Part I

Framework and fundamentals

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Overview and summary

This book recognizes that sustainable development is a primary challenge of the twenty-first century (with poverty alleviation as the main goal), and sets out a framework called 'Sustainomics' developed over the past 15 years to meet that challenge. Sustainable development is broadly defined here as 'a process for improving the range of opportunities that will enable individual human beings and communities to achieve their aspirations and full potential over a sustained period of time, while maintaining the resilience of economic, social and environmental systems'.

The main message of this volume is optimistic – although the problems are serious, an effective response can be mounted, provided we begin immediately. Sustainomics seeks to show us the first practical steps in making the transition from the risky business-as-usual scenario to a safer and more sustainable future.

Sustainomics is 'a transdisciplinary, integrative, comprehensive, balanced, heuristic and practical framework for making development more sustainable'. Unlike other traditional disciplines, it focuses exclusively on sustainable development. Thus, the main principle of the framework seeks to make ongoing and future development efforts more sustainable, as a first step toward the ultimate goal of sustainable development. Other key principles stress: (a) balanced consideration of the three dimensions of the sustainable development triangle (social, economic and environmental); (b) better integration by transcending conventional boundaries imposed by discipline, space, time, stakeholder viewpoints and operational needs; and (c) practical application of innovative methods and tools throughout the full cycle from data gathering to policy implementation and feedback.

This volume also seeks to illustrate clearly the methodology with empirical case studies that are practical and policy-relevant over a wide range of geographic and time scales, countries, sectors, ecosystems and circumstances. Every application does not necessarily give equal weight to all elements of the triangle (i.e. social, environmental and economic). Many cover all three aspects, while others primarily address two aspects (e.g. economic and environmental), or a single aspect (e.g. economic cost–benefit analysis, social multistakeholder consultative process, etc.), with the other aspects covered less prominently. In general, the book shows how a broad array of sustainomics-compatible methods and tools could be applied simply and practically to a variety of problems, to make development more sustainable.

I have tried to make the book both accurate and readable. However, because of its wide coverage and length, some parts may seem complex and others too simple, depending on the academic training and disciplinary background of the reader. A fair balance is maintained between theory and applications, recalling the famous rebuke by Nobel Laureate Wassily Leontief (Leontief, 1982): 'Page after page of professional economic journals are filled with mathematical formulas leading the reader from sets of more or less plausible but entirely arbitrary assumptions to precisely stated but irrelevant theoretical conclusions.' Generally, the analytical sections are rigorous but relatively free of technical jargon, while mathematical and other details are provided in appendixes. The case studies have been simplified to show, as clearly as possible, the practicality and policy-relevance of the underlying principles involved. They are presented in decreasing order of geographic scale – from global to local applications. The extensive bibliography should be useful to those who wish to research specific topics further. I hope that the book will appeal to a wide audience, including students, researchers, teachers, policy analysts, development practitioners, public and private sector decision makers, concerned citizens and all stakeholders.

To conclude, sustainomics is put forward as an innovative transdisciplinary framework (or transdiscipline), based on a holistic set of key principles, theories and methods. It draws on many other approaches and techniques, because no single traditional discipline can cover the vast scope and complexity of sustainable development issues. The advantages and shortcomings of sustainomics are frankly laid out, with the expectation that future contributions by other potential 'sustainomists' will rapidly build on the strengths, remedy gaps and inconsistencies, and further flesh out the initial framework and applications.

1.1 Outline of the book

Part I of the book contains four chapters covering the introduction and fundamentals. Chapter 1 provides a broad overview of the entire volume. The first section outlines the various chapters and provides a road map for the reader. Next, we set out the rationale and motivations for the book, including key sustainable development challenges (especially poverty), major global agreements on sustainable development, lessons of history and future scenarios and a vision for a practical way forward. A brief history and introduction to the fundamental elements of sustainomics are provided, followed by a review of key ideas. The chapter ends with selected information on the status of modern development.

Chapter 2 lays out the basic principles, concepts and methods of sustainomics in greater detail. A practical approach based on *making development more sustainable*, or MDMS, is described as an alternative to pursuing abstract definitions of sustainable development. The sustainable development triangle, comprising the social, economic and environmental domains, is introduced, and the driving forces and concepts of sustainability underlying each viewpoint are explained. The integration and synthesis of these three viewpoints is facilitated by two complementary approaches, based on the concepts of optimality and durability. The poverty–equity–population nexus and linkages between economic efficiency and social equity are discussed. A variety of practical analytical tools are outlined to

implement the sustainomics framework – including the Action Impact Matrix (AIM), sustainable development assessment (SDA), cost–benefit analysis (CBA), multicriteria analysis (MCA), etc. It is important to select relevant, time and location specific indicators of sustainable development. The need to harmonize development with nature, and restructure the pattern of growth is explained, especially in developing countries, where poverty alleviation will require continued increases in income and consumption.

In Chapter 3, we explore the economy–environment interface (and related social linkages). Economic CBA is a key element of SDA and the project cycle. Basic concepts of CBA are set out, including decision criteria, efficiency and social shadow pricing and measurement of costs and benefits. Practical techniques for economic valuation of environmental assets and services play a key role in incorporating externalities into traditional CBA. When such economic valuation is difficult, MCA helps to make trade-offs among disparate objectives. Key issues, such as discounting, risk and uncertainty, are discussed. The two-way links between economy-wide (macroeconomic and sectoral) policies and environment (and social) issues are outlined. The incorporation of environmental considerations into the conventional system of national accounts is explained.

Chapter 4 expands on the social and ecological interlinkages that play a key role in determining the use of natural resources. The Millennium Ecosystem Assessment (MA) conceptual framework and cyclic interaction between the ecological and socioeconomic domains is summarized, including the main ecosystem services which sustain key components of human well-being. Ecological cycles involving birth–growth–decay–death–regeneration help us understand ecosystem dynamics. Property rights regimes determine how socioeconomic forces interact with environmental resource, especially in the case of traditional societies and native peoples, who are heavily dependent on ecological resources, as well as the landless poor, who subsist in degraded areas. Finally, environmental and social assessments are described as important tools that complement economic assessment (CBA) – all three are key elements of SDA.

Next, we turn to applications of sustainomics at various scales: global and transnational, national and macroeconomic, sub-national sectoral and system, project and local. Part II of the book contains two chapters (5 and 6) with case studies covering the global and transnational levels.

In Chapter 5 the sustainomics framework is applied to study the circular linkage between two global-level issues – climate change and sustainable development. The role of adaptation and mitigation are analysed, and several applications are provided. First, alternative climate change mitigation response strategies are assessed in terms of optimality and durability. Next, we examine the interplay of equity and efficiency in joint implementation (JI) and emissions trading, between Annex 1 and non-Annex 1 countries. The final case study describes how climate change might interact with sustainable development at the national level – by analysing greenhouse gas (GHG) mitigation prospects in Sri Lanka.

Chapter 6 examines a unique transdisciplinary, international scientific dialogue within the Intergovernmental Panel on Climate Change (IPCC), describing how researchers are analysing climate change and sustainable development links. Then, the AIM tool is used to

explore two-way linkages between two international activities – the millennium development goals (MDGs) and the findings of the MA. Finally, we examine the practical functioning of a transnational, multistakeholder, multilevel consultative process, involving the UNEP Dams and Development Programme (DDP).

Part III of the book comprises three chapters (7, 8 and 9), covering case studies of sustainomics at the country-wide and macro levels, which deal with a wide range of countries, policy issues and models.

Chapter 7 reviews past research on the sustainability of long-term economic growth, including economy–environment linkages. Some stylized facts about environmental and social impacts of growth-oriented macroeconomic policies are summarized. Unforeseen economic imperfections can interact with growth to cause environmental and social harm. An environmental-macroeconomic analysis confirms that second-best remedial measures could help to limit the damage. Environmental concerns may be introduced into the standard static IS-LM macroeconomic model. The role of green accounting and concepts such as genuine savings are discussed. The AIM approach plays a key role in environmental-macroeconomic analysis. A 'policy-tunnelling' model shows how elimination of economic imperfections permits continued growth while limiting environmental and social harm. Finally, some of these ideas are illustrated through a case study of Brazil. A combination of sectoral and macroeconomic models are used to examine the effects of the growth-oriented strategy pursued by the Brazilian government during the past decades, on a range of sustainable development issues including poverty, employment, urban pollution and deforestation in the Amazon region. Ideas for future research are discussed.

Chapter 8 explores two different theoretical approaches to making development more sustainable at the national macroeconomic level. The literature on the relationship between optimization and sustainability in growth models is reviewed. First, a sustainomics-compatible mathematical model examines the conditions under which development paths, focusing on optimal economic growth, might also be made more sustainable. The model is solved numerically using stylized data. Second, a theoretical model looks at the circumstances that may justify the use of second-best adjustments to macroeconomic policies, to compensate for pre-existing economic distortions that give rise to environmental harm. Three developing world examples (Botswana, Ghana and Morocco) show how macroeconomic polices might combine with local imperfections to harm the environment, and appropriate remedial measures are discussed.

Chapter 9 focuses on computable general equilibrium (CGE) models. First, we apply the ECOGEM model to assess economic, environmental and social policy linkages in Chile. The model systematically and holistically analyses different economy-wide policies and their impact on the Chilean economy. It combines different environmental and social policies so as to enhance positive cross-effects or to mitigate the negative side effects of any single policy. Complex interrelations between the diverse sectors and agents of the economy are captured. Winners and losers are identified, but the results obtained are not always obvious, i.e. indirect effects are also relevant. In the second example, a static CGE model is applied to study the effects of macroeconomic policies on deforestation in Costa

Rica. The results support the more conventional partial equilibrium approach that establishing property rights tends to decrease deforestation, because such rights allow forest users to capture the future benefits of reduced logging damage today. Findings about effects of discount-rate changes also parallel results of partial equilibrium models – higher interest rates promote deforestation, and vice versa. The CGE approach also identifies the indirect effects of intersectoral links, and shows the importance of pursuing sectoral reforms in the context of growth. A dynamic CGE model of Costa Rica, where the value of forest conservation, capital accumulation and interest rate are endogenized, gives the same results as the static CGE model.

Part IV of the book contains five chapters (10 to 14) describing case studies and applications of sustainomics at the sub-national and meso levels within several countries – involving energy, transport, water, ecological and agricultural systems and resource pricing policies.

In Chapter 10, we begin with a general review of links between energy and sustainable development, including a worldwide assessment of energy sector status and issues. Next, the sustainomics approach is used to develop a comprehensive and integrated conceptual framework for an energy-related decision-making framework called sustainable energy development (SED), which identifies practical sustainable energy options by taking into account multiple actors, multiple criteria, multilevel decision making and policy constraints. The methodology is applied to demonstrate how social and environmental externalities could be incorporated into traditional least-cost power-system planning in Sri Lanka, using both CBA and MCA. The study is relatively unique in its focus on assessing environmental and social concerns at the system-level planning (including technology choices among hydro, oil, coal and renewable-energy-based generation), as opposed to the more usual practice of carrying out such analyses only at the project level. Sustainable energy policies for Sri Lanka are identified. Another case study applies SED to the South African energy sector, using MCA to assess the social, economic and environmental trade-offs arising from policy options relating to electricity supply and household energy use. Finally, long-term UK electricity expansion options are examined, to show that decentralized energy may be more sustainable than centralized generation.

Chapter 11 starts by reviewing generic sustainable transport priorities. Then we examine how transport policy could be made more sustainable in Sri Lanka, including the analysis of fuel pricing policy, alternative fuel choices and a range of transport projects. Two classic externalities are discussed. First, the detrimental impact on health from local air emissions are estimated using the benefit transfer method, and the specific health benefits of introducing unleaded petrol are assessed. Second, the effects of traffic congestion in the city of Colombo are studied, including estimation of the cost of time wasted. Several specific infrastructure projects and other measures for reducing congestion are analysed, and an overview is provided of sustainable transport policy options for Sri Lanka.

Chapter 12 explores how to make water resource management more sustainable. The first section describes the natural hydrological cycle and how interventions have affected it. Next, water and development linkages are examined, including a review of the global status

of water resources, water shortages and rising costs, poverty issues and sustainable livelihoods. A comprehensive framework for sustainable water resources management and policy (SWAMP) is outlined, which parallels the SED approach of Chapter 10. The SWAMP methodology is practically applied to a typical water resources project involving groundwater for urban use in Manila, Philippines. The case study analyses the effects of environmentally harmful externalities like aquifer depletion, saltwater intrusion along the coast and land subsidence, and then identifies remedial policy measures. Finally, another case study demonstrates a simple, low-cost, socially acceptable and environmentally desirable approach to purifying drinking water and reducing waterborne diseases that has yielded significant economic, social and environmental gains to poor villagers in Bangladesh.

Chapter 13 sets out case studies dealing with both natural and managed ecological systems – i.e. forests and agriculture, respectively. First, we analyse the management of megadiverse natural ecosystems in rainforests to identify generic policies that make forest management more sustainable. Next, a case study of Madagascar is presented to achieve a better understanding of the specific environmental and socioeconomic impact of national parks' management policies on tropical forests. Relevant policy implications are drawn. Various techniques are used to value damage economically to forests and watersheds, timber and non-timber forest products, impact on local inhabitants and biodiversity and ecotourism benefits. In a second case study, we examine the potential impact of climate change on managed ecosystems (agriculture) in Sri Lanka. A Ricardian model is used to estimate the past effects of natural variations in both temperature and precipitation. Several scenarios of future climate change are imposed to assess future agricultural production. The harmful impact of rising temperatures generally dominate the beneficial effects of increased precipitation. Policy conclusions are drawn for sustainable agricultural policy in Sri Lanka.

Chapter 14 examines natural-resource pricing policy issues within a national economy – the economics of both renewable and non-renewable resources are discussed. The principles of sustainable pricing policy (SPP) are explained and applied to energy, based on the sustainable energy development framework (Chapter 10). First, economic principles are used to determine efficient energy prices, which lead to economically optimal production and consumption of energy. Second, environmental aspects may be incorporated by economically valuing relevant impacts (Chapter 3). Finally, efficient prices may be made more sustainable by adjusting for economic second-best distortions, social consideration, such as affordable (subsidized) prices to meet the basic needs of the poor, and other general policy objectives such as regional or political considerations. The closing section describes how the SPP framework might be used for pricing of other natural resources, such as water, and examines water-specific issues.

Part V of the book contains two chapters (15 and 16) dealing with case studies and applications of sustainomics at project and local levels, which cover topics such as hydropower, solar energy, water supply, sustainable hazard reduction and disaster management and urban growth.

Chapter 15 commences with the SDA of small hydro-projects in Sri Lanka, by applying MCA to economic, social and environmental indicators. The second case study analyses

new and renewable energy projects and national energy policy in a typical developing country. It highlights the use of different policy tools (including the interlinked shadow and market prices) to influence human behaviour and ensure more sustainable energy use – based on solar photovoltaic (PV) energy for agricultural pumping. Then, rural electrification projects in Sri Lanka are analysed with a focus on new and renewable energy technologies, and rural energy priorities are set out.

Chapter 16 explains how natural hazards become major disasters because of heightened vulnerability, often due to prior damage inflicted by unsustainable human activities. A practical framework is presented for mainstreaming sustainable hazard reduction and management (SHARM) into national development – involving the stages of relief, rehabilitation and reduction (planning, preparedness and prevention). The two-way linkages between hazards and sustainable development are analysed. These ideas are illustrated by a case study that assesses the impacts of the 2004 Asian Tsunami in India, Indonesia, Maldives, Sri Lanka and Thailand. A comparison of the Tsunami impacts on Sri Lanka and Hurricane Katrina on New Orleans raises important questions about the role of social capital in coping with disasters. Issues concerning the sustainability of long-term growth in Asian cities are described, including policy options to address these problems – especially in the rapidly expanding mega-cities. The vulnerability of cities to natural hazards and environmental degradation is analysed and illustrated through a case study of floods in Rio de Janeiro. Finally, we examine two examples of how urban development is becoming more sustainable in developed nations – in Canada and the European Union.

1.2 Rationale and motivations

This section summarizes several important motivations underlying this book.

1.2.1 Addressing key sustainable development challenges today

The first and main rationale is the urgent need to address key sustainable development challenges of the twenty-first century.

Poverty, inequity and human well-being

The key sustainable challenges that arise are as follows (see also Box 1.1).

- Alleviating *poverty* for the 1.3 billion people who live on less than $1 per day and the 3 billion people who live on less than $2 per day.
- Providing adequate *food*, especially for the 800 million people who are malnourished today – this will require food production to double in the next 35 years without further land and water degradation.
- Supplying *clean water* to the 1.3 billion people who live without clean water, and providing *sanitation* for the 2 billion people who live without sanitation.
- Supplying adequate *energy* for basic needs, and providing access to the 2 billion people who live without electricity.

- Providing a *healthy environment* for the 1.4 billion people who are exposed to dangerous levels of outdoor pollution and the even larger number (especially women and children) exposed to dangerous levels of indoor air pollution and vector-borne diseases.
- Providing *safe shelter* for those who are vulnerable to natural disasters and those that live in areas susceptible to civil strife.

The extreme poverty and deprivation captured by these statistics are further highlighted by high levels of global inequality. For example, the richest 20% of the world population currently consumes about 60-fold more than the poorest 20%. Highly inequitable income

Box 1.1 Summary of Millennium Development Goals (MDGs)

The UN Millennium Development Goals provide a basis for measuring global progress toward sustainable development. In 2000, all countries agreed on eight development goals that would serve as targets for 2015.

Goal 1: **Eradicate extreme poverty and hunger**, by halving the population (1) whose income is less than a $1/day and (2) who suffer from hunger, between 1990 and 2015.

Goal 2: **Achieve universal primary education**, by ensuring that all children will complete full primary schooling by 2015.

Goal 3: **Promote gender equality and empower women**, by eliminating gender disparity in primary and secondary education, preferably by 2005 and in all levels of education no later than 2015.

Goal 4: **Reduce child mortality**, by lowering the under-five mortality rate by two-thirds between 1990 and 2015.

Goal 5: **Improve maternal health**, by reducing maternal mortality rates by 75% between 1990 and 2015.

Goal 6: **Combat HIV/AIDS, malaria and other diseases**, by reversing the spread of HIV/AIDS and the incidence of malaria and other major diseases by 2015.

Goal 7: **Ensure environmental sustainability**, by (1) integrating sustainable development into country policies and programmes and reversing the loss of environmental resources; (2) halving the population without sustainable access to safe drinking water and basic sanitation by 2015; and (3) achieving a significant improvement in the lives of at least 100 million slum dwellers by 2020.

Goal 8: **Develop a global partnership for development**, by (1) improving trading and financial systems; (2) addressing the special needs of the least-developed countries; (3) addressing the special needs of landlocked countries and small island developing states; (4) dealing comprehensively with the debt problems of developing countries; (5) developing and implementing strategies for decent and productive work for youth; (6) providing access to affordable, essential drugs in developing countries; and (7) making new technologies available in cooperation with the private sector, especially information and communications.

Energy services, although not explicitly identified, are essential to achieve the MDGs (UNDP, 2005c).

distributions also persist within many countries (World Bank, 2000). In Brazil and South Africa, the ratios of national income received by the richest and poorest 10% of the population are 53% and 42%, respectively. Corresponding figures for India and the USA are 10% and 14%.

Globalization

Globalization is a major sustainable development challenge. There are many benefits, but the focus here is on identifying potential risks in order to address the underlying problems. This phenomenon has been driven by two fundamental forces – underlying technological change, which has accelerated the integration of markets, and the freer movement of raw materials, goods, services, labour, capital, information and ideas. For example, during 1950 to 1998, world exports of goods increased 17-fold (from $311 billion to $5.4 trillion); the global economy expanded six-fold; international tourist arrivals increased 25-fold (from 25 million to 635 million); during 1970 to 1998 the number of transnational corporations grew eight-fold (from 7000 to 54 000); and during 1960 to 1998 the number of non-cellular telephone lines linked directly to the global phone network grew eight-fold (from 89 million to 838 million) (French, 2000).

Globalization also implies a gradual weakening of the influence of individual national governments. While this process may improve opportunities for economic growth, recent research has pointed out that it fails to provide equal opportunities either across or within nations (Ehrenfeld, 2003). In addition, globalization is associated with significant social and environmental costs that are rarely assigned monetary values and often fall on the poor and disadvantaged, while the benefits accrue mainly to the wealthy.

The environmental costs of globalization (due to pollution of air, land and water and the depletion of natural resources) are mostly associated with increased free trade across borders and industrial activities. Pollution may shift to (mainly developing) countries where environmental protection laws and property rights are not adequately enforced or do not exist. Meanwhile, the burden of global environmental issues like climate change will fall disproportionately on poorer countries that have contributed least to the problem. Furthermore, these countries are less well equipped to deal with such impacts due to lack of financial and technical resources (IMF, 2002). Biodiversity loss has worsened due to the wave of globalization and stimulation of unsustainable development activities, reduction of forests, over-fishing, land degradation, etc. (MA, 2005a). Loss of biodiversity in turn impacts on sustainable development, as it undermines ecosystem health and reduces resilience (Munasinghe, 1992a). For example, globalization has promoted monoculture agricultural practices that favour commercially successful crops and reduce the diversity of less successful crop varieties.

The social costs of globalization often remain hidden and indirect before surfacing suddenly (Ahmad, 2005). Among many such social issues are growing inequity, social unrest, unemployment, dissolution of families and communities and instability of socio-economic systems (Stiglitz, 2002). The widening of the gap between rich and poor is a frequent issue that is raised by many critics of globalization. Open borders for flow of capital