve to remove the polluting industries and processes to less developed countries, Evidence for supporting the general adaptation of the Kuznetz hypothesis to the relationship between **economic growth** and environmental impact is conflicting. For despite **economic growth**, and technical innovation, **market failure** and **policy failure** continue to occur to sustain a pressure on environmental resources. Kuznetz was born in Russia, and became head of a statistical office in the Ukraine before migrating to the USA where he taught in the Universities of Pennsylvania, Harvard and Johns Hopkins. He was president of the American Economic Association in 1954.

Lewis, Sir Arthur, 1915–1991

Nobel Prize-winning economist noted for his work on **development economics** from a developing country perspective. Noted for his 1955 Theory of Economic growth. In this work, the core concept was that of the 'dual economy'. In the economies of **developing**

countries he observed that, on the one hand, the agricultural sector survives at subsistence level, with low wages, no saving and low productivity, whilst on the other, investment in industrial projects produces profits, creates savings and promotes growth. Industrialisation reaps benefits from the use of surplus labour from the primary sector. It develops by promoting import substitution of domestic products which gives rise to increasing wages as surplus labour is reduced. But he observed that rapid industrialisation creates problems of sustainability for those countries and inequitable distribution of wealth and services. Intervention is necessary to ensure a balanced provision of physical infrastructure for transport, communications, education, etc. as pre-requisites for sustained growth. Lewis is often credited with the birth of the academic discipline of **development economics** along with others such as Raúl Prebisch, working in Latin America, and Gunnar Myrdal, a Swedish Nobel Prize-winning economist, from his work in India. Lewis also explored the paradox of the sugar and wheat industries. He observed that the sugar industry is highly productive in developing countries where 'the rate of productivity is unparalleled by any other major industry in the world – certainly not by the wheat industry. Yet the workers continue to walk barefoot and to live in shacks while workers in wheat enjoy among the highest living standards in the world'. He explained the paradox as an intersection between labour supply and the terms of trade. (Lewis, A., 1954 *Economic Development with Unlimited Supplies of Labour.*)

Lomborg, Bjorn, 1965–
Associate Professor of Statistics, University of Aarhus, Denmark, noted for his deconstructive critique of environmentalism and its claims for a doomsday scenario for the world, especially in his 2001 book *The Skeptical (sic) Environmentalist, measuring the real state of the world.* His conclusion is that 'children born today will live longer and be healthier, they will get more food, a better education, a higher standard of living, more leisure time and far more possibilities, without the global **environment** being destroyed'. It is an antidote to the environmentalists' worst-case scenario. It stimulates thought about the **opportunity cost** of investment in environmental improvement.

Malthus, Thomas, 1766–1834
Noted for his 1798 *Essay on the Principle of Population as it Affects the Future Improvement of Society.* He saw the exponential growth in population outstripping the linear growth in food supplies and condemning most people to live in poverty with only epidemics, war and famines curbing the population increase. His views on economics contributed to it the cachet 'the dismal science'. Whilst this view was much discredited by Keynes who observed that fertility declined with **economic growth**, poverty remains a core global development issue.

Marshall, Alfred, 1842–1924
Noted for his 1890 *Principles of Economics,* which became in its many revised editions a standard textbook for students and commercial managers in what is referred to as the new or 'neo' classical economics. He expressed concern about the simplistic interpretation of the geometric approach that he developed using two-dimensional diagrams to show the differential relationship between, for example, price and demand. But these

brought a new transparency to the subject of micro-economics and the application of classical economic theory to the realm of practical business. Core concepts for Marshall were the marginal (differential or the slope of the) relationship between variables, marginal **utility**, elasticity of demand with respect to price, and diminishing returns to scale. His principles continue to be applied in business economics and in **environmental economics**, for example in the examination of abatement costs and emissions reduction, and to road use and transport costs.

Marx, Karl, 1818–1883
Social scientist from Germany who in *Das Capital* challenged the framework of classical economics, drawing attention to key areas of market failure and the economic and social gap between rich and poor. His analysis was based upon observations of the working of capitalism in mid-nineteenth century Germany and in England, where he spent much of his time studying the 'blue books' and the reports by the implacable British factory inspectors of the problems in implementing the then-new British regulations on health and safety at work. With Frederick Engels, he developed a meta theory of the historical process of development. He saw the history of man as being continually determined by a conflicting power relationship (a dialectic) between two competing classes of society: firstly, the landowners against the urban industrial capitalists; and then the capitalists against the workers. The inescapable conflict arose, he asserted, from the economic status of each in relationship to the ownership of the means of production. Each phase in history was punctuated by revolution. The revolution of the capitalist against the land-owning aristocracy was the feature of the French and other republican revolutions. He claimed that a spectre hung over Europe in his time and predicted this would result in an inevitable convulsion and a revolution of the proletariat (the workers) over the capitalists. This would ultimately give rise to a new millennium under communism in which all assets would be owned by the state, which itself would ultimately wither away. Marx considered that the market would be replaced by social and economic supply-based planning. Marx's theories were a dominating theme in much radical thinking about political economics in the late nineteenth and twentieth centuries, worldwide. His analysis of market failure, however, remains one of his few surviving legacies, the collapse of the Soviet Union having discredited much of the rest of his meta thinking on the determinants of social and economic development and the value of long-term, state supply-side planning.

Meade, James Edward, 1907–1995
Nobel Prize-winning economist in 1977 and British professor of Economics at the London School of Economics (LSE) and at Cambridge. He worked with the League of Nations and with the British Cabinet Office. He is noted for his social and economic study of Mauritius in the 1950s and for his Theory of International Economic Policy. In his Nobel banquet speech he said: 'The well balanced economist is a normal human being with his warm heart on the Left, his practical work-a-day hand on the Right, and his clear and thoughtful head in the Centre'.

Meadows, Donella ('Dana'), 1941–2001
Lead author of the ground-breaking 1972 study, *The Limits to Growth*, commissioned by

the Club of Rome, a German-based think-tank. The book, which sold over 30 million copies, was followed up with a further study publication *Beyond the Limits.* Both studies, using computer-based models, addressed the issue of the impact of **economic growth** and population growth on the use of finite **natural resources** – a kind of Malthusian analysis with a computer. The authors proposed mitigative and adaptive action that can avert the doomsday end-game painted in their worst-case scenario. Adaptation would include cleaner technology, better education and environmental friendly governance.

Mill, John Stuart, 1806–1973
Noted for his seminal 1848 work *Principles of Political Economy with some of their Applications to Social Philosophy,* and for his work as a social reformer to lighten the impact of unregulated markets on social well-being. He promoted the desirability of government intervention in the free market to correct against market failure, especially for the fairer distribution of income and for the temporary protection of infant industries. This had an important influence on the early thinking about the special economic and social needs of developing countries.

Myrdal, Gunnar, 1898–1987
Swedish economist and politician and Nobel Prize winner in economics, he worked closely with the UN Economic Commission for Europe. He is noted for his contributions to **welfare economics**. These can be explored principally through his studies of inequality in the USA, the divergence in wealth between rich and poor countries, and through his analysis of issues of economic and social underdevelopment in Asia in *Asian Drama, An Enquiry into the Poverty of Nations,* 1968. He is generally considered one of the key influences, with his wife Alva Myrdal, also a Nobel Prize winner, on social welfare policy in western Europe in the twentieth century.

Nash, John Forbes, 1928–
Joint Nobel Prize winner in economics for his application of game theory to problems of non-co-operative games such as the prisoners' dilemma and the identification of the Nash equilibrium point. This work had the effect of challenging the neo-classical methods of exploring economic issues. It has had a penetrating impact on economic theory and its application to business and government policies and practice. Nash was the subject of the unauthorised biography *A Beautiful Mind* by Sylvia Nasar, and an Oscar-winning film of the same title, which broadly reflected his life, his mental illness and his special contributions to mathematics and economics.

Nordhaus, William D, 1941–
Professor of Economics at Yale University USA since 1973, and regarded as an expert on the economics of climate change and non-market accounting and integrating environmental values into national accounts. He is joint author with Paul Samuelson of the classic textbook, *Economics,* now in its 18th edition. His research has concentrated on **economic growth** and **natural resources**. He has constructed the RICE computer-based model on the subject of adapting to climate change. He supports the use of carbon taxes for controlling carbon emissions rather than arbitrary targets as in the Kyoto Protocol. He has

also published a study on the costs of the war in Iraq. See Nordhaus, W. (2007) *The Challenge of Global Warming; economic models and environmental policy*, Yale University.

Pareto, Vilfredo, 1848–1923
Noted for his contribution to the theory of economic welfare, in which he asserted that equilibrium exists in the exchange of goods when the welfare of one person cannot be improved except by reducing the welfare of another. He accepted that **utility** could not be measured but that a purely ordinal notion of **utility** (a is better than b) was a sufficient basis on which to construct a theory of choice and welfare. To overcome the obvious practical constraint on the use of the concept, **John Hicks** and **Nicholas Kaldor** proposed the modification known as the 'Potential Pareto Improvement', which allows compensation for loss to be assessed and the improvement to be conceded if after allowing for compensation for any losses (whether paid or not) people are not less well off.

Pearce, David, 1941–2005
Noted for his 1989 *'Blueprint for a Green Economy'* and 2001 *'Blueprint for a Sustainable Economy'* (with Edward Barbier). These books set out a framework for multidisciplinary ecological economics. He promoted through teaching at University College London and through policy advice to governments in UK and abroad the concepts of 'internalising **externalities**' through the use of economic instruments – such as road pricing, now operating effectively in London – and the creation of markets for environmental improvements – such as carbon trading, now operating in the EU. Through the Commonwealth Secretariat in the Pacific and Caribbean SIDS, he established training for integrating economic and environmental policies and practices for environmentally sustainable development.

Petty, William, 1623–1687
Petty was a notorious exponent of the brutal subjugation by the English of the peasantry and the neo-feudal expropriation of their agricultural land in the Cromwellian re-conquest of Ireland in the seventeenth century. He is also noted for his early historical contribution to the analysis of economic transition as part of the infancy of **development economics**. Whilst pirating the Irish, he explored notions of establishing national accounts, the price of labour, including non-wage earnings, economic planning and the three-fold division of the economy into capital, labour and land as the factors of production. The context of his writing was fiscal-military dictatorship starting in Ireland and subsequently transferred as a model for the colonies at large. This system of control was a key part of the European imperial **globalisation** in the Americas, South West Asia, Australia, New Zealand and Africa. The amoral predatory political intent of his economics was parodied by Jonathon Swift in 1729 in *A modest proposal for preventing the children of poor people from being a burthen for their parents or country, and for making them beneficial to the public.* This was a satire envisaging breeding children, like animals, for human consumption. Whilst acknowledged as a founding father, Petty has thus become an iconic challenge to all development economists concerned with equity and the distributional aspects of wealth and power.

Pigou, Arthur Cecil, 1877–1959
Successor to Professor Alfred Marshall at Cambridge, Pigou is noted for his 1919 *The Economics of Welfare.* He advocated the use of taxes and subsidies to remedy market failure and its impact on resource allocation, where prices failed to reflect social as well as private values for goods and services. He also promoted the policy of income redistribution on the grounds of the diminishing marginal **utility** of income. These notions underpin much subsequent theory and practice in **development economics**. They are also part of the intellectual underpinning of the welfare state, policies of international aid and of economic integration at regional, sub-regional and national levels. These mechanisms have been an integral part of development practice in the EU, USA, UK provinces and in France with its peripheral Departments, such as Réunion.

Polyani, Karl, 1886–1964
As a radical revisionist critic of classical and neo-classical economics, Polyani developed fresh insights from comparative studies of anthropologically-based economic analysis. He is noted for his 1944 *Great Transformations, the Political and Economic Origins of our Time,* and his deconstruction of the conceptual framework of the self-regulating market economy. This title has been adopted by UNEP to embrace sound policies for sustainable development in scenario planning. Polyani wrote of the 'free market', *'... such an institution could not exist for any length of time without annihilating the human and capital substance of society'.* He saw the process of regulation in the nineteenth century by different governments throughout Europe as a means of checking unbridled capitalism advancing under the protection of the misplaced classical economic theories. Such intervention was manifested through legislation on public health, factory conditions, social insurance, public utilities, municipal services, and trade union rights. His notion of *The Great Transformation* was that of halting the advance of economic liberalism by restoring social values as the guiding principles for political economics. He did not see this dual mechanism, market economics v. social economics, as a regulating process, akin to the invisible hand, nor as a dialectic process akin to the Marxist view of history. His legacy to **development economics** is the notion that markets are only sustainable if they are 'embedded', that is if they operate within an institutional framework of dominant social and political values, which regulate, stabilise and legitimise market outcomes. In the twenty-first century, in the face of market **globalisation**, it is increasingly evident that the necessary national institutions for promoting the countervailing social and political values, identified as essential for sustainable development by Polyani, have yet to be established at global and regional level. In many countries, at national level, though evident in law, they remain in practice weak, suffering under severe limitations which frustrate the process of implementation.

Quesnay, Francois, 1694–1774
French economist of the Physiocratic school and contributor to the French *Encyclopaedia*. Noted for his economic table published in 1758, which is one of the first analyses of the workings of the economy. He met and influenced **Adam Smith.** He was adviser to Louis XV and many of his ideas on policy were developed and implemented by Jacques Turgot, French Minister of Finance. In opposition to the Mercantilists, the Physiocrats, the first organised group of economists, considered that wealth is derived not from gold but from the size of the

net product, principally of agriculture; from this concept was later developed the **labour theory of value**. The Physiocrats supported the concept of 'laissez-faire' in trade and were also opposed to the Mercantilist policies of monopolist charters, trade controls, restrictions on the movement of labour and protective tariffs. Physiocracy means literally 'the rule of nature' and the Physiocrats considered that the state should have merely an enabling role to allow the state of nature to flourish.

Rawls, John, 1921–2002
Noted for his 1971 *Theory of Justice* and its later restatement in his 2003 *Justice and Fairness*. His theory has been influential in both politics and economics. His framework of social justice for a democratic pluralistic society was built on two principles, liberty and difference. The first asserts the equality of claims to liberty. The second asserts that social and economic inequality should satisfy two conditions that are attached to offices and positions. They should be open fairly to all and they should be of greatest benefit to the least advantaged members of society. Rawls' theory has assisted **development economics** in its consideration of disparities in the distribution of wealth and of political power. His mission was to find a theory that would provide the basis for a stable, democratic, pluralistic society. For this purpose, he proposed a process of overlapping consensus that would provide the glue for cohesion and the resolution of conflict, yet would allow dissent, individualism and the pursuit of the interests of minority groups, including different political philosophies and different religious faiths.

Sachs, Jeffrey D, 1954–
Sachs is currently director of the Earth Institute and Professor of Sustainable Development, and of Health Policy and Management at Columbia University, USA. He is noted for his 2005 *End to Poverty* (Penguin Books). He was also chairman of the WHO Commission on Macroeconomics and Health. He subsequently was Chairman of the UN Millennium Development Project. He is engaged in the Millennium Villages Project in Africa which promotes cost-effective sustainable development initiatives at community level and the pursuit of the **Millennium Development Goals.**

Schumacher, E.F., 1911–1977
Schumacher is noted for his 1973 *Small is Beautiful, Economics as if people Mattered*. In this and other papers and books he provided a critical analysis of factors for sustainable development, overturning Keynesian concepts of **economic growth** and applying what he called 'Buddhist principles' to economic theory and practice. He was founder of what may be called the 'humanist economic movement' and was a prime mover in the adoption of 'appropriate technology' for industrial and social progress, especially in developing countries. In this work, his core notion was 'the aim ought to be to obtain the maximum amount of well-being with the minimum of consumption.' He attacked the political economic assumptions that 'growth is good' and 'bigger is better'. He denounced the focus on output and technology as dehumanising. Many of his ideas have been subsequently absorbed into environmental and ecological economics. They anticipated the use of the **'ecological footprint'** as the denominator for assessing the impact of human activity on **natural resources**.

Sen, Amartya, 1933–
Nobel Prize winner in economics in 1998, Sen is noted for his contributions to **welfare economics**, to the analysis of causes and remedies of famine, of gender inequalities, and to human **development theory**. His principal works include in 2000 *Development is Freedom*, and in 2006 *Identity and Violence, the Illusion of destiny,* a retort to Samuel Huntingdon's 1997 *The Clash of Civilisations*. He was also influential in the establishment of the Human Development Index of the UNDP and the conceptual approach of the annual *Human Development Reports*. He is currently Professor at Harvard University, USA.

Singer, Hans, 1910–
Noted for his establishment of the Institute for Development Studies, Singer was a student of J.A. Schumpeter, in Austria. As an émigré from Nazi Germany, he subsequently settled in the UK becoming a research assistant to **J.M. Keynes**, examining the causes and effects of unemployment. After a period in local government planning he joined the UN and was instrumental in setting up the UN Special Fund, the World Food Programme, and the African Development Bank. He supported the emergence of the UNDP from the UN Special Fund and the UN Expanded Programme for Technical Assistance. These were administered at that time by Paul Hoffman, formerly the administrator for the US post-war European Marshall Plan. Singer was influential in the ILO policies on the informal sector and promoted the use of growth as the source of funds for redistribution. He was a stern critic of **John Williamson** and the **Washington Consensus**. One focus of concern, with Raul Prebisch, was the greater rate of growth in developed countries compared with developing countries, which he attributed to their declining terms of trade. This he saw created an ever-widening gap between North and South with the 'lion's share going to the lions'. His pet themes were 'redistribution of the fruits of progress', and 'assuring equitable participation in economic improvements'. These, when translated into economic concepts, were 'distributive justice and distributive efficiency'. He believed that a key to the development of the South was a combination of import substitution and industrial production for export. This combination would overcome declining commodity prices. Both these policies were implemented in Mauritius after independence, supported by an analysis of economic and social factors in development undertaken in the 1950s by James Edward Meade.

Smith, Adam, 1723–1790
Father of classical economics through his hugely influential 1776 publication *An Inquiry into the Nature and Causes of the Wealth of Nations.* He stressed in this the benefits of the division of labour, specialisation and exchange, and the market mechanism of the price system. He introduced the metaphor of the **'invisible hand'** of market forces which would ensure that the right goods and services were produced, provided that markets were freed from the kind of government intervention of the then prevailing Mercantilist system in Europe. The wealth of nations, he considered, depended on capital, labour and land as the factors of production. But he acknowledged that the self-seeking behaviour of producers could only be harnessed to the common good in markets through competition. Smith opposed monopolies – at the time commonly in the gift of governments, and he promoted the notion of national and international free trade. His theories were readily adopted by

those who argued that the ruthless pursuit of personal gain by capitalists inescapably led to the greatest good of all. He asserted, 'It is not from the love or goodwill of the butcher or baker that we get our dinner, but from our appeal to their self interest through our paying for meat and bread.' His theories, combining moral and economic precepts, largely masked the practical fallacies of his thinking, arising from market failure and the unequal distribution of wealth within and between countries. Despite his achievements in advancing economic theory, he did not address the question of the non-economic values attached to ways of living, the depletion of non-renewable **natural resources** and the adverse impact of economic and population growth on the **environment** and on human life and welfare.

Solow, Robert Merton, 1924–
Awarded the Nobel Prize in Economics in 1987 for his contributions to the theory of **economic growth**. He is noted for identifying the diminishing return to capital investment and the critical importance of technological innovation, called the Solow residual, which he claimed accounted for 80 per cent of **economic growth**. Solow was reputedly a witty critic of interventionist and non-interventionist economists. He was a senior economist with US President Kennedy's Council of Economic Advisers. Environmental economists have criticised Solow's theory for lack of attention to the impact of **economic growth** on **natural resources**.

Stiglitz, Joseph, 1943–
He was a Nobel Prize winning economist in 2002, for his work on the asymmetric nature of information in market economies, its adverse effect on efficiency and its implications for more interventionist government policy. Noted also for his 2002 *Globalization and its Discontents*, and in 2006 for *Making Globalization Work.* A former chief economist at the World Bank, he became the centre of a fierce debate about World Bank and IMF economic policies during the economic transition of former Soviet countries and their wider damaging application to the Third World. He has called for greater attention to be given to the international problems of environmental degradation, poverty and disease, having served on the IPCC. Under President Clinton he was an advocate for the political economic policies of the 'Third Way' providing a bridge between socialist state intervention and reforms of the free market. He has now extended this approach in proposals for reform of international institutions such as the UN, the IMF and the World Bank. His reform proposals call for greater transparency, more involvement of **developing countries** in policy-making, improved accountability, better judicial procedures (for example, to penalise the USA for its failure to act on global warming as an implicit trade subsidy), renewed commitments for meeting aid targets (0.7 per cent GDP), greater debt forgiveness to developing countries, more accountability of multinational companies for environmental damage, and a reduction in arms sales to **developing countries** that undermine fledgling democracies. He is currently Professor of Finance and Economics at Columbia University.

Williamson, John, 1937–
As an adviser to the IMF and the UK Treasury he is noted for his initiative in defining the 'Washington Consensus' which was used by the IMF and World Bank as a framework of

support for **developing countries** in the 1990s. It also became a key element in neo-liberal Western policy towards developing countries. Engulfed in subsequent fierce controversy, following failures of the policy in many continents on account of its disappointing impact on poverty, unemployment and even **economic growth**, Williamson developed adaptations to the framework. These recognised the need for greater attention to the role of the informal market, institutional and infrastructure development, equity and the distribution of wealth. Williamson is senior fellow at the Institute for International Economics. (See 2002 *Did the Washington Consensus fail?*: www.iie.com)

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