1 *Introduction and Conceptual Framework*

Executive Summary

- The goal of the Millennium Ecosystem Assessment (MA) is to establish the scientific basis for actions needed to enhance the contribution of ecosystems to human well-being without undermining their long-term productivity.
- The conceptual framework for the MA places human well-being as the central focus for assessment while recognizing that biodiversity and ecosystems also have intrinsic value and that people take decisions concerning ecosystems based on considerations of both well-being and intrinsic value.
- The MA conceptual framework assumes that a dynamic interaction exists between people and ecosystems, with the changing human condition serving to both directly and indirectly drive change in ecosystems and with changes in ecosystems causing changes in human well-being. At the same time, many other factors independent of the environment change the human condition, and many natural forces influence ecosystems.
- A full assessment of the interactions between people and ecosystems requires a multiscale approach, as this better reflects the multiscale nature of decision-making, allows the examination of driving forces from outside particular regions, and provides a means of examining the differential impact of ecosystem changes and policy responses on different regions and groups within regions.
- Effective incorporation of different types of knowledge in an assessment can both improve the findings and help to increase their adoption by stakeholders if they see that their information has contributed to those findings.
- The usefulness of an assessment can be enhanced by identifying and seeking to address its structural biases. Any assessment empowers some stakeholders at the expense of others by virtue of the selection of issues and of expert knowledge to be incorporated.

Introduction

Human well-being and progress toward sustainable development are vitally dependent upon Earth's ecosystems. The ways in which ecosystems are affected by human activities will have consequences for the supply of ecosystem services—including food, fresh water, fuelwood, and fiber—and for the prevalence of diseases, the frequency and magnitude of floods and droughts, and local as well as global climate. Ecosystems also provide spiritual, recreational, educational, and other nonmaterial benefits to people. Changes in availability of all these ecosystem services can profoundly affect aspects of human well-being—ranging from the rate of economic growth and health and livelihood security to the prevalence and persistence of poverty.

Human demands for ecosystem services are growing rapidly. At the same time, humans are altering the capability of ecosystems to continue to provide many of these services. Management of this relationship is required to enhance the contribution of ecosystems to human well-being without affecting their long-term capacity to provide services. The Millennium Ecosystem Assessment (MA) was established in 2001 by a partnership of international institutions, and with support from governments, with the goal of enhancing the scientific basis for such management.

The MA is being carried out through four working groups on condition and trends, scenarios, responses, and sub-global assessments. Each working group will involve a regionally balanced group of between 50 and 400 experts from dozens of countries as authors. The MA was launched in June 2001, the full assessment reports will undergo two rounds of peer-review by governments and experts in 2004, and the assessment reports will be released in 2005. Five short synthesis reports containing the key policy-relevant findings will also be released at that time focused on the needs of particular users such as the international conventions and the private sector. The MA includes at this time up to 15 sub-global assessments that are applying the MA conceptual framework and methodology to assessments designed to meet needs at local, national, and regional scales, and the products of these assessments will be released over the next three years. Throughout the MA process, an ongoing dialogue is taking place involving experts preparing the assessment and intended users of the findings in order to focus the assessment on the needs of users and to ensure that users are sufficiently engaged in the process that they will be able to make direct use of the findings.

All economies depend on ecosystem services. The production and manufacture of industrial wood products in the early 1990s contributed on the order of $400 billion to the global economy (Matthews et al. 2000). The world's fisheries contributed $55 billion in export value in 2000 (FAO 2000). Ecosystem services are particularly important to the economies of low-income developing countries. Between 1996 and 1998, for example, agriculture represented nearly one fourth of the total gross domestic product of low-income countries (Wood et al. 2000).

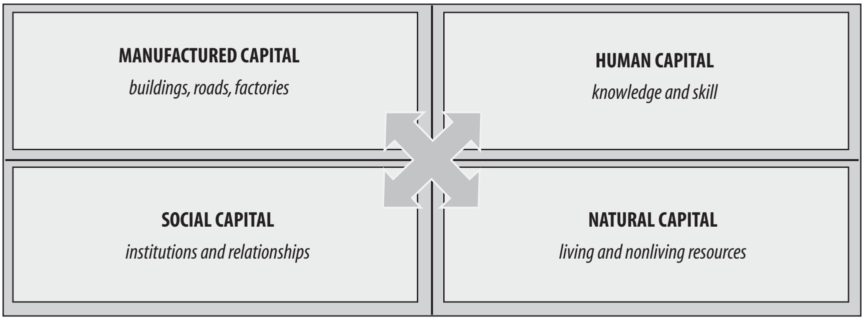
Certain ecosystem services—such as inland fisheries and fuelwood production—are particularly important to the livelihoods of poor people. Fisheries provide the primary source of animal protein for nearly 1 billion people, and all but 4 of the 30 countries most dependent on fish as a protein source are in the developing world (WRI et al. 2000). In Cambodia, for instance, roughly 60 percent of the total animal protein consumed is from the fishery resources of the Tonle Sap, a large freshwater lake. In Malawi, freshwater fisheries supply 70–75 percent of the animal protein for both urban and rural low-income families (WRI et al. 2000). Similarly, more than 2 billion people depend directly on biomass fuels as their primary or sole source of energy, and in countries like Nepal, Uganda, Rwanda, and Tanzania, woodfuel meets 80 percent or more of total energy requirements (Matthews et al. 2000). Moreover, poor people are highly vulnerable to health risks associated with ecosystems: some 1–3 million people die each year from malaria, with 90 percent of them in Africa, where problems of poverty are most pressing (WHO 1997).

Yet many ecosystem services are largely unrecognized in their global importance or in the pivotal role they play in meeting needs in particular countries and regions (Daily 1997a). For example, terrestrial and ocean ecosystems provide a tremendous service by absorbing nearly 60 percent of the carbon that is now emitted to the atmosphere from human activities (IPCC 2000), thereby slowing the rate of global climate change. A number of cities—including New York and Portland, Oregon, in the United States, Caracas in Venezuela, and Curitiba in Brazil—reduce water treatment costs by investing in the protection of the natural water quality regulation provided by well-managed ecosystems (Reid 2001). The contribution of pollination to the worldwide production of 30 major fruit, vegetable, and tree crops is estimated to be approximately $54 billion a year (Kenmore and Krell 1998). Even in urban centers, ecosystems contribute significantly to well-being, both aesthetically and economically: Chicago's trees remove more than 5,000 tons of pollutants a year from the atmosphere (Nowak 1994).

A society's "natural capital"—its living and nonliving resources—is a key determinant of its well-being. The full wealth of a nation can be evaluated only with due consideration to all forms of capital: manufactured, human, social, and natural. (See Figure 1.1.) Historically, given the abundant supply of natural capital and the application of new technologies to enhance the production of certain services, humanity has been remark-

FIGURE 1.1 Society's Productive Base

A society's productive base is composed of four types of capital: manufactured, human, social, and natural.



ably successful in meeting growing demands for particular services. Between 1967 and 1982, for example, conversion of native ecosystems to agricultural ecosystems, combined with a 2.2-percent annual increase in cereal yields, led to net increases in per capita food availability even though there was simultaneously a 32-percent increase in world population (Pinstrup-Andersen et al. 1997). But despite the success in meeting growth in aggregate demand, there have been significant problems in meeting demands in particular regions. Moreover, increased supply of certain goods, such as food, has often meant a trade-off with the supply of other ecosystem services, such as protecting water quality or supplying timber.

Current demands for ecosystem services are growing rapidly and often already outstrip capacity. Between 1993 and 2020, world demand for rice, wheat, and maize is projected to increase by some 40 percent and livestock production by more than 60 percent (Pinstrup-Andersen et al. 1997). Humans now withdraw about 20 percent of the base flow of the world's rivers, and during the past century withdrawals grew twice as fast as world population (Shiklomanov 1997; WHO 1997). By 2020, world use of industrial roundwood could be anywhere from 23 to 55 percent over 1998 consumption levels (Brooks et al. 1996).

These growing demands can no longer be met by tapping unexploited resources (Watson et al. 1998; Ayensu et al. 2000). A country can increase food supply by converting a forest to agriculture, but in so doing it decreases the supply of goods that may be of equal or greater importance, such as clean water, timber, biodiversity, or flood control. Even more significant, humans are increasingly undermining the productive capability of ecosystems to provide the services that people desire. For example, world fisheries are now declining due to overfishing, and some 40 percent of agricultural land has been strongly or very strongly degraded in the past 50 years by erosion, salinization, compaction, nutrient depletion, biological degradation, or pollution (WRI et al. 2000).

Continuing degradation of the world's ecosystems is neither inevitable nor justified. Many instruments now exist that can aid in the management of human demand for ecosystem services and of impacts of human activities on ecosystems. Recent progress in cost-effective technologies, policies, and regulation can contribute to management systems that can reduce and eventually reverse many of today's problems. Investments in improved management of ecosystem services tend to be highly leveraged strategies for sustainable development. Like the benefits of increased education or improved governance, the protection, restoration, and enhancement of ecosystem services tend to have multiple and synergistic benefits. For example, technology allows partial substitution of the ecosystem service of water purification through the construction of water treatment facilities. But by protecting the watershed to enable the ecosystem to provide this service instead, a variety of other benefits can often be obtained—such as the maintenance of fisheries, reduction of flood risks, and protection of recreational and amenity values.

New policies and initiatives in diverse economies and cultures illustrate practical mechanisms for protecting vital ecosystem services and enhancing their contributions to human development. More effective balances in the supply of various services can often be restored: reduction of subsidies that have contributed to excessive fishing harvest in many fisheries, for instance, can lessen harvest pressure now, protect biodiversity, and ultimately lead to increased catch per unit of effort.

Institutional arrangements such as changes in land tenure or rights to resources can help ensure that those paying to protect ecosystem services receive a fair share of the benefits: some power companies, for example, are now paying countries to protect and restore forests for their carbon sequestration service as a means of offsetting carbon emissions (Daily and Ellison 2002). And in Costa Rica, a new national program pays private landowners for a suite of ecosystem services flowing from forested (and reforested) land, including watershed protection, biodiversity conservation, and preservation of scenic beauty (Castro et al. 1998). Techniques for restoration can also be used: in the Murray-Darling River Basin of Australia, which supplies 75 percent of Australia's irrigation water and over 40 percent of the nation's agricultural production, native vegetation is being replanted as a cost-effective tool in con-

BOX 1.1 Commitment to Sustainable Development

The interlinkages among environmental management, poverty alleviation, and sustainable development have long been recognized by governments and international institutions. Examples of conferences, initiatives, and reports that have stressed this theme in recent years include:

Conferences and Initiatives

- United Nations Conference on the Human Environment (Stockholm, 1972)
- United Nations Conference on Environment and Development (Rio de Janeiro, 1992)
- World Conference on Human Rights (Vienna, 1993)
- International Conference on Population and Development (Cairo, 1994)
- Global Conference on the Sustainable Development of Small Island Developing States (Bridgetown, 1994)
- World Summit for Social Development (Copenhagen, 1995)
- World Conference on Women (Beijing, 1995)
- World Food Summit (Rome, 1996)
- United Nations Millennium Summit (New York, 2000)
- Initiative for the Heavily Indebted Poor Countries (2001)
- World Summit on Sustainable Development (Johannesburg, 2002)

Reports and Statements

- *World Conservation Strategy* (IUCN et al. 1980)
- *Our Common Future* (WCED 1987)
- *Caring for the Earth* (IUCN et al. 1991)
- *Statement on Population* (statement of 58 scientific academies, 1994)
- *The Challenges of an Urban World* (statement of 72 scientific academies, 1996)
- *Our Common Journey: A Transition Toward Sustainability* (NRC 1999)
- *United Nations Millennium Declaration* (2000)
- *Transition to Sustainability in the 21st Century: The Contribution of Science and Technology* (statement of 73 scientific academies, 2000)

trolling devastating salinization of farmland (Murray-Darling Basin Ministerial Council 2001).

Roughly half of the world's poorest people live in marginal areas such as arid lands, steep slopes, or coastal margins that are prone to degradation and highly vulnerable to floods, droughts, or landslides (UNDP 1998). Some 80 percent of poor people in developing countries live in rural areas where people directly harvest ecosystem goods (Jazairy et al. 1992). Ap-

BOX 1.2 Millennium Development Goals

The Millennium Development Goals were adopted in September 2000 during the 55th Session of the United Nations General Assembly, known as the Millennium Assembly.

Goal 1: Eradicate extreme poverty and hunger

- Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.
- Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

Goal 2: Achieve universal primary education

- Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.

Goal 3: Promote gender equality and empower women

- Eliminate gender disparity in primary and secondary education preferably by 2005 and at all levels of education no later than 2015.

Goal 4: Reduce child mortality

- Reduce by two thirds, between 1990 and 2015, the under-five mortality rate.

Goal 5: Improve maternal health

- Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio.

Goal 6: Combat HIV/AIDS, malaria, and other diseases

- Have halted by 2015, and begun to reverse, the spread of HIV/AIDS.
- Have halted by 2015, and begun to reverse, the incidence of malaria and other major diseases.

proaches to poverty alleviation through environmental management can provide cost-effective and lasting solutions that often work in concert with education, empowerment of women, and improved governance. Fortunately, the need for more effective investment in ecosystem management is increasingly being recognized by governments as a tool for poverty alleviation.

Various conferences and reports over the past two decades, culminating in the 2002 World Summit on Sustainable Development, have outlined key principles of a more socially responsible and environmentally sustainable world for both industrial and developing countries, recogniz-

BOX 1.2 continued

Goal 7: Ensure environmental sustainability

- Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.
- Halve, by 2015, the proportion of people without sustainable access to safe drinking water.
- By 2020, have achieved a significant improvement in the lives of at least 100 million slum dwellers.

Goal 8: Develop a global partnership for development

- Develop further an open, rule-based, predictable, non-discriminatory trading and financial system (includes a commitment to good governance, development, and poverty reduction—both nationally and internationally).
- Address the least developed countries' special needs (includes tariff- and quota-free access for their exports, enhanced debt relief for heavily indebted poor countries, cancellation of official bilateral debt, and more generous official development assistance for countries committed to poverty reduction).
- Address the special needs of landlocked countries and small island developing states (through Barbados Programme and 22nd General Assembly provisions).
- Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term.
- In cooperation with developing countries, develop and implement strategies for decent and productive work for youth.
- In cooperation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries.
- In cooperation with the private sector, make available the benefits of new technologies, especially information and communications technologies.

ing that current and projected consumption patterns of rich people, coupled with projected demographic changes, lead to resource depletion and undermine the capacity of ecosystems to contribute to human well-being. (See Box 1.1.) In particular, the Millennium Development Goals established by the United Nations in 2000 identify key goals to be achieved on the path to sustainable development. (See Box 1.2.) Achieving most of these—eradicating poverty and hunger, reducing child mortality, improving maternal health, combating HIV/AIDS, eradicating malaria and other diseases, and ensuring environmental sustainability—will require major investments in ecosystem services.

Many private-sector interests also depend on improved ecosystem management. Industries directly dependent on biological resources, such as timber, fishing, or agriculture, have an ever-growing incentive for more effective and efficient management of ecosystem services as demand grows and new sources of supply become increasingly scarce. Far more significant, the condition of ecosystems has become a concern even to companies not directly harvesting biological resources, such as the insurance industry in relation to events associated with climate change. Increased regulation and citizen scrutiny, along with new market incentives and paradigms of corporate stewardship, now drive industries to devote considerable attention to minimizing ecosystem degradation and to factor the condition of the environment into their business strategy. The MA seeks to support and accelerate this process.

Overview of Conceptual Framework

While it is obvious that humans depend on Earth's ecosystems, it is another matter altogether to identify, assess, and undertake practical actions that can enhance well-being without undermining ecosystems. Humans influence, and are influenced by, ecosystems through multiple interacting pathways. Long-term provision of food in a particular region, for example, depends on the characteristics of the local ecosystem and local agricultural practices as well as global climate change, availability of crop genetic resources, access to markets, local income, rate of local population growth, and so forth. Changes at a local scale that may have positive impacts on the local supply of ecosystem services, such as clearing a forest to increase food production, may at the same time have highly detrimental impacts over larger scales: significant loss of forest cover in upstream areas may reduce dry-season water availability downstream, for instance.

Given these complex links between ecosystems and human well-being, a prerequisite for both analysis and action is agreement on a basic conceptual framework. A well-designed framework for either assessment or action provides a logical structure for evaluating the system, ensures that the essential components of the system are addressed as well as the relationships among those components, gives appropriate weight to the different components of the system, and highlights important assumptions and gaps in understanding.

In the case of an ecosystem assessment, an appropriate conceptual framework must cut across spatial dimensions from local to global and across temporal dimensions from the recent past to projections into the next

BOX 1.3 Overarching Questions Guiding the Millennium Ecosystem Assessment Design

The Millennium Ecosystem Assessment is designed to provide decision-makers with information to manage ecosystems in a more sustainable manner that will maintain both biodiversity and the ecosystem services that are essential to human well-being. Five overarching questions, along with the detailed lists of user needs provided by convention secretariats and the private sector, guide the issues being assessed:

1. What are the current conditions and trends of ecosystems and their associated human well-being?
   - What ecosystems make what contributions to human well-being?
   - How have ecosystems changed in the past and how has this increased or reduced their capacity to contribute to human well-being?
     - What thresholds, regime shifts, or irreversible changes have been observed?
     - What were the most critical factors affecting the observed changes?
     - What are the costs, benefits, and risks of the observed changes in ecosystems, and how have these affected different sectors of society and different regions?
2. What are the plausible future changes in ecosystems and in the supply of and demand for ecosystem services and the consequent changes in health, livelihood, security, and other constituents of well-being?
   - Under what circumstances are thresholds encountered or are regime shifts or irreversible changes likely to occur?
   - What are the most critical drivers and factors affecting future changes?
   - What are the costs, benefits, and risks of plausible future human-induced changes in ecosystems, and how will these affect different sectors of society and different regions?
3. What can we do to enhance well-being and conserve ecosystems? What are the strengths and weaknesses of response options, actions, and processes that can be considered to realize or avoid specific futures?
   - What are the trade-off implications of the response options?
   - How does inertia in the social and natural systems affect management decisions?
4. What are the most robust findings and key uncertainties that affect provision of ecosystem services (including the consequent changes in health, livelihood, and security) and other management decisions and policy formulations?
5. What tools and methodologies developed and used in the Millennium Ecosystem Assessment can strengthen capacity to assess ecosystems, the services they provide, their impacts on human well-being, and the implications of response options?

century. It must encompass the accessibility and sustainability of natural resources and systems and their products for the benefit of human societies as well as for the maintenance of these systems in their own right. It must examine how the capacities of ecosystems are being compromised or enhanced, and what mechanisms can be brought to bear to improve the access and delivery of services for human well-being. It must examine all resources simultaneously and in an integrated manner, and must evaluate past and potential future trade-offs and their consequences. To meet all these requirements in a single operational framework for an assessment is a bold venture. Without such comprehensiveness, however, an assessment cannot achieve its goal of understanding the multiple and complex natural and social drivers that are affecting ecosystems and how society can respond in positive ways to maintain ecosystem services that are central to human well-being.

This report describes the conceptual framework that has been developed for the Millennium Ecosystem Assessment. We believe that this framework will be of value to a wide range of analysts and decision-makers who are confronting the challenge of factoring considerations of ecosystems and their services into planning and management, whether it be the design of a business strategy for an agribusiness or the drafting of a national development plan.

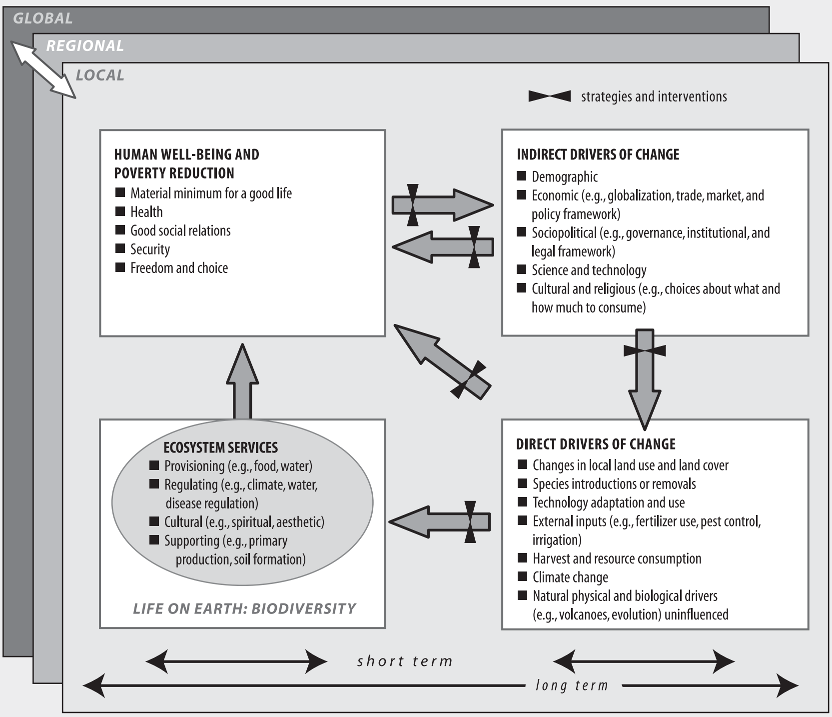
The conceptual framework elaborated here has been designed to address a set of core questions developed through extensive interaction with users of the MA, including international conventions, national governments, the private sector, and civil society. (See Box 1.3.)

The basic framework for the MA is shown in Box 1.4. The figure lists the issues that will be addressed in the Millennium Ecosystem Assessment and illustrates their interrelationships. It cannot, of course, portray the complexity of these interactions in their temporal and spatial domains. In particular, the apparent linearity of the relationships between elements of the figure does not fully capture the complex interactions that can occur among them. Given these caveats, the figure and the issues it includes capture the essence of the approach of the MA and provide a framework for structuring the work that needs to be accomplished in the process. Human well-being and poverty reduction are indicated in the upper left-hand box of the conceptual framework diagram. They are placed in this central location to emphasize the primary focus of these issues to the Millennium Ecosystem Assessment.

The MA conceptual framework is designed to assess the consequences of changes in ecosystems for human well-being. It assumes that the cen-

BOX 1.4 Millennium Ecosystem Assessment Conceptual Framework

Changes in factors that indirectly affect ecosystems, such as population, technology, and lifestyle (upper right corner of figure), can lead to changes in factors directly affecting ecosystems, such as the catch of fisheries or the application of fertilizers to increase food production (lower right corner). The resulting changes in the ecosystem (lower left corner) cause the ecosystem services to change and thereby affect human well-being. These interactions can take place at more than one scale and can cross scales. For example, a global market may lead to regional loss of forest cover, which increases flood magnitude along a local stretch of a river. Similarly, the interactions can take place across different time scales. Actions can be taken either to respond to negative changes or to enhance positive changes at almost all points in this framework (black cross bars).



tral components of human well-being—including health, the material minimum for a good life, freedom and choice, health, good social relations, and security—can be linked to the status of the environment. The framework allows examination of the degree to which this is true and under what circumstances. We propose in the work of the MA that the processes maintaining human well-being be the center and keystone of most of the work that is done. In doing this work there is a clear appreciation of the intrinsic value of ecosystems, independent of the services that they provide.

In order to partition the work of the Millennium Ecosystem Assessment, we examine the various services that ecosystems provide and how those services influence human well-being, as well as the forces that have the capacity to alter these services. More specifically, we consider ecosystem services to be the benefits people obtain from ecosystems. For our analysis, we divide these into provisioning, regulating, cultural, and supporting services. These categories overlap extensively, and the purpose is not to establish a taxonomy but rather to ensure that the analysis addresses the entire range of services. There are other ways of categorizing ecosystem services, but the particular approach of the MA seeks to distinguish supporting ecosystem services, which are important for maintaining ecosystems, from those that provide direct benefits to people. Chapter 2 provides a detailed treatment of the role of ecosystems and their services within the MA framework.

Changes in ecosystems affect life on Earth independent of human uses of their services, but we focus particular attention on the consequences of changes in ecosystem services for human well-being. Just as it is not enough to examine a single ecosystem service in isolation from its interaction with other services, so too it is insufficient to focus on only a single attribute of human well-being. Changes in ecosystem services affect many aspects of human well-being. We emphasize in particular the equity dimensions of these changes. Because poor people are often most directly dependent on harvesting ecosystem services, they are often most vulnerable to changes in ecosystems. This framework emphasizes that it is not just the average impact on human well-being that is of interest, but rather the consequences of ecosystem change for different groups of people. We describe the framework used to examine the consequences for human well-being in Chapter 3.

Understanding the factors that are causing ecosystem services to change is essential to designing interventions that can have positive benefits for ecosystems and their services. For convenience of analysis, we consider factors that affect ecosystems directly either through natural processes (such as volcanic eruptions or changes in the sun's energy) or through human actions, such as:

- changes in local land use and land cover;
- modification of river flow;

- species introductions and removals;
- external inputs (such as fertilizer use, pest control, irrigation water);
- discharge of pollutants; or
- harvest of crops, wildlife, or fish.

These factors have had, and are continuing to have, dramatic impacts on ecosystem structure and processes and hence on the services they provide. Many of these factors are in turn driven by demographic, economic, technological, sociopolitical, cultural and religious, physical, biological, and chemical forces that we call indirect drivers of change.

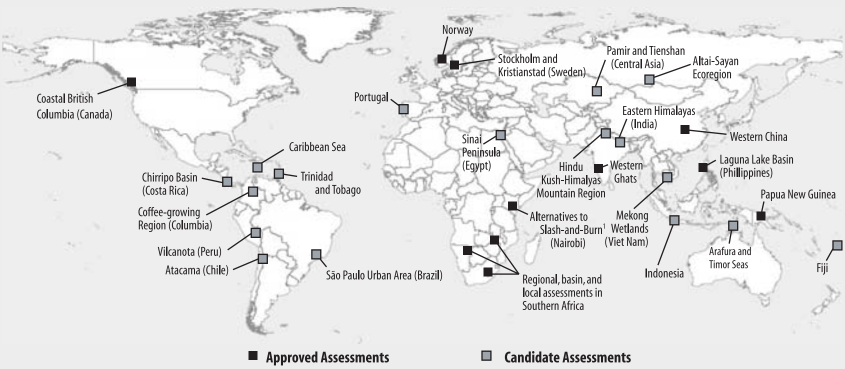
For any given decision-maker, some of these drivers are exogenous, meaning that the individual's decisions will not affect them, while others are endogenous, meaning that decisions directly affect the driver. Thus the small farmer in Africa can decide how much fertilizer to use but cannot influence the global maize price. In contrast, decisions of a finance minister of a major country could influence global maize prices. The role of the direct and indirect drivers of change and their links to decision-makers are examined in Chapter 4.

By depicting a closed loop between its major boxes, the figure in Box 1.4 reflects the existence of feedbacks within the system. In the course of time, indirect drivers are changed not only by long-term general trends, but even more by people's and society's strategies to cope with changing ecosystems in order to maintain well-being. The arrows among the principal contextual boxes of the figure indicate the causal interactions among the components of the system and the general directions of the interactions. The arrows present simplified "if-then" relationships among components: for example, if there is a change in a direct driver, then by definition there will be a change in the ecosystem. In reality, of course, the interactions and their directions are much more complex than depicted.

An important feature of the MA conceptual framework is its multiscale structure, which is depicted in the conceptual framework by the three geographic scales (local, regional, global) and two time scales (short term, long term). The multiscale approach is described in Chapter 5. Briefly, a multiscale assessment contains interlinked assessments conducted at many different geographic scales, which could range from local communities to the entire planet. (See Box 1.5.) It also addresses different time scales, from months or years to decades or centuries. The multiscale component of the MA includes a set of sub-global assessments being conducted within the MA framework, which are now under way or being developed in the

BOX 1.5 Millennium Ecosystem Assessment Sub-global Components

Millennium Ecosystem Assessment (MA) sub-global assessments use the MA conceptual framework; examine conditions, scenarios, and response options; and agree to a set of criteria concerning peer-review, data handling, stakeholder involvement, and intellectual property rights. Each sub-global assessment has significant flexibility in order to meet the needs of its stakeholders effectively. At the same time, the set of sub-global assessments interact extensively to take full advantage of the opportunities for cross-scale integration. The MA includes a set of fully approved and funded sub-global assessments, candidate assessments that have agreed to meet the MA criteria and are now in the design and fundraising stage, and initial ideas for assessments. (See map.) In addition to those shown on the map, close links have been established with ongoing assessments being undertaken by the European Environment Agency and other institutions. More sub-global assessments are expected to join the MA in 2003.



[1] ASB Sites: Sites of the Alternatives to Slash-and-Burn Consortium coordinated by the World Agroforestry Centre (ICRAF). These sites are located in humid tropical forests around the world: Western Brazilian/Peruvian Amazon; Southern Cameroon; Sumatra, Indonesia; Northern Thailand and the Philippines.

Arafura and Timor Seas, Brazil, Canada, the Caribbean Sea, the mountains of Central Asia, Chile, China, Colombia, Costa Rica, Egypt, Fiji, the Hindu Kush-Himalayas, India, Indonesia, Papua New Guinea, Peru, the Philippines, Portugal, Russia, Southern Africa (including Botswana, Mozambique, South Africa, Zambia, and Zimbabwe), Sweden, Trinidad and Tobago, and Viet Nam. In addition, a pilot assessment has been completed in Norway. We expect that other similar sub-global assessments will be established in the next several years.

The choices that people make concerning ecosystems are shaped by what they value in the system. Valuation of ecosystems and their services is unusually difficult, partly because of the intrinsic values that some people ascribe to ecosystems and partly because of the challenge of measuring economic values associated with nonmarketed ecosystem services (Wall et al. 1999; Daily et al. 2000). Typically, economists rely on market prices to provide a measure of the worth of various commodities, but for many ecosystem services, markets simply do not exist. In some cases this is because the costs of transaction and monitoring are too high.

Economic activities affected by ecological interactions involving long geographical distances provide one example of valuation problems. Another example is interactions separated by large temporal distances (the effect of carbon emissions on climate in the distant future, in a world where forward markets do not exist because future generations cannot negotiate with people today). Then there are situations (the atmosphere, aquifers, the open seas) in which the distribution of a resource makes private property rights impossible and so keeps markets from existing. In other cases, ill-specified or unprotected property rights prevent markets from being formed (as happens frequently with mangroves and coral reefs) or make them function incorrectly even if they do get formed. In each of these cases, markets are not providing the correct signals with regard to the value of an ecosystem service. Sound management thus requires alternative means for measuring value as well as policies that can internalize the externalities associated with ecosystem services. Chapter 6 summarizes the various frameworks for thinking about the value of ecosystems and describes how this will be approached in the MA.

Chapter 7 explains the basic analytical approach that can be used in an integrated ecosystem assessment, focusing on the three basic elements of the MA: assessment of current conditions and historical trends; assessment of the consequences of plausible future changes in driving forces; and assessment of the strengths and weaknesses of various response options.

Ultimately, the most important components of the conceptual framework are the black cross bars in the figure in Box 1.4 indicating intervention points where the dynamics of the system can be altered. A major goal of an integrated ecosystem assessment is to provide decision-makers with the information they need to make wise choices concerning these strategies and interventions. This decision-making process is described in Chapter 8.

Much of the work of the Millennium Ecosystem Assessment will involve evaluating interventions that have been successful in the past, as well as proposing novel possibilities that fit the current situation. The MA itself will not recommend specific policies or interventions, since the choice of policies and interventions must be influenced by more than just science. Following the experience of previous assessments, such as the Intergovernmental Panel on Climate Change (IPCC) and the Ozone Assessment, the MA will appraise the strengths and weaknesses of various options, with examples of where and why they have worked. The purpose of a scientific assessment is not to assume a decision-making role by actually selecting the most appropriate option, but rather to contribute to the decision-makers' understanding of the scientific underpinning and implications of various decisions.

The conceptual framework used in the MA differs from the standard environmental impact assessment (EIA) framework in that it places ecosystems and the environment in a central role in the effort to reach development goals. The MA framework is designed to allow the examination of how changes to ecosystems influence human outcomes. The EIA approach, in contrast, focuses on the impacts of human actions on the environment and is designed to explore the relative costs and benefits of various project options. Ecosystems and the environment are treated as externalities in an EIA (affected by development activities), whereas they are internal in the MA framework—something that can be managed sustainably in order to contribute to human development.

The framework also differs from the commonly used pressure-state-impact-response (PSIR) framework by virtue of the feedbacks that it incorporates. The PSIR framework is designed to focus on the impacts of pressures (driving forces) on the environment and the responses that can be taken to alter negative impacts. The MA framework extends the PSIR framework by incorporating the consequences of the environmental impacts on human well-being and as a result turns the relatively linear PSIR framework into a more dynamic system in which environmental changes (the I) can change the human condition and thereby change the pressures (the P).

Equally significant, the MA framework differs from frameworks such as the PSIR or EIA by explicitly including multiscale considerations, as described in the next section. Assessments conducted at different geographic and temporal scales will inevitably focus on different issues and reach different conclusions. No assessment can meet all needs at all scales, but a multiscale framework helps to provide decision-makers with a more complete view of both the issues that need to be addressed and the relative merits of interventions that can be made at different levels of governance.

Each of the four MA Working Groups organizes its work within this conceptual framework. The Condition and Trends Working Group will examine each box of the figure in Box 1.4 (drivers, services, well-being) and their interactions over the past 50 years. The Scenarios Working Group will examine each box and their interactions for different plausible future changes in driving forces, extending out 50 years (and for some variables, 100 years). The Responses Working Group will examine the strategy and intervention points in the figure, which depict options that are available to achieve particular outcomes in the delivery of services from ecosystems. Finally, the Sub-global Working Group will examine all these features (condition, scenarios, and responses) for each of the MA sub-global assessments but at the scale of local communities, river basins, or nations.

The Multiscale Approach

The MA is structured as a multiscale assessment in order to enable its findings to be of greater use at the many levels of decision-making. A global assessment cannot meet the needs of local farmers, nor can a local assessment meet the collective needs of parties to a global convention. A multiscale assessment can also help remedy the biases that are inevitably introduced when an evaluation is done at a single geographic scale. For example, while a national ecosystem assessment might identify substantial national benefits from a particular policy change, a local assessment would be more likely to identify whether that particular community would be a winner or loser as a result of the policy change.

Through the use of a multiscale approach, the findings of the assessment at any scale can in principle be enhanced by virtue of the information and perspectives from other scales. Several factors act together to strengthen the findings of a multiscale assessment. First, a multiscale structure helps to ensure that perspectives or concerns at any given scale are reflected in the analysis and conclusions at other scales. For example, a local community may have quite a different perception of the costs and benefits of various features of the ecosystem than the "global" community. Neither perspective is right or wrong, but a single-scale assessment could miss important differences that could affect the usefulness of various approaches to managing ecosystem change.

Second, a multiscale assessment enables the evaluation of cross-scale factors. Ecosystems are highly differentiated in space and time, and sound management requires careful local planning and action. At the same time, local assessments are insufficient, because some processes are global and because local goods, services, matter, and energy are often transferred across regions. A local assessment of a downstream farming community, for example, would be incomplete without information on upstream activities influencing the community's supply of fresh water.

Finally, a multiscale assessment allows evaluation of the scale-dependence of various actions and policies. Often the aggregate beneficial impacts of a policy change at a national scale may obscure the winners and losers at a local scale. Although differential impacts of change will always exist, the net benefits of actions and policies can be enhanced through more careful assessment of these scale-dependent impacts.

The multiscale framework of the MA is unique among international assessments. Various other global programs include strong regional analyses (such as the *Third Assessment Report* of the IPCC) or produce global findings by aggregating multiple regional assessments (for example, the Global International Waters Assessment, and the *Global Environment Outlook*). The sub-global components of the MA, however, are not just regional analyses or case studies; they are formal assessments undertaken at the sub-global scale, with their own stakeholders, authorizing environments, and user-driven processes.

Types of Knowledge Assessed

Scientific assessments, particularly global assessments, have generally been based on a particular western epistemology (way of knowing), one that often excludes local knowledge, ignores cultural values, and disregards the needs of local communities. Sources such as lay knowledge or practitioners' knowledge tend to be excluded, since assessment procedures often define the information base for an assessment to be the published scientific literature.

Scientists and policy-makers alike have become aware of the need to establish new assessment processes that can accommodate and value these different ways of knowing. For example, a rich body of knowledge concerning the history of ecosystem change and appropriate responses exists within local and traditional knowledge systems, as recognized in principle in the Convention on Biological Diversity. It makes little sense to exclude such knowledge just because it has not been published. Moreover, incorporation of traditional and local knowledge can greatly strengthen the legitimacy of an assessment process in the eyes of indigenous and local communities.

Similarly, substantial knowledge concerning both ecosystems and policy interventions is held within the private sector among the "practitioners" of ecosystem management, yet only a small fraction of this information is ever published in the scientific literature.

Effective incorporation of different types of knowledge in an assessment can both improve the findings and help to increase their adoption by stakeholders if they believe that their information has contributed to those findings. At the same time, no matter what sources of knowledge are incorporated into an assessment, effective mechanisms must be established to judge whether the information provides a sound basis for decisions.

Relatively little experience can be drawn on today of assessment mechanisms that effectively bridge epistemologies. Within the MA, a concerted effort is being made to enable the incorporation of traditional and local knowledge through the establishment of mechanisms for verification even where that knowledge is not first published in peer-reviewed literature. (See Chapter 7.) The MA's multiscale structure provides an unparalleled opportunity to incorporate both traditional and scientific knowledge in the process, since assessments conducted at the smaller scales of individual communities or watersheds will tend to involve much more input of lay and traditional knowledge.

Minimizing Structural Biases

A scientific assessment is a social process to bring the findings of science to bear on the needs of decision-makers. The success of such assessments rests on their saliency, credibility, and legitimacy (Clark and Dickson 1999). Scientific information is salient if it is perceived to be relevant or of value to particular groups who might use it to change management approaches, behavior, or policy decisions. It is credible if peers within the scientific community perceive the scientific and technical information and conclusions to be authoritative and believable. It is legitimate if the process of assembling the information is perceived to be fair and open to input from key political constituencies, such as the private sector, governments, and civil society. The MA has been designed to meet these three basic criteria.

But even the most credible and scientifically unbiased assessment will necessarily give power to some stakeholders at the expense of others. The usefulness of an assessment to different stakeholders is strongly influenced, to begin with, by which stakeholders are involved in choosing its focus. For example, in the face of food insecurity in a particular region, some people may frame the issue as a problem of production and request an assessment of new agricultural technologies for the region, while others may see it as a problem of resource ownership or purchasing power and request an assessment of experience with land redistribution or employment-generating opportunities. Similarly, a global assessment of ecosystem services would naturally examine the role of ecosystems as a source of carbon sequestration, but farmers would be unlikely to select this as an important service unless a mechanism were in place for them to be paid for that sequestration.

The MA, by virtue of its multiscale, multistakeholder structure, will be more neutral with regards to these concerns of focus than other global assessments, but it is not devoid of structural biases. Because its primary authorizing environment is governmental, it will be devoting particular attention to decision-making needs of governments as articulated through the parties to the Convention on Biological Diversity, the Convention to Combat Desertification, the Ramsar Convention on Wetlands, and the Convention on Migratory Species. In addition, although the MA is a multiscale assessment, it will include only about 15 sub-global components. Clearly, an international assessment with thousands of local community components would more strongly reflect the agenda of local communities than an assessment with 15. Thus although the MA for the first time provides a way to increase the input of local or national stakeholders into questions being addressed by an international assessment, it falls short of being scale-neutral and will inevitably focus particular attention on global concerns and questions.

An assessment's usefulness to different stakeholders will also depend on the composition of the scientific community that conducts it. The most effective global assessments, such as the IPCC and the Ozone Assessment, emphasize regional balance of the scientists involved and the involvement of both natural and social sciences. Both regional and disciplinary balance is essential to ensure the credibility and legitimacy of the process. Yet considerable knowledge of ecosystems and their influence on human well-being is held not just in the formal scientific literature but in traditional and local knowledge systems as well. As noted earlier, therefore, the MA is seeking to expand the community of experts conducting the assessment to include local and traditional knowledge. Inevitably, however, while the MA will make an evolutionary step toward more holistic treatment of different ways of knowing the world, the process will still give greater emphasis to peer-reviewed scientific literature.

No assessment can hope to be all things to all people, nor should it be—as it would become highly diffuse. But recognition of the structural biases that exist in any assessment can aid in the interpretation of the findings. And by identifying and describing structural biases, it may be possible to address some of them during the course of the assessment.

Use in Decision-making

Decision-makers confront the full complexity of social-environmental systems with nearly every decision that they take. Scientific assessments, in contrast, have traditionally focused on narrow slices of that complexity. But they increasingly can provide insights into the more complex realities that are at the core of the most difficult choices confronting policy-makers. These tough choices involve trade-offs among different sectors, goals, or time frames. They often involve trade-offs between national and local benefits. And they involve actions to address the structural causes of problems like poverty, not just the symptoms.

Can integrated ecosystem assessments and the information that they make available actually contribute to the real world of decision-making? Despite the growing pressures on ecosystems today, this period in history offers an unprecedented opportunity to modify the development paths being pursued around the world to ones that will secure and sustain human well-being. The last decade has seen progress in understanding how to address environmental and development issues and how to decrease the impact of industry on the environment, but more progress needs to be made in addressing environment and development simultaneously. Today, the world is on the threshold of an era in which integrated environmental management can become a central tool in achieving sustainable development goals. The factors that may have set the stage for this transition include:

- *Advances in science.* Considerable scientific progress has been made in the past several decades in understanding the complex interactions both within ecosystems and between ecosystems, human activities, and human well-being.
- *Advances in information technologies and improved access to information.* Computers and data systems now allow analysts and decision-makers to better monitor ecosystems and predict the consequences of various changes; at the same time, they help provide stakeholders with access to information they need for both decision-making and accountability.
- *Changing paradigms of well-being and poverty.* Historically, human well-being was largely defined in terms of income and consumption; it is now recognized to include the material minimum for a good life, freedom and choice, health, good social relations, security, and peace of mind and spiritual experience.

- *Policy and institutional reform.* Pressures on ecosystems may be exacerbated by misguided policies and institutional arrangements, such as inappropriate subsidies and inequitable patterns of ownership and access to resources. Decision-makes are increasingly aware of the long-term costs of these policies, and many countries are beginning to take steps to reform them.
- *Changing governance.* The relative power of nation-states has diminished with the growth of power and influence of a far more complex array of institutions, including regional governments, multinational companies, the United Nations, and civil society organizations. Many small stakeholders are also increasingly involved in decision-making.

These economic, scientific, institutional, and technological changes have created a new environment for decision-making and action. It is an environment in which multiple users in governments, the private sector, and civil society all have needs for better scientific information and understanding such as that provided through assessments like the MA. And it is an environment in which the general public can make use of information to hold decision-makers accountable. It is also an environment in which it is possible to envision the emergence of new institutional and policy arrangements and changes in rights and access to resources that may be necessary to address fully the challenges of sustainable ecosystem management. In the words of United Nations Secretary-General Kofi Annan in his Millennium Report to the United Nations General Assembly:

> It is impossible to devise effective environmental policy unless it is based on sound scientific information. While major advances in data collection have been made in many areas, large gaps in our knowledge remain. In particular, there has never been a comprehensive global assessment of the world's major ecosystems. The planned Millennium Ecosystem Assessment, a major international collaborative effort to map the health of our planet, is a response to this need (Annan 2000).

Ecosystems and Human Well-being: A Framework for Assessment describes the framework within which such an assessment of the health of the planet can be made. In 2005, the MA will release a series of global assessments undertaken through the application of that framework.