Mapping Sustainability

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Aims and Scope of the Series

The aim of this series is to provide timely accounts by authoritative scholars of the results of cutting edge research into emerging barriers to sustainable development, and methodologies and tools to help governments, industry, and civil society overcome them. The work presented in the series will draw mainly on results of the research being carried out in the Alliance for Global Sustainability (AGS).
The level of presentation is for graduate students in natural, social and engineering sciences as well as policy and decision-makers around the world in government, industry and civil society.

Mapping Sustainability

Knowledge e-Networking and the Value Chain

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The Alliance for Global Sustainability

DEDICATION

In memory of

Elizabeth McLaughlin.

CONTENTS

PREFACE

Challenges and Focus

This book focuses on three interdependent research initiatives designed to facilitate the management of transitions toward sustainable development. These initiatives consist of: (a) mapping sustainability as a domain of knowledge; (b) contributing to the development of global knowledge e-networking and extending the knowledge value chain; and (c) exploring new methods to expand our knowledge and to improve e-networking practices. While the activities differ in nature, scale and scope, they are highly interconnected. It is our hope that, jointly, they will contribute to our common quest for a sustainable future.

Our underlying objectives are to contribute to the provision, management, and sharing of knowledge, and to enhance the value of knowledge and its uses by different constituencies in diverse contexts and at different stages of development. The central theme of this book, connecting its different parts, is about ways of transcending critical barriers to the effective uses of knowledge and e-networking. Of special relevance is the development of new approaches to the provision and transmission – from local sources to global networks and from global sources to local networks. In many ways, this is a book of theory and methods, as well as policy and performance.

Concepts Defined

According to *Webster's New Collegiate Dictionary*, *to map* is "to make a survey," and "a network" is "an interconnected or interrelated chain, group, or system." *Mapping Sustainability* means surveying the broad area of sustainable development and presenting a detailed accounting of its characteristic features, and, on this basis, generating a structured ontology of the knowledge domain. In this context, *global knowledge e-networking* means engaging in cyber-based interaction and communication, around a knowledge domain of shared interest, framed by common organizing principles that enable further consolidation as well as greater expansion of knowledge. *Extending the value*

chain means identifying and engaging in effective ways of enhancing the gains associated knowledge and e-networking. *Exploring new knowledge and e-networking* means designing and using novel methods for generating knowledge and enhancing the utility of e-networking. It also means illustrating the potentials of the innovation and demonstrating its relevance to the issues at hand.

In this context, *Mapping Sustainability* is both a concept-based and a content-based, approach to the domain of "sustainable development," with the full realization that the nature of such understanding changes over time, and that representations of concept and of content must evolve accordingly. *Mapping* generates the ontology for the sustainable development domain, which serves as a baseline for future inquiry.

The ontology represents our prevailing understandings of dominant problems due to human activities as well as the range of solutions as currently conceived – in scientific and technical terms, as well as in social and regulatory terms. For mapping purposes, the focus is on the content-architecture: the levels, linkages, and complexities of sustainability. By extension, *global knowledge e-networking* is about innovations in strategic uses of cyberspace for providing sharing, developing, creating, and organizing knowledge for sustainability.

The various initiatives that bear upon about the *knowledge value chain* are about ways of thinking about and creating new knowledge pertaining to transitions toward sustainable development – taking into account global complexities associated with states and firms, local and global considerations, and diversity in methods and technologies of inquiry.

Finally, *new explorations and innovations* involve relatively untested approaches for enhancing our stock of knowledge, to specific value for the sustainability domain, and to enhancing modes of facilitating knowledge-based transition foundations of the global agenda.

Plan of the Book

As a collaborative initiative – involving the efforts, ideas, contributions, and insights of a large number of individuals and institutions worldwide – this book is in three Parts.

Part I focuses on developing a map for sustainability and its computational implementation in an e-Laboratory, known as the *Global System for Sustainable Development* (GSSD), as well as on several applications that represent the e-Laboratory to date. Part I is theoretical and analytical, as well as methodological and computational – focused on the process of *mapping sustainability*, designing ways of transcending the barriers to knowledge, and implementing a knowledge networking system of global reach.

Among the dominant barriers to sustainable development, several of the most compelling are addressed in this book. Among these are fundamental ambiguities surrounding the concept of sustainability, compounded by multiplicity of perspectives, conflicts and contentions, as well as powerful cleavages due to differences in language, culture, and socio-economic condition. Then there are barriers on the ground, involving infrastructure conditions and constraints, differentials in price and cost, and differences in access to new user-based technologies for exploiting the power of cyberspace. In addition, there are key impediments embedded in existing venues for knowledge networking, related to content development and its provision in e-venues. Individually, each of these barriers is daunting in its own right, but collectively they become especially powerful.

The chapters of Part I are about ways in which we have addressed these critical barriers. A key feature of Part I is the ontology of sustainability, which puts forth a detailed profiling of the domain content. In terms of methods, the key features include new applications of e-technology and computational tools, the design and management of distributed workflow, and the related instrumentalities of e-collaboration on a global scale.

Part II focuses largely on the issue of value – the value of knowledge and the value chain. It concentrates on contextual, institutional, and operational challenges associated with knowledge e-networking in private and public domains and explores particular types of innovations and technological applications. Accordingly, Part II addresses methodological, institutional, and cross-cultural challenges related to global knowledge e-networking as well as applications in fundamentally different cultural, linguistic, socio-economic, political and decision contexts.

The chapters of Part II are written from the perspective of concerns and issues evident at the end nodes of distributed global knowledge networking. Several chapters involve e-based interactions across languages and cultures and address different ways of understanding challenges of sustainable development. They also illustrate the operational implications of some new trajectories for knowledge and derived from experience to date. More specifically, we focus on the perspectives of Arabic-speaking and Chinese-speaking participants in global e-networks. This means that we need to better understand how knowledge can be utilized in order to realize targeted changes.

In addition, Part II also considers specific aspects of e-knowledge value for global business, and reviews various ways in which the value of knowledge can be captured. The chapters that address such challenges highlight the importance of driving functions, organizational reach, and decision scope for different types of global enterprises.

Part III is about new exploration and innovations in a wide range of issue areas, to illustrate both the novel perspective as well as its potential applica-

tions. While these chapters may seem disjointed in focus when considered individually, collectively however, they illustrate explorations and innovations in a wide range of contexts bearing on transitions toward sustainable development. More specifically, individual chapters focus on: (a) new visualization technologies for extracting inferences and information about the global system, on the whole and in its individual parts, (b) attention to new activities and functionalities for government and governance of states, given the technological opportunities provided by cyber venues, electronic communication, and access to the Internet, (c) *Global Agenda!*, a simulation and gaming e-system, and potential teaching tool, for grappling with decision and choice in a world of increasingly severe hotspots, (d) ways of illustrating the synergy between law and sustainability, (e) empirical manifestations of the role of property rights in environment and growth, and (f) early data on the ways in which the banking system is responding to the challenges of climate change and attendant implications for risk associated with finance of critical projects.

These chapters are followed by an effort to take stock of the conceptual foundations in the study of international relations. This chapter highlights key differences between basic (mainstream) theoretical perspectives and the more advanced (emergent) logic. The former represents the traditional views that remain dominant to date. The latter departs from tradition and takes into account key interconnections between social systems and natural systems over the past decades – between human and nature – and provides important correctives for the distorting effects of the pervasive homo-centrality imposed by tradition.

In its entirety, this book is an international initiative. It is a product of sustained collaboration among a large number of individuals in the scientific and academic communities, in business, industry, and in public policy. Many aspects of this effort are rooted in activities of the *Alliance for Global Sustainability*. But, it is clearly the persistent interest and commitment of the editors, the authors and all of the contributors that has brought this initiative to its successful conclusion.

Nazli Choucri

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PART ONE

Chapter 1

MAPPING SUSTAINABILITY

Logic and Framework

Nazli Choucri

Introduction

While almost everyone agrees that the quest for sustainable development is one of the most significant challenges for all societies in all parts of the world, there are considerable disagreements about the specific meaning of *sustainable development* and a range of contentions surrounding the term *sustainability*. This situation is particularly problematic in light of the explosion of information about sustainability now available in electronic form, the increasing use of the Internet as a mode of communication and exchange, and the difficulties often encountered in locating and selecting relevant knowledge on any specific set of issues. These conditions create a critical imperative, namely, one of devising a strategy for organizing and managing information flows about sustainability on the Internet, where quantity dominates and quality is often sacrificed. This imperative revolves around matters of *content* and of *conduit.*

The purpose of this chapter is to present a conceptual framework to guide our understanding of the overall issues at hand and examine their constituent elements in order to organize existing knowledge on sustainable development. The conceptual framework also serves as the basic architecture for thinking about, searching for, and retrieving knowledge bearing on the specific aspects of sustainability of interest in any situation. Since the process of engaging in transitions to sustainability is itself a moving target, we would expect that efforts to develop a knowledge-base on sustainability will yield results that change over time. In this context, the challenge is to capture the elements that appear to be most relevant, and to discard others as appropriate.

A fundamental prerequisite, however, is to recognize the all-encompassing context within which such issues take on their most fundamental

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meaning, namely the nature of the global system and globalization process. It is no longer possible to consider sustainability of individual entities, states, or groups without taking into account the broader configuration of natural and social systems within which all entities are embedded. Accordingly, in this chapter we highlight some of the most important facets of the global system as currently understood, particularly focusing on critical features of the globalization process. These facets frame the terms of reference, within which we will engage in Mapping Sustainability.

1.1 Globalization and the Global System

Over the course of many centuries, a major alteration of the international system has occurred as populations expanded their activities and political entities broadened their reach. The concept of the global system – recent addition to the semantics of international relations and world politics – formalized our recognition of the powerful interconnections among natural systems and social systems. This concept highlights the embeddedness of social activities within prevailing environmental contexts and all attendant considerations. An inevitable extension of this understanding is reflected in the notion of globalization. The ongoing globalization – a legacy of the 20th century – may well constitute the greatest challenge to world populations since the end of Western European Feudalism, which led to the Congress of Westphalia and the establishment of the nation-state system.[1]

In principle, the global system refers not just to the social, political, and economic systems, but also to the earth, its geological and geographical features, its flora and fauna, and its surroundings (including the sun) which provide a unique and indispensable environment for life as we experience it. In a sense, the natural environment holds us all hostage and the implications of such bindings have become increasingly more complicated as population growth and advances in technology have enabled human beings to extend their activities and interests into remote enclaves of the planet (and space). As a result, we increasingly intervene in natural processes, often blindly and without knowledge of the consequences.

Such interventions lead to toxins. Once we have released our toxins into the soil, water, and air, for example, nature's processes take control. Once released, the trajectory, intensity, and damages of effluents are seldom, if ever, subject to legal or strategic control. The global system remains disrespectful of, even oblivious to, our political regimes and state boundaries.

[1] The Westphalia principles defined the state and its sanctity as the basic unit of international relations, and thus reinforce those very factors that undermine the emergence of a global, rather than an international, system.

And the forging of cyberspace, an essentially technological achievement, invariably alters the traditional distributions of voices in international relations, shaping new domains of interactions relevant to human behavior, the role of the state, and the structure of the international system.

In this connection, Peter Haas argues that the growing importance of epistemic communities is shaping our understanding of the global system and its fundamental processes, and that this role is a clear acknowledgement of the interconnections between natural and social processes (1989).[2] Haas argues that these environmental conditions constitute a formal recognition of a *fourth image reversed* scenario, where international politics are shaped by global conditions.[3] It can be compared only indirectly to Peter Gourevitch's *second image reversed* since the latter focuses entirely on social interactions (political, economic, strategic, etc.) with no recognition of the natural system (Gourevitch, 1978). With these considerations in mind, later in this chapter we shall point to key features of the changing contexts for states and firms, and then focus specifically on our strategy for charting this new 21st century reality.

More immediately, we can consider the forging of cyberspace and the new domain for the conduct of political discourse to be a critical feature of the global system. Clearly created by human beings and their technological ingenuity, this fourth level encompasses the third image, namely the international system that is composed of state actors and others enfranchised by the state, as well as those that are commonly thought of as transnational. New policy arenas for discourse are responses to new modalities of actions and interactions are in the offing. As a result, there are new demands for global accord and coordinated action.

Whatever we may do that drastically interferes with the natural system – at any level – can have global repercussions. And any such repercussions at the global level could have local implications. Only a global view will demonstrate the extent to which war, peace, environmental, and other problems

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[2] This characterization refers to the concept of 'image' in the study of international relations which signals levels of analysis. The traditional levels – defined by the individual, the state, and the international system – were first defined by Waltz (1959) extending the notion of 'image' introduced earlier by Boulding (1956). North (1990) and Choucri and North (1993) first articulated the concept of the global system, as the fourth image. Choucri (1993) made the first extension of the fourth image, as the global system by taking into account cyberspace, as a human-created, technological driven generation of new space of interactions that transcend the conventional three images of the international system.

[3] Among the related efforts in international relations theory contributing to the articulation of the fourth image are Modelski (1996), Alker and Haas (1993), Ostrom (1990), Starr (1997), Vitousek et al. (1997), Holling (1995), and, of course, Hardin (1968) in the context of framing sustainability. Implications of the fourth image for the properties of the second image can be derived from Litfin (1998) while at the same time taking into account select imperatives of the third image. See also Pollins and Schweller (1999) "linking the levels" focusing on shifts in U.S. foreign policy over long spans of time.

impinge on one another. In this context, we need to consider how individual humans and their needs, wants, desires, demands, capabilities, and actions create, constitute, train, shape, and constrain the state and the international system, and how all three – individuals, the state, and the international system – are embedded in an overall global system.

A rather simple way of looking at global trends and select constitutive elements is presented in Figure 1.1, which shows the distribution of states in terms of carbon emission and GDP.

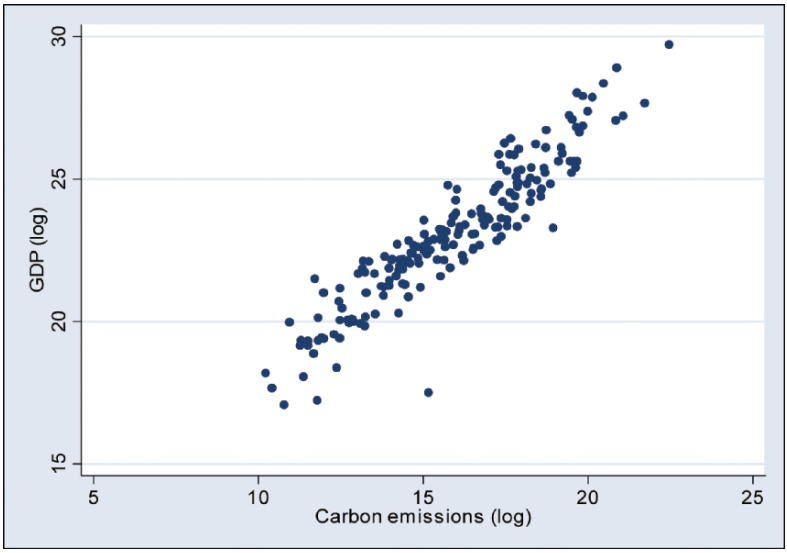

Figure 1.1 **Carbon emissions (thousands of metric tons) and GDP (constant USD), 2000. Based on observations from the *United Nations Common Database.*** [4]

An obvious inference is that poor countries produce less and pollute less; while the richer countries produce more and pollute more. What happens, however, when the poor become richer? What are the stresses that result from growth? Can sustainability substitute for growth?

In this figure, as well as all of the ones that follow, the observations displayed contain two sets of information: one pertains to the distribution of countries at one point in time, and the other pertains to the imputed evolutionary pattern of development over time. In the context of Figure 1.1, therefore, over time countries located on the lower bottom left side of the graph will gradually 'travel' along a trajectory of change that leads from lesser to greater levels of development toward the top right side.

When observed empirically, such trajectories go a long way toward helping us understand the patterns of growth, development, and evolution of

[4] All figures in this chapter are constructed using Stata 9.

states and empires from their pristine beginnings through their rises, declines, and eventual disintegrations. A different set of issues is raised in Figure 1.2, which shows the distribution of states in terms of energy consumption and population size. Since both variables represent aggregate characteristics of states, it is not surprising to observe that countries with larger population consume a greater amount of energy.

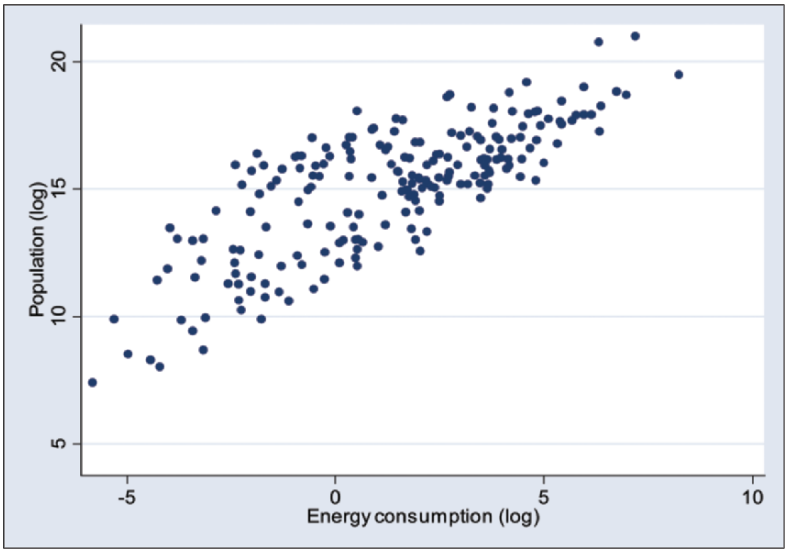

Figure 1.2 **Population and energy consumption (electricity, in millions of kWh), 2000. Based on observations from the *United Nations Common Database*.**

In still a different vein, we show in Figure 1.3 another perspective on the distribution of countries in the global system, namely the distribution of life expectancy at birth, on the one hand, and GDP per capita on the other. The obvious is worth noting since it reflects the stark reality of inequality in the international system: with few exceptions, the countries with higher GDP per capita are also those with higher life expectancy.

Finally, we show in Figure 1.4 the distribution of countries in terms of military expenditures and economic output, GDP.

Once more, we see the generic inter-state pattern signaling a now-familiar view of distribution of states worldwide. This distribution is especially informative as it allows for a simple inference. With the exception of one or two cases, it is clear that with greater material output (an indicator of wealth) come greater expenditures on the military (an indicator of security or insecurity as the case may be). Both of these factors are usually correlates of the globalization process.

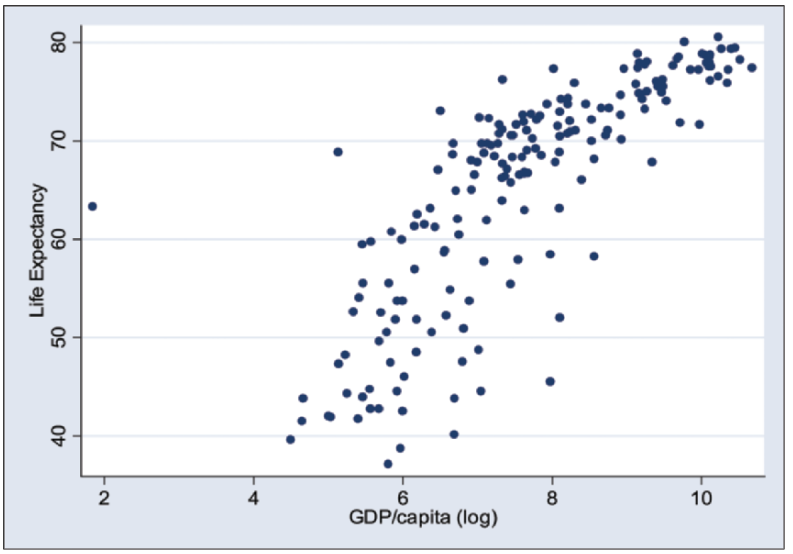

Figure 1.3 **Life expectancy (years) and GDP/capita (constant USD/person), 2000. Based on observations from the *United Nations Common Database.***

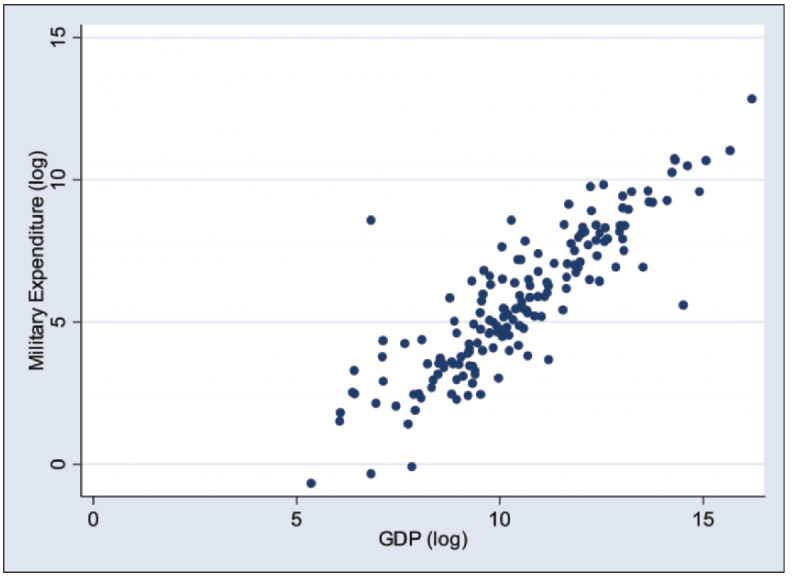

Figure 1.4 **Military expenditure (constant USD) and GDP (constant USD), 2000. Based on observations from the *United Nations Common Database.***

1.1.1 The Meanings of Globalization

Despite the dominance of *globalization* in both development and international relations debates and discourses, fundamental differences persist about the meaning of this term. It is not always easy to determine which is growing faster: the globalization debates or the globalization process itself.[5] At the very minimum, globalization refers to growing patterns of cross-border activities involving aggregations of human activities at various levels of analysis. These aggregations shape social interactions, as well as environmental considerations.

From a theoretical perspective, however, the spectrum of globalization is bracketed by two views. At one end is the conventional view, which is focused largely on economics and economic transactions; at the other end is an emergent view which stresses the dynamics and complexities of globalization.

More specifically, the conventional view defines globalization as the increased integration of national economies in terms of input, factor, and final product markets. This view focuses on *intra-state* impacts and on issues surrounding convergence and divergence of cross-border of policy responses. While the economy-centric view is important, it is very restrictive as it obscures many of the more pervasive system-transforming features of today's realities. It may also impede an appreciation of ways in which globalization creates new demands for governance induced by social, political, and economic transformations. When placed in the context of current realities, the conventional view of globalization represents the processes of growth from the perspective of those on the 'top' of the global system and pays considerably less attention to than by those situated at the 'bottom.'

1.1.2 Emergent Logics

At the other end of the continuum is the emergent logic of globalization – the view assumed in this book – which stresses the complexities and attendant interdependences created by the movements of goods, services, people, ideas, and influences across national borders. This perspective is particularly dynamic in that it is focused on *transformations* within and across states due to various patterns of mobility, notably those which strain prevailing modes of governance and forge new policy spaces as well as demands for new forms of coordinated policy responses.

In this context, we define *globalization* as the complex process engendered by (a) the movement of populations, goods and services, influences,

[5] See Castells (1996) for a sociological perspective on globalization and its challenges.

effluents, and ideas across state boundaries, such that (b) these alter the structure of national economies and societies, and create new forms of interdependencies across economies; (c) these changes, in turn, alter the subsequent movements of goods, services, people, and ideas across boundaries; as a result, (d) changes in international structures and process forge new policy spaces and (e) create demands new forms for coordinated policy responses.

In short, this emergent view centers on impacts of flows and movements along a causal chain and draws attention to the feedback logic. The causal logic flows from differential national and international conditions to shaping the movements across boundaries; from movements across boundaries to impacts on national economic, political and social structures to conditions that create new movements and new processes; from new process effects to alterations in the structure of the international system; and from such alterations to shaping of new policy spaces that, by necessity, create demands for new policy responses.

The essence of globalization lies in the transformations of structures and processes that lead to the formation of common policy spaces and require new institutional responses. This emerging logic suggests that almost everyone is involved in the process and everyone is affected – albeit in different ways. The specific manifestations of structure and process may differ, but the inherent logics and the feedback dynamics are generic in nature.[6]

Increasingly, the socio-political and economic dimensions of today's globalization appear to be knowledge-driven, making knowledge intensity one of the most significant features of the world economy at this time. While enhanced economic dependence on knowledge has fueled competitiveness worldwide, its impacts are considerably less evident in development contexts. Against such imperatives, we now turn to the deployment of knowledge for facilitating transitions toward sustainable development.[7]

1.2 Knowledge for Sustainable Development

According to *Webster's New Collegiate Dictionary*, *to know* is to "hold something in one's mind as true or as being what it purport to be"…[this] "implies a sound logical or factual basis" [and it also means] "to be convinced of…."

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[6] As an example, if we consider extended enterprises, private and public, whose performance is contingent on efficiencies of the internationally distributed supply chain, the exposure to globalization pressures is not only unprecedented in scale and scope, but also rapidly changing.

[7] Such imperatives further compel us to question the wisdom of the conventional economic model that views more growth as a necessary imperative, and the requisites of efficiency as a dominant value.

By extension, knowledge refers to the "fact or condition of knowing something with familiarity gained through experience or association; acquaintance with our understanding of a science, art, technique, condition, context, etc." [including] ... the range of one's information and understanding to the best of abilities in place [as well as]… "The fact or condition of being aware of something…" accordingly, what is 'known' is that which is 'generally recognized….' However lacking in elegance these observations might seem, they aptly characterize common views of knowledge (1976).

1.2.1 Knowledge System Defined

We extend the standard view to take into account a cluster of understandings that we refer to as a knowledge system. Thus, we define a *knowledge system* as:

> An organized structure and dynamic process of interaction generating and representing content, components, classes, or types of knowledge, that are (a) characterized by domain-relevant features as defined by the user community, (b) reinforced by a set of logical relationships that connect the content of knowledge to its value, (c) enhanced by a set of iterative processes that enable the evolution, revision, adaptation, and advances, and (d) subject to criteria of relevance, reliability, and quality.

Among the most fundamental attributes of knowledge is that its acquisition and utilization follows the law of *increasing returns*. This means that the more knowledge which is obtained and used, the greater the likelihood that it will be valuable to the user. This critical feature is a distinctive input into social and economic activities. Our purpose here is only to highlight a feature upon which much of the trends toward knowledge intensity are based. The presumption is that a knowledge system has value, in one form or another, and that capturing this value is essential for enhancing knowledge intensity in economic activities. Further along, we specify the constituent elements of a knowledge market in modular terms.

Conventionally, *value* is defined as "fair return or equivalent in goods, services, or money for something exchanged" (Webster, 1976). *Value* also connotes worth of some kind, as well as being of some importance. But the terms of *value* are not implied in the core concepts, nor are its units of measurement. The value of knowledge has different meanings in private and in public settings. In public settings it is viewed in terms of facilitating the provision of services for meeting social needs and for implementing policies to improve social and public well being. In private contexts, it is often connected to economic gain, notably to market prices and conditions.

At the same time, however, harnessing knowledge is only part of the challenge. Equally, if not more, important is the ability to communicate, share, manage, expand, revise, and generate new knowledge.

As noted in the Preface, *Webster's Collegiate Dictionary* states that *to map* is "to represent … to delineate … to assign to every element of a … set an element of the same or another set," and "to be located near the corresponding structural [element]" (1976). In such terms, *Mapping Sustainability* presents a way of representing knowledge content in the domain of sustainable development, with the full expectation that such knowledge changes over time, and that its representations must adjust accordingly. For mapping purposes, the focus here is on the content-architecture – the levels, linkages and complexities – that characterizes the domain of sustainability.

1.2.2 Sustainable Development

Our view of sustainable development focuses on human activities, and places the individual, in social settings, at its core, while taking into account and respecting the imperatives of nature and natural systems. We define sustainable development as *the process of meeting the needs of current and future generations without undermining the resilience of the life-supporting properties of nature and the integrity and security of social systems.*

Extending this definition further, we differentiate among critical fundamental processes that represent the sustainability arena. These processes refer to the nature of *ecological* systems, the type of *economic* activities, modes of *governance*, and *institutional* performance. To become sustainable, a social system must exhibit a certain degree of viability within and across each of these processes. Accordingly, it is useful to consider the various features of these processes and the ways in which these processes may lead toward sustainability.

Specifically, a system will tend toward sustainability if the (a) ecological systems exhibit balance and resilience; (b) economic production and consumption account for efficiency and equity; (c) governance involves participation and responsiveness; and (d) institutions demonstrate adaptation and feedback. In short, if – and only if – prevailing trends point toward these conditions will a social system tend toward sustainability.

In this connection, access to, and effective use of, knowledge is critical in shaping and managing social goals. This knowledge imperative is especially relevant for trajectories toward sustainable development – in all contexts and in both industrial and industrializing countries. Despite advances in information and communication technologies, major political, strategic, economic and institutional barriers continue to impede the use of knowledge for policy purposes. In the sustainability domain, as in many others, the making of decisions and the formation of policy seldom draw on the full range of relevant knowledge, or utilize critical knowledge materials that may be available. Moreover, the complexity of sustainability, coupled with ambiguities in

its meanings and understandings, further reinforce the difficulties of bringing existing knowledge into policy debates.

The challenge at hand does not arise from a lack of knowledge, data, information, published materials, raw observations, and so on, but rather from the absence of intellectual coherence and some internally consistent logic, which if put in place, would lead to best uses of existing materials. The dearth of integrative approaches (or frameworks) may well be among the most significant barriers preventing effective access to large bodies of knowledge that bear upon the domain of sustainable development. Different stakeholders in different parts of the world have different views and priorities about what is real, what is important, and what can be done as a result. This is especially true in the domain of sustainable development where a wide range of knowledge and knowledge systems are emerging.

1.2.3 Rationale for Mapping Sustainability

Given that the quest for sustainable development has become a global challenge, we need to converge on a shared understanding of the knowledge domain. This convergence requires a multidisciplinary perspective, spanning local to global levels as well as a range of very diverse forms and types of knowledge. More specifically, there are four imperatives shaping this mapping initiative:

Conceptually, while everyone recognizes that sustainable development is a holistic and integrative concept, there are considerable ambiguities pertaining to interconnections among various facets of human activities, to the constituent elements of sustainability, and to the proverbial matter of interlinkages. More importantly, there is as yet no overall view of the ways in which major forms of human activities generate problems that threaten social systems and natural environments or a coherent understanding of various solutions, socio-economic and political, as well as scientific and technical.

Disagreements also persist regarding the solutions to sustainability problems, and the conditions under which one alternative might be better than another. *Mapping Sustainability* is a step in the direction of intellectual order and coherence. It involves unbundling the knowledge content, and rendering a detailed account of issues central to sustainable development.

Strategically, mapping the knowledge domain of sustainable development is intended to help organize evolving knowledge about sustainability, and to make it more accessible for agents of change in public policy, business strategy, and creative ventures. It is also intended to facilitate access to cutting-edge analysis, innovative technologies, and multidisciplinary perspectives. We also seek to expand opportunities for knowledge provision and

sharing through experimenting with different forms of collaboration and take into account diverse views and perspectives.

Operationally, mapping provides a set of rules for organizing existing knowledge about sustainability in ways that are functional as well as replicable. As such, it serves as a means of enhancing our understanding and reducing barriers to sustainable development. At the same time, mapping alerts us to situations in which the solution to one problem becomes, itself, the sources of another problem.

Functionally, to the extent that the mapping initiative is effective, it provides the foundations for the design of web-based capabilities for knowledge management, networking and sharing. It also enhances our appreciation of the details surrounding this domain of human activity helps to define policy responses and practices.

1.3 Frame System for Mapping Sustainability

Clearly articulated, the framing challenge is straight-forward: how best can we apply intellectual order to a domain of knowledge which remains *ad hoc* in its nature? In this book, we frame the domain of sustainable development, formulate a basic ontology, and derive rules for indexing knowledge materials in internally consistent and structured terms.

1.3.1 Frame and Ontology

Drawing on the work of Marvin Minsky – the founding Director of MIT's Artificial Intelligence Laboratory – it is useful to think of a frame as "a sort of skeleton, something like an application form with many blanks or slots to be filled" (1986: 245). Our framing challenge is to provide the skeleton within which to fill knowledge materials pertaining to the general subject of sustainable development. In so doing, we are developing the framework for articulating the parameters of sustainable development as a knowledge domain. Moreover, as Minsky reminds us, "[f]rames are drawn from past experience and rarely fit new situations perfectly. We therefore have to learn how do adapt our frames to each particular experience" (1986: 245).

The knowledge pertaining to the sustainability domain consists of the materials that are used to fill the slots. When the frame is fully articulated, and the slots are defined in sufficient detail, we can accommodate multiple aspects of sustainable development.

This way of thinking about knowledge representation is particularly useful in new domains, where the referent is of increasing importance to an every growing community of people and of countries, but where there remain

considerable uncertainties and ambiguities about the nature of the slots, and about the items that should be used to fill in the blanks. The challenge now becomes one of deriving a knowledge-representation architecture.

Earlier in this chapter we put forth our operational definition of sustainable development, and identified its fundamental conditions. Useful as that definition may be, it is still too general a statement to serve as anything other than delineating the nature of the framing challenge. The skeleton remains to be structured and the slots remain to be defined, so that the blanks can be filled. What is now needed is a set of rules for articulating a complete frame system, one that can yield an internally consistent ontology for sustainability.

Given the origins of ontology in philosophy and epistemology, it is often easy to overlook the operational implications for knowledge representation. In the context of devising a frame system for sustainability, the term ontology refers to the detailed description of concepts and sub-concepts, as well as relationships that represent interactions among entities associated with the domain. An *ontology* is a description – like a formal specification of a program – of the concepts and relationships that can exist for an agent or a community of agents. For our purposes, given the computational objectives, the term *ontology* takes on a specific operational meaning.

Consistent with the *mapping* objectives signaled above, the goals of ontology for sustainability are conceptual, strategic, operational and functional. More specifically, for architectural purposes, we need to articulate knowledge content with sufficient specificity as to enable computational representation which, when successful, then ensures effective knowledge sharing and management. The one critical ontology rule is that of respecting internal consistency in structuring the *skeleton* and then populating the *slots* – both italicized terms due to Minsky (1986).

The frame system yields an architecture structured as a set of nested and hierarchical relationships, or individual parts and coherent wholes. In terms of core principles, the representation of sustainability is anchored in three basic principles. The first principle consists of the definition of the individual *domains* of human activity (i.e. topics or conditions at hand). The second principle involves the specification of attendant *dimensions* spanning each of the domains (i.e. problem created and types of solutions proposed). The third principle of the frame system is an accounting of the *coordinated international actions* that are designed to steer, reduce, mitigate, or otherwise manage the challenges to sustainable development through the use of multilateral policy instruments.

We now turn to the content of the domain and dimensions, and their intersection (thus addressing the first and the second principles), and then we consider the types of coordinated actions among members of the international community in response to sustainability challenges (the third framing principle).