Part I

Framework and Fundamental

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Overview and Summary

This book recognizes that sustainable development (SD) is a primary challenge of the twenty-first century (with poverty alleviation as the main goal), and sets out a framework called "sustainomics" (including the balanced inclusive green growth, or BIGG, path) developed over the past twenty-five years to meet that challenge. SD is defined here as "a process for improving the range of opportunities that enables 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." Links with the United Nations (UN) 2030 Agenda and the sustainable development goals (SDGs) are also explained.

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" (MDMS) (Munasinghe 2002a, p.1). Unlike other traditional disciplines, it focuses exclusively on SD. Thus, the first principle of the framework seeks to make ongoing and future development efforts more sustainable as a first step toward the ultimate goal of SD. Other key principles stress: (a) balanced consideration of the three dimensions of the SD triangle (social, economic and environmental); (b) fresh ideas by transcending conventional boundaries imposed by values, 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 clearly illustrate 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 (economic cost–benefit analysis [CBA], 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 (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 annexes. 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 and up-to-date 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 (including BIGG) 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 SD 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 SD challenges (especially poverty), major global agreements on SD, the 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 in relation to the SDGs.

Chapter 2 sets out the basic elements of sustainomics. Section 2.2 describes fundamental principles and methods. SD, traditional development and growth are defined. A practical approach based on MDMS is described as an alternative to pursuing abstract definitions of SD. The SD triangle (comprising social, economic and environmental dimensions) is introduced, and the driving forces and concepts of sustainability underlying

each viewpoint are explained. Sustainomics also promotes methods that transcend conventional boundaries of thinking and full cycle analysis from data gathering to practical policy implementation. In Section 2.3, the dimensions of the SD triangle, their interactions and different concepts of sustainability are explained. Methods for integrating these three dimensions are described in Section 2.4, including the complementary concepts of optimality and durability. The poverty–equity–population–natural resources nexus and linkages between economic efficiency and social equity are discussed. Next, Section 2.5 introduces the BIGG path that harmonizes social, environmental and economic approaches. Section 2.6 describes a variety of practical methods and tools for applying sustainomics to the real world, including the action impact matrix (AIM), SD assessment (SDA), CBA, multicriteria analysis (MCA) and so on.

Chapter 3 explores how economics relates to environmental (and related social) concerns. Section 3.2 outlines how human activity harms the environment, while environmental degradation impedes economic development. Sections 3.3 and 3.4 expand on economic CBA and the project cycle, covering economic decision criteria, efficiency and social shadow pricing, economic imperfections, methods of measuring costs and benefits, and qualitative considerations. Section 3.5 describes various environmental assets and services, and practical methods of valuing them. Section 3.6 outlines MCA, which is useful for decision making when economic valuation is difficult. Key issues relating to discounting, risk and uncertainty are set out in Section 3.7. Finally, Section 3.8 explains links between economywide policies and environmental (and social) issues, as well as environmentally adjusted national accounts.

Chapter 4 provides an in depth discussion of the linkages between the environmental and socioeconomic domains of SD. It expands on ideas introduced in Chapter 2, concerning the sustainability of ecological and social systems. It also complements the discussion in Chapter 3, about the basic role of ecosystems in supporting human society and economic activities, and methods of assessing this contribution (including monetary valuation). These ideas are extended in Section 4.2, which summarizes the comprehensive conceptual framework based on the Millennium Ecosystem Assessment (MA), including the cyclic interactions between ecological and socioeconomic systems, and the main ecosystem services that sustain human well-being. The MA and the Economics of Ecosystems and Biodiversity (TEEB) highlight the precarious situation of many critical ecosystems (Teebweb.org 2018). The idea of "panarchy" of living systems help us understand ecosystem behavior. Section 4.3 describes the key mediating role played by property rights regimes, in determining how societies exploit natural resources. Property rights regimes play an important role in designing and implementing sustainable environmental management measures. In Section 4.4, we examine how unsustainable development is driven by unethical social values, which lead to economic mal-development and severe environmental debt. Finally, environmental and social assessments are outlined as important elements of SDA, which complement CBA (or economic assessment).

Next, we turn to applications of sustainomics at various scales: global and transnational, national and macroeconomic, subnational sectoral and system, and 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, applications of key elements of the sustainomics framework are illustrated through several examples dealing with two critical global problems – climate change (SDG 13) and SD. Section 5.2 provides a general analysis of the circular linkages between these two issues. In Section 5.3, challenges posed to the social, economic and environmental dimensions of SD, and relevant principles for formulating a policy response are described. Section 5.4 defines and analyzes the principal potential human responses – adaptation and mitigation. Several practical applications are provided. Three international-level case studies are described in Section 5.5. First, alternative climate change mitigation response strategies are assessed in terms of the optimality and durability approaches. Next, we examine the interplay of equity and efficiency in joint implementation (JI) and in emissions trading. Sections 5.6 and 5.7 show how a global problem like climate change interacts with SD at the national level – through a case study that examines greenhouse gas (GHG) mitigation prospects in Sri Lanka. National energy sector responses are analyzed, including a real options framework for carbon options trading under uncertainty.

Chapter 6 focuses on participatory-consultative processes relating to social sustainability, including case studies on global multistakeholder, multilevel, transdisciplinary dialogues that are crucial for the BIGG path. Section 6.2 describes how climate change (SDG 13) and SD (see Chapter 5) were handled in the Intergovernmental Panel on Climate Change (IPCC) writing process, involving thousands of scientists addressing complex, transdisciplinary, interlinked, large-scale, long-run issues. In the second case study, Sections 6.3 and 6.4 describe how a UN global program was implemented at the national level. A multidisciplinary, multistakeholder presidential expert committee (PEC) prepared a strategic national plan called "Sustainable Sri Lanka Vision and Strategic Path," to facilitate the national application of the 2030 Agenda and the SDGs (see Chapter 1). Finally, Sections 6.5 and 6.6 examine a unique multistakeholder, multilevel process involving the UN Environment Programme (UNEP) Dams and Development Project (DDP) and addressing water issues (SDG 6) at international, regional and national levels (see Chapter 12).

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

In Chapter 7, the sustainomics framework is used to study the powerful and widespread social and environmental impacts of economywide policies (SDGs 1 and 8) – see Section 3.8. Section 7.2 contains a brief review of the historical evolution of ideas linking economywide policies (both macroeconomic and sectoral) and the environment. Section 7.3 describes empirical evidence, beginning with a discussion of the environmental impacts of structural adjustment programs since the 1980s, and followed by some stylized results. Section 7.4 sets out a basic framework for analyzing environmental–macroeconomic links. Unforeseen economic imperfections can interact with growth to cause environmental and social harm. Second-best remedial measures could help to limit

the damage. In some cases, the timing and sequencing of macroeconomic reform policies could be adjusted to limit environmental and social harm. The standard static IS-LM macroeconomic model may be extended to include environmental concerns. The role of green accounting is discussed. The AIM is a key tool for prioritizing environmental–macroeconomic links. The BIGG path (Section 2.5) incorporates a "policy tunneling" approach showing how complementary policies that eliminate economic imperfections will permit continued growth while limiting environmental and social harm. A case study analyzing options for making Brazilian long-run economic growth more sustainable is presented in Section 7.5. Both sectoral and macroeconomic models are used to examine the effects of growth strategies pursued by the government during past decades on various SD issues like poverty, employment, urban pollution and deforestation in the Amazon region.

Chapter 8 expands on the generic results of Chapter 7 by exploring two different theoretical approaches to MDMS at the national macroeconomic level (SDG 1, 8). In Section 8.2, we review the literature on the relationship between optimization and sustainability in growth models (see also Section 2.4). Section 8.3 describes the debate on the costs and benefits of economic growth, and outlines methods for making growth models more sustainomics compatible. In Sections 8.4 and 8.5, such a mathematical model is developed to examine how development paths focusing on optimal economic growth might also be made more sustainable. The second case in Sections 8.6 and 8.7 describes a theoretical model that looks at the use of second-best adjustments to macroeconomic policies in order to counteract economic distortions that cause serious environmental harm. Three case studies of Botswana, Ghana and Morocco show how macroeconomic policies might harm the environment and appropriate remedial measures are discussed.

In Chapter 9, two case studies demonstrate the use of computable general equilibrium (CGE) models to analyze economywide SD issues (SDG 1, 8), and explore economic–social–environmental links on BIGG paths (see Section 2.5). Sections 9.2–9.5 develop the ECOGEM model to assess economic, social and environmental policy linkages in Chile – focusing on urban air pollution, poverty, income distribution and employment. The model examines the potential for combining different policies to enhance positive cross effects of environmental and social policies or to mitigate the negative side effects of any single policy. In Sections 9.6–9.8, a static CGE model of Costa Rica is used to study the effects of macroeconomic policies on deforestation and identify remedial policy options. The model confirms the results of partial equilibrium analyses: (1) establishing property rights tends to decrease deforestation because such rights allow forest users to capture the future benefits of reduced logging damage today and (2) higher interest rates promote deforestation and vice versa. A dynamic CGE model of Costa Rica gives essentially the same results as the static CGE model presented here.

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

Chapter 10 applies the sustainomics framework to the energy sector (SDGs 7 and 9). Section 10.2 reviews energy-development issues and status. In Section 10.3, a comprehensive and integrated framework for sustainable energy development (SED) is developed within the BIGG path (see Section 2.5). It identifies practical sustainable energy options. A case study of Sri Lanka is presented in Sections 10.4 and 10.5 that illustrates application of the SED approach to electricity planning and renewable energy. Both CBA and MCA are used to show how environmental and social externalities may be incorporated into traditional least-cost power system planning. Sustainable energy policies for Sri Lanka are identified. Section 10.6 describes an SED application in South Africa, using MCA to assess the social, environmental and economic trade-offs relating to electricity supply and household energy use.

Chapter 11 focuses on transport infrastructure (including fuel pricing policy) (SDGs 9 and 11). Section 11.2 reviews generic priorities for sustainable transport and discusses key issues worldwide, as well as economic, social and environmental linkages. Then we examine how transport policy could be made more sustainable in a typical developing country (DC). In Section 11.3, health damage externalities due to transport-related air pollution in Sri Lanka are discussed. Section 11.4 covers another classic externality – the effects of traffic congestion in the city of Colombo, including estimation of the cost of time wasted. Section 11.5 analyzes several specific infrastructure projects and other measures for reducing congestion. Section 11.6 provides an overview of sustainable transport policy options for Sri Lanka.

In Chapter 12 we examine how sustainomics may be applied to develop and manage water resources more sustainably (SDG 6). Section 12.2 describes the natural hydrological cycle and how interventions have affected it. Water and development linkages are examined in Section 12.3. In Section 12.4, a framework for sustainable water resources management and policy (SWAMP) within a country is outlined briefly, which has many parallels with the SED approach explained in Chapter 10. Sections 12.5 and 12.6 describe the practical application of SWAMP to a typical water resources project involving groundwater for urban use in Manila, Philippines, including an analysis of the effects of harmful environmental externalities like aquifer depletion, saltwater intrusion and land subsidence. Remedial policy measures are identified. Section 12.7 sets out the empirical example of 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. A case study involving the evaluation of a rural water supply project in a poor African township is described in Chapter 15.

Chapter 13 describes sustainomics applications to two main types of ecological systems – forests (natural ecosystems) and agriculture (managed ecosystems) (SDGs 2 and 15). Section 13.2 describes the underlying reasons for deforestation. It analyzes the management of mega-diversity natural ecosystems in rainforests, and then identifies generic policies that make forest use more sustainable. In Section 13.3, a case study of Madagascar seeks to better understand the specific impact of parks management policies

on tropical forests. The environmental and social and economic consequences of human actions are assessed with specific focus on the economic valuation of environmental impacts. Various methods are used to economically value damage to forests and watersheds, timber and non-timber forest products, impacts on local inhabitants and biodiversity, and ecotourism benefits. Relevant policy implications are drawn. Sections 13.4 and 13.5 present a second case involving the vulnerability of managed ecosystems (agriculture) to climate change in Sri Lanka. A Ricardian agricultural production model analyzes past effects of natural variations in both temperature and precipitation. Then, several scenarios of future climate change are imposed to assess future agricultural production. Policy conclusions are drawn for sustainable agricultural policy in Sri Lanka.

Chapter 14 examines pricing policy issues within a national economy – the economics of both renewable and nonrenewable resources are discussed. The principles of sustainable pricing policy (SPP) are explained and applied to energy based on the SED framework (Chapter 10). First, economic principles are used to determine efficient energy prices, which lead to economically optimal production and consumption of energy. Next, 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 like affordable (subsidized) prices to meet basic needs of the poor, and other general policy objectives. The closing section describes how the SPP framework might be used for pricing of other natural resources like water.

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

Applications of the sustainomics approach at the project level are illustrated in Chapter 15. In Sections 15.2 and 15.3, the SED framework applied at the sector level (see Chapter 10) is extended and used to evaluate small hydroelectric power projects (SDG 7) in Sri Lanka. MCA is used to assess social, economic and environmental indicators. Section 15.4 highlights the use of different policy tools (including the interplay of shadow and market prices) to influence human behavior relating to new and renewable energy use. Practical investment and pricing policies are formulated to make energy development decisions more sustainable, in the case of solar photovoltaic energy projects for agricultural pumping. In Section 15.5, rural electrification projects in Sri Lanka are analyzed, focusing on new and renewable energy technologies. Rural energy priorities (solar homes and village hydro) in Sri Lanka are compared with renewable energy projects in the Philippines and Vietnam. Section 15.6 presents a case study involving the analysis of a project that supplies water (SDG 1, 6) to a poor African village. The focus is on quantitative economic CBA, using both border and domestic shadow prices to determine water investment decisions and pricing policy. Finally, options for encouraging sustainable consumption and production (SDG 12) are discussed in Section 15.7. In particular, we show how modern tools like value/supply chain life cycle analysis can promote win–win outcomes in sustainable production along the BIGG path.

In Chapter 16 we use the sustainomics framework to analyze more localized events like hazards and disasters, as well as to assess the sustainability of growth in densely populated urban areas (SDGs 9 and 11). Section 16.2 describes how the harmful impacts of hazards on both socioeconomic and ecological systems are often exacerbated by heightened vulnerability and prior damage inflicted by unsustainable human activities. A practical framework is presented for mainstreaming sustainable hazard reduction and management (SHARM) into national development. Two-way linkages between hazards and SD are analyzed. In Section 16.3, the SHARM approach is used to assess the impacts of the biggest single disaster in modern history – the 2004 Asian Tsunami, which resulted in over 250,000 deaths in five countries (India, Indonesia, the Maldives, Sri Lanka and Thailand). Effects on the macroeconomy, vulnerable sectors, employment and livelihoods, poverty, women and children, and the environment are analyzed, and appropriate policy responses are identified. A comparison of the impacts of the 2004 Asian Tsunami on Sri Lanka and Hurricane Katrina on New Orleans in 2005 highlights the role of social capital in coping with disasters. In Section 16.4, we study the vulnerability of urban development to environmental damage and hazards (like floods, landslides and earthquakes), and present a case study of Rio de Janeiro. Finally, in Section 16.5, we discuss the global trend toward urbanization and analyze a unique model of modern sustainable urban development in the city of Guimaraes, Portugal.

1.2 Rationale and Motivations

This section summarizes several important motivations underlying this volume.

1.2.1 Addressing Key SD Challenges Today

The first and main rationale for sustainomics is the urgent need to address key SD challenges of the twenty-first century, as summarized in this section.

Human Well-Being, Poverty and Inequality

To achieve a better future, the UN 2030 Agenda (UN 2015, World Bank 2016) has identified a set of universal SDGs for all countries – see Box 1.1

The adoption of the SDGs was driven by pressing global issues, including the need for greater well-being, keeping resource use within planetary boundaries, and reducing poverty and inequality (UN 2015, World Bank 2016). There are 169 targets and 230 indicators to monitor the progress of SDGs. Although SDGs are listed as separate goals, there are multiple interlinkages among SDGs and their indicators. The SDGs often overlap, many targets might contribute to several goals, and some goals may even conflict. Although SDGs are universal, countries need to prioritize them to local needs, and implement those priorities in the context of specific national development and socioeconomic contexts.

Despite their broad coverage, the SDGs still pay inadequate attention to issues such as globalization (Stiglitz 2006) and the world economic system and their consequences