4. Environmental and Social Systems*

Overview

This chapter provides an in depth discussion of the linkages between the environmental and socio-economic domains of sustainable development, institutional settings, and environmental and social assessments. Some ideas underlying the sustainability of ecological and social systems were discussed earlier in Chapter 2. The basic role of ecosystems in supporting human society and economic activities, and methods of assessing this contribution (including monetary valuation), were explained in Chapter 3. These ideas are extended in Section 4.1, which summarizes the comprehensive conceptual framework based on the Millennium Ecosystem Assessment (MA), including the cyclic interactions between ecological and socioeconomic systems, and the main ecosystem services which sustain human well being. The MA highlights the precarious situation of many critical ecosystems. The idea of "panarchy" of living systems, and dynamic ecological cycles involving birth, growth, adaptation, decay, death, and regeneration, help us understand ecosystem behaviour. Next, Section 4.2 describes the key mediating role played by property rights regimes, in determining how societies exploit natural resources. Property rights regimes play an important role in designing and implementing sustainable environmental management measures. Their effectiveness largely depends on the congruency of well-specified property rights regimes with ecological and social factors, especially in the case of traditional societies and native peoples who are heavily dependent on ecological resources, as well as the landless poor who subsist in degraded areas. Finally, in Section 4.3, environmental and social assessments are described as important elements of sustainable development assessment, which complement cost-benefit analysis (or economic assessment).

4.1 CONCEPTUAL FRAMEWORK LINKING ECOLOGICAL AND SOCIO-ECONOMIC SYSTEMS

The Millennium Ecosystem Assessment (MA) was launched by United Nations Secretary-General Kofi Annan in 2000 (UN, 2000a). Conducted during 2001-05, the goal of the MA was to assess the impacts of ecosystem change on human well-being and then identify the actions needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. Briefly, an ecosystem is

* The valuable contributions of S. Hanna, W. Reid and W. Shearer to this chapter are gratefully acknowledged. Some parts of the chapter are based on material adapted from Hanna and Munasinghe (1995c), Munasinghe (1992c), Munasinghe and Reid (2005) and Munasinghe and Shearer (1995).

a "dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit" (CBD, 1992).

The MA results provide valuable inputs to the work of four international environmental treaties – the UN Convention on Biological Diversity, the Ramsar Convention on Wetlands, the UN Convention to Combat Desertification, and the Convention on Migratory Species. The work was supported by 22 of the world's leading scientific bodies, and involved more than 1,360 experts from 95 countries. Their findings on the condition and trends of ecosystems, scenarios for the future, possible responses, and assessments at a sub-global level are set out in technical reports. Several synthesis reports draw on these detailed studies to answer questions posed by specific groups of users (MA, 2005a, b, c, d, e, f).

4.1.1 Ecosystem services and human well being

Managing a complex ecosystem to balance delivery of all of its services is at the heart of ecosystem-based management (Palumbi et al 2009; Fisher et al. 2008). Figure 4.1 summarizes the complex, circular and dynamic relationship between the ecological and socio-economic (development) domains. The large horizontal arrows at the top and bottom indicate the cyclic relationship. Starting from the top, ecosystem services have social, economic and environmental impacts, from which alternative future development paths will emerge, with different consequences for human well being. The alternative development scenarios affect indirect drivers of change, which in turn, influence direct drivers of change (two downward arrows). The two upward vertical arrows also indicate key feedback effects between both indirect and direct drivers and human well being. Finally, the direct drivers have important impacts on ecosystems and their services.

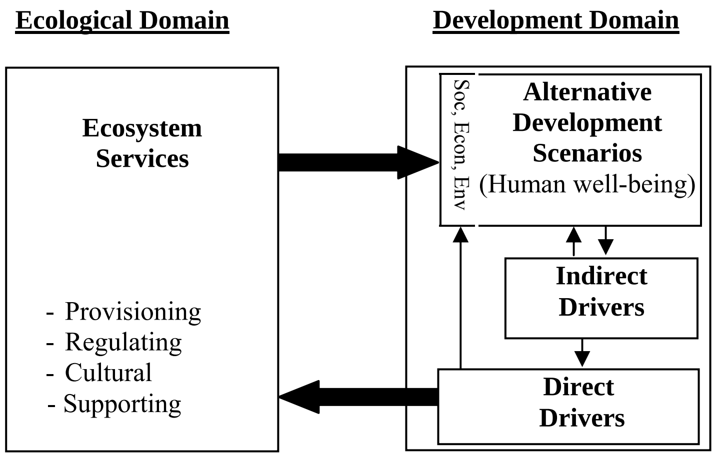
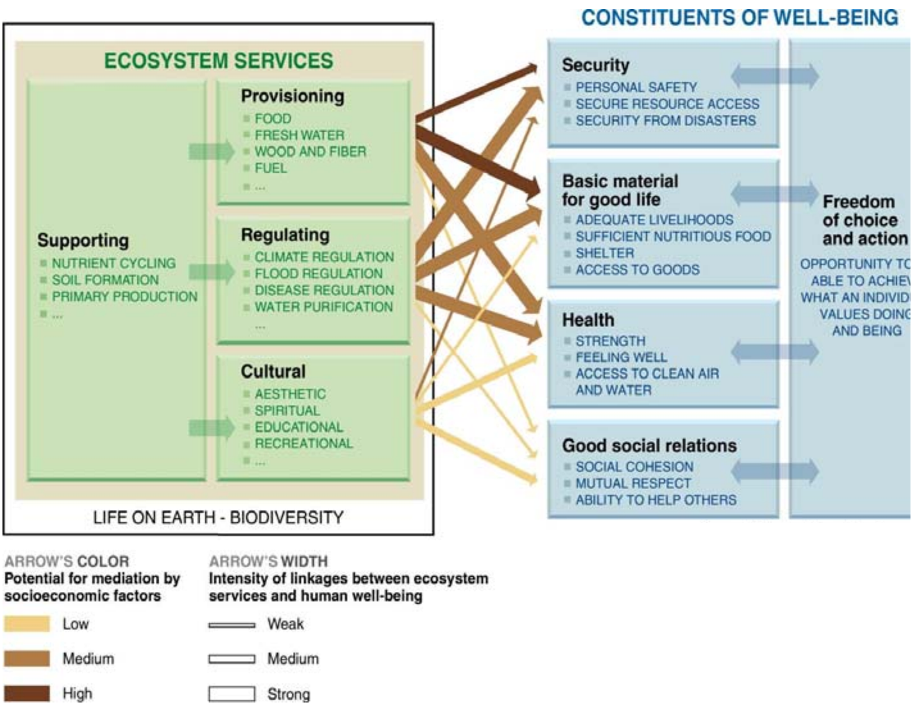


Figure 4.1 Circular interaction between ecological and development (socio-economic) domains.

Indirect drivers include the following major components: demographic; economic (globalization, trade, market and policy framework); sociopolitical (governance and institutional framework); science and technology; and cultural and religious. Direct drivers include: changes in land use; species introduction or removal; technology adaptation and use; external inputs (e.g. irrigation); resource consumption; climate change; and bio-geophysical drivers (e.g. volcanoes)

Figure 4.2 further elaborates the basic linkages in Figure 4.1, by providing an overview of the key ways in which ecosystems and their services support and affect human well being (see also Chapter 3).



Source: MA 2005a

Figure 4.2 How ecosystem services sustain key components of human well-being

Overall Supporting Services: The left hand side of Figure 4.2 shows that all other ecosystem functions (provisioning, regulation and cultural) ultimately depend on a set of broad supporting services, which include soil formation, nutrient cycling, primary production, etc.

Provisioning Services: Ecosystems provide products to support human activities and consumption, including food, fresh water, fuelwood, fiber, biochemicals, and genetic resources.

Regulating Services: Ecosystems regulate natural processes and purify natural resources, affecting areas such as climate, disease, and water.

Cultural Services: Ecosystems yield non-material benefits, including spiritual and religious support, recreation and ecotourism, aesthetic pleasure, inspiration, education, sense of place, and cultural heritage.

We note that provisioning, regulating and cultural ecosystem services correspond roughly to the respective categories of economic value – direct use value, indirect use value and non-use value, defined in Chapter 3.

The right hand side of Figure 4.2 summarizes the elements of human well being which are supported by ecosystem services, with the width and shading of each arrow indicating the intensity of the linkage, and the potential for human mediation, respectively. The expansion of freedoms and options intrinsic to the sustainable development process (Chapter 2), is associated with the following constituents of human well being: security; basic material needs; health; and good social relations.

In Section 4.2, this underlying conceptual framework is used to study how property rights regimes embedded in the fabric of human communities influence the way in which environmental resources are used.

4.1.2 Main findings of the Millennium Ecosystem Assessment (MA)

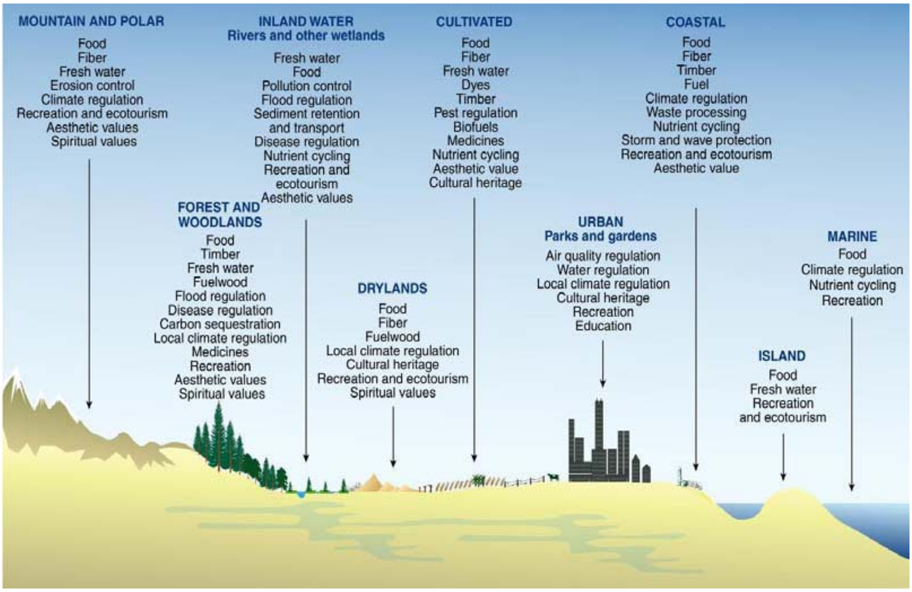
Based on the foregoing framework, the MA arrived at a number of key conclusions (MA 2005a).

Major issues

All human beings depend on nature and ecosystem services for their well being (Figure 4.3). We have made unprecedented changes to ecosystems in recent decades to meet growing demands for food, fresh water, fiber and energy, and improve the lives of billions. These changes have weakened nature's ability to deliver other key services such as purification of air and water, protection from disasters and the provision of medicines.

About 60 percent of the ecosystem services that support life on Earth (e.g. fresh water, capture fisheries, air and water regulation, and the regulation of regional climate, natural hazards and pests), are being degraded or used unsustainably. Specific problems include: the dire state of many of the world's fish stocks; great vulnerability of 2 billion people living in dry regions to the loss of ecosystem services (especially lack of water resources); and growing pressure on ecosystems from climate change and nutrient pollution. The loss of services derived from ecosystems is a significant barrier to the achievement of the Millennium Development Goals (MDG), especially the reduction of poverty, hunger, and disease.

A further threat to our well-being has arisen from human activities that have taken the planet to the edge of a massive new wave of species extinctions. Fossil records indicate that the historical extinction rate was less than one species per thousand every thousand years. In recent years, this extinction rate has increased between one hundred and one thousand fold. Projected future extinction rates are likely to be ten times higher.



Source: MA (2005a)

Figure 4.3 Ecosystems and some services they provide.

The degradation of ecosystems will increase globally in coming decades, unless human attitudes and actions change. The current status and continuing decline of 15 of the 24 ecosystem services examined in the MA, has increased the likelihood of abrupt changes that will seriously affect human well-being. Such changes include the emergence of new diseases, sudden loss of water quality, creation of "dead zones" along the coasts, the collapse of fisheries, and shifts in regional climate. Only provisioning services like crops, livestock and aquaculture show gains.

Policy options and remedies

Some important steps to protect and manage ecosystem services more sustainably are summarized in Table 4.1. Measures to conserve natural resources will be more successful if local communities are empowered by giving them ownership of these resources, a fair share of the benefits, and a greater role in decision making. Even the technology and knowledge available today could considerably reduce human impacts on ecosystems. However, such measures are unlikely to be deployed fully until the full value of ecosystem services is taken into account.

Table 4.1 Measures to manage ecosystem services more sustainably

Change the economic background to decision-making
- Ensure the value of all ecosystem services, not just those bought and sold in the market, are taken into account when making decisions
- Remove subsidies to agriculture, fisheries and energy that cause harm to people and the environment.
- Introduce payments to landowners in return for managing their lands in ways that protect ecosystem services, such as water quality and carbon storage, that are of value to society.
- Establish market mechanisms to reduce nutrient releases and carbon emissions cost-effectively.

Improve policy, planning, and management
- Integrate decision-making between different departments and sectors, as well as international institutions, to ensure that policies are focused on protection of ecosystems.
- Include sound management of ecosystem services in all regional planning decisions and in the poverty reduction strategies being prepared by many developing countries
- Empower marginalized groups to influence decisions affecting ecosystem services, and recognize in law the local communities' ownership over natural resources
- Establish additional protected areas, particularly in marine systems, and provide greater financial and management support to those that already exist.
- Use all relevant forms of knowledge and information about ecosystems in decision-making, including the knowledge of local and indigenous groups.

Influence individual behavior
- Provide public education on why and how to reduce consumption of threatened ecosystem services.
- Establish reliable certification systems to give people the choice to buy sustainably harvested products.
- Give people access to information about ecosystems and decisions affecting their services.

Develop and use environment-friendly technology
- Invest in agricultural science and technology aimed at increasing food production with minimal harmful trade-offs.
- Restore degraded ecosystems.
- Promote technologies to increase energy efficiency and reduce greenhouse gas emissions.

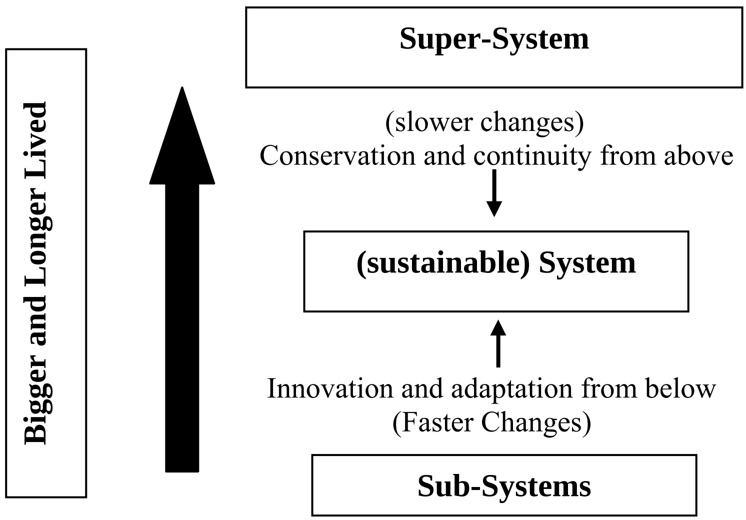
Source: MA (2005a)

Better protection of natural assets will require co-ordinated efforts across governments, businesses, civil society, and international institutions. The state of ecosystems will depend, *inter-alia,* on critical policy choices concerning investment, trade, subsidies, taxation, and regulation.

4.1.3 Dynamics of interlinked living systems

Chapters 2 and 3 indicated that socio-economic and ecological systems are closely linked and have co-evolved dynamically within a larger complex adaptive system over a long span of time. In this section, we briefly summarize the dynamics of such a "panarchy" of systems, using the cycle of growth, adaptation, transformation, collapse and regeneration described by Gunderson and Holling (2001).

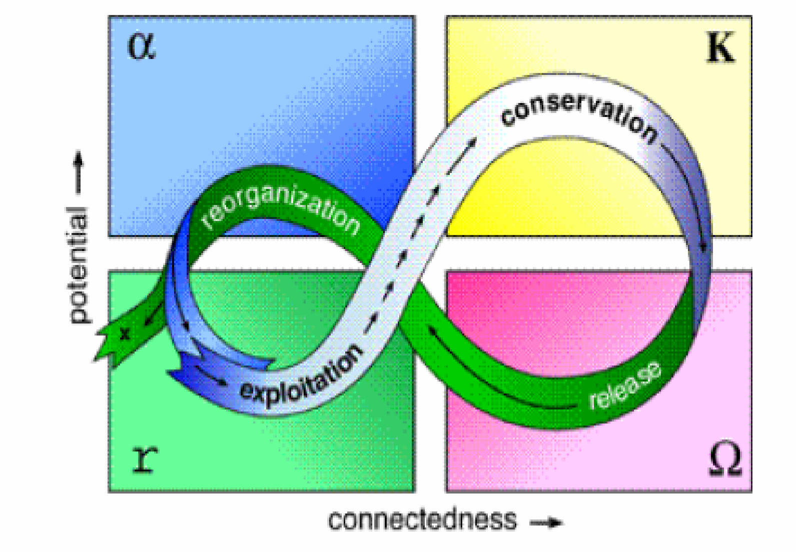
Box 2.2 introduced panarchy as a nested hierarchy of living systems and their adaptive cycles across scales. Figure 4.4 shows how a system at a given level is able to operate in its stable (sustainable) mode, because it is protected by the slower and more conservative changes in the super-system to which it belongs. At the same time, the system will be invigorated and energized by the faster cycles taking place in the many sub-systems within it. In brief, both conservation and continuity from above, and innovation and change from below, are integral to the panarchy-based approach, helping to maintain the dynamic balance between the twin requirements for stability and for change.



Source: Author, based on Gunderson and Holling (2002)

Figure 4.4 Dynamic interaction and continuity of living systems across scales

The dynamic path of a given system (ranging in scale from a cell to a biome) is shown in Figure 4.5. The cycle shows four phases: 1) entrepreneurial exploitation (*r*); 2) conservation and organizational consolidation (*K*); 3) release and creative destruction (Ω); and 4) reorganization and destructuring (α). Each phase is characterized by different degrees of potential (ability to develop and grow) and connectedness (internal linkages and structure). Using the example of the centuries-long evolution of a forest, the first part of the cycle shows exploitation of novelty to grow and evolve from pioneer species (*r*) to climax species (*K*). Accumulation of biomass and wealth results in reduced resilience and increased vulnerability, raising the risk of destruction due to major disturbances such as fire, storm, or pest (Ω). This is followed by the release of accumulated nutrients and biomass, which may be reorganized into the start of a new cycle (α). Each phase of the cycle creates the conditions for the next phase.



Source: Gunderson and Holling (2002).

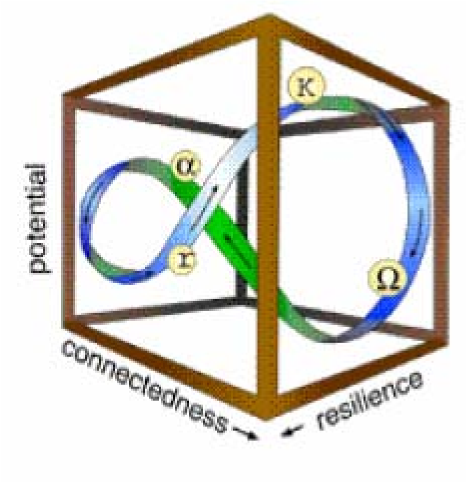
Figure 4.5 Cycle of growth and reorganisation for living systems

The slower and steadier "forward loop" consists of the first two "growth" phases, while the less predictable "backward loop" includes the second two "reorganization" phases.

Resilience is a key concept, which indicates the ability of a system to continue functioning within normal limits when externally perturbed, and maintain the component elements needed to renew or reorganize if a large shock significantly changes system structure and function (Walker et al. 2002; Scheffer et al. 2009; Liu et al. 2007). The more resilient the system, the more sustainable it is.

If a third axis of resilience is included in the analysis, the figure-eight shape in Figure 4.5 becomes the twisted but non-intersecting loop shown in Figure 4.6. Each system is still a part of the panarchy shown earlier in Figure 4.4. Thus the exploitation phase (r) of a smaller system could trigger change or revolt in the larger system to which it belongs, while the consolidation phase (K) of a larger system will stabilise and facilitate re-organisation of a subordinate system.

Holling (2004) argues that the concept of panarchy could be extended also to study how social systems grow, adapt, transform, and collapse. The backward loop (usually involving abrupt change) is a critical time when opportunities arise for experimentation and learning -- systems face risk and their resilience is tested and established. As we consider the long term co-evolution of socio-economic and ecological systems, it would be useful to determine if we are entering into a phase of higher risk, during such a backward loop -- by assessing the changes brought about by the challenges described in Chapter 1.



Source: Gunderson and Holling (2002)

Fig. 4.6 Adding the third dimension of resilience unravels the twist in the two-dimensional figure-eight shape of Figure 4.5.

4.2 PROPERTY RIGHTS, GOVERNANCE AND ECOLOGICAL-SOCIAL LINKAGES

Next, we examine the institutional dimensions of environmental-social sustainability. Humans interact with their environment through systems of property rights and governance (that are embedded in social, political, cultural, and economic context), and thereby affect both the quantity and quality of environmental resources. While national and international economic policies have often ignored the environment, institutions could play a key role in reconciling economic development and the maintenance of environmental carrying capacity and resilience (Arrow et al. 1995a, Grima et al. 2003). Ecology and Society (2006) and Environment and Development Economics (2006) describes recent research on resilience in social-ecological systems. Folke and Gunderson (2006) identify several papers which explain how better ecological-social research can help to address global environmental issues. We explain below how the functioning of property rights regimes in relation to human use of the environment, is critical to the design and implementation of sustainable environmental management measures (Hanna and Munasinghe 1992a).

4.2.1 Sustainability, sustainable development, and property rights regimes

Property rights regimes consist of *property rights*, bundles of entitlements defining rights and duties in the use of natural resources, and *property rules*, the rules under which those rights and duties are exercised (Bromley 1991). Property rights regimes influence the use of environmental resources, a fact that has long been well established, if not well practiced. Warming (1911) wrote of the dangers of fisheries overexploitation without ownership, an argument enhanced by Gordon (1954). In "The Tragedy of the Commons," Garrett Hardin (1968) focused widespread attention on the problem of environmental degradation in the absence of rules governing use. For many years, the general interpretation of Hardin's argument was that collectively owned property was the culprit, and that private property was necessary to sustain environmental resources. However, a rapidly expanding body of scientific evidence indicates that sustaining environmental resources is not dependent on a particular structure or type of property regime, but rather on a well-specified property rights regime and a congruency of that regime with ecological and social factors.

In this ecological and social context, sustainability is a difficult concept to interpret because it has a wide range of meanings based on different disciplines and world views. What is being sustained, how it is to be sustained, and for how long, are all open to interpretation. Regardless of the specific meaning used, it is clear that, to some extent, sustainability is a human construct. Humans use their environment for a range of objectives (Section 4.1.1), which leads to different expectations as to what is to be sustained, and who is to have claims on environmental services. Cochrane (2006) argues that social (cultural) capital determines the sustainability of environmental capital by influencing management objectives, efficiency of use, and demand relating to natural resource use (Chapter 2).

The question of sustainability is a complicated one whose answer involves more than the generic application of a property rights regime. Property rights regimes need to reflect both general principles and specific social and ecological contexts, in order to be effective in modulating the interaction between humans and their environment. General principles include the structural and functional attributes of property rights regimes which transcend a particular context (Hanna, Folke and Maler 1995). General principles are the necessary conditions for effective property rights regimes, because a property rights regime cannot succeed over the long run without them. They include several key elements, such as congruence of ecosystem and governance boundaries; specification and representation of interests; matching of governance structure to ecosystem characteristics; containment of transaction costs; and monitoring, enforcement, and adaptation processes at the appropriate scale (Eggertsson 1990, Ostrom 1990, Bromley 1991, Hanna 1992):

General principles are necessary, but not sufficient in themselves for effective property rights regimes. In addition, specific attributes of social and ecological context must be represented. Social contexts contain all the dimensions of the human relationship to environmental resources, including social arrangements, cultural practices, economic uses, and political constraints. Ecological contexts contain the structure of ecosystems in which humans live and work, as well as the particular functional properties of those ecosystems. The particular details of the social and ecological context are what give a human social–environmental interaction its variety and detail. The match between a property rights regime and the contextual characteristics of the affected humans and ecosystems will determine success or failure in terms of sustainability.

Better economic valuation of environmental and socio-cultural assets (see Chapter 3), and their internalization in the price system, is one means of ensuring that market forces lead to more sustainable resource use. The more equitable distribution of resources and assets is a step toward poverty reduction and social sustainability, as is greater participation and empowerment of disadvantaged groups. Clearly, property rights regimes that specify access to the natural resource base and rights of use have a crucial role to play, in this context.

The literature addressing questions of property rights and natural resource use is growing, but there are large gaps in knowledge (Hanna and Munasinghe 1992, Poteete and Ostrom 2008). Five of these areas are explored below.

4.2.2 Governance systems

Questions of governance over environmental resources have to do with the ability to predict and oversee probabilistic ecosystem responses to human behavior and management, and to external drivers such as climate. The complexity of the human systems and ecosystems affects the ability to extract consistent objectives, design meaningful control systems, and monitor response. The scale of the ecosystem in comparison with scales of social organization or legal jurisdiction determines the extent of the match between the human and environmental systems. The delineation and coordination of authority over environmental decisions is critical to relating actions to outcomes. The ways in which governance is coordinated between authorities at different levels determine consistency across scales. The success of decentralised governance systems may be improved by applying the principle of subsidiarity, which requires that each decision is made and implemented at the lowest practical and effective level.

Most studies assume that the manager is outside the system being managed (Walker et al. 2002). However, in the context of long-term sustainability, linked socioeconomic and ecological systems (SESs) behave as complex adaptive systems, with the managers as integral components of the system. Ostrom (1995) argues that since many biological processes occur at small, medium, and large scales, governance arrangements that can cope with this level of complexity also need to be organized at multiple scales and linked effectively together. The importance of nested institutional arrangements is emphasized, with quasi-autonomous units operating at very small, up through very large, scales. The concept of distributed governance is analysed by Townsend and Pooley (1995a) using competing models of cooperative management, co-management, and rights-based management in the context of fisheries. They pay attention to both internal and external governance issues. Fitzpatrick (2000) also looks at distributed governance in the case of Canada. He emphasizes that there is a need for partnership arrangements, especially between multiple sectors and levels of governance to meet shared objectives. Distributed authority affects governance efficiency and in particular, through the role played by user participation in lowering management costs (Hanna 1995). The contribution of user participation to governance efficiency may be analyzed in terms of the structure and function of user participation and its effect on management costs. More recently, Cinner and Aswani (2007) have focused on integrating customary local practices into cooperative fisheries management. Kaitala and Munro (1995) address the question of governance coordination over multiple jurisdictions, as exemplified by transboundary fishery resources categorized as highly migratory fish stocks and straddling fish stocks. The high seas portions of these stocks are exploited by both coastal states and distant water fishing nations. The difficult issue of managing such resources (characterized by ill-defined property rights over the high seas portion of the resources) is the focus of a major United Nations intergovernmental conference.

Several case studies illustrate the application of the various principles of governance to the environmental challenges of air pollution, fishery management, and pesticide use. Tietenberg (1995) examines the question of governance design and scale through an analysis of the use of market-based mechanisms in his chapter on the transferable permits approach to pollution control problems in the United States. From the various examples described, he extracts lessons for both the implementation process and program design. Townsend and Pooley (1995b) consider the question of appropriate levels of authority—through a potential application of the distributed governance concept to the lobster fishery of the Northwestern Hawaiian Islands. Gren and Brännlund (1995) show that although geographic differences in environmental impacts may call for region-specific environmental regulations, regional differences in enforcement costs will lead to different levels of cost-effective regulation. Grima (2003) discusses the role of institutions at the international, national, and community levels (including property rights), in making the forestry sector development more sustainable.

4.2.3 Equity, stewardship, and environmental resilience

Generally, the degree of equity represented by a property rights regime helps to create the incentive structure which either promotes or inhibits stewardship of environmental resources. In turn, the degree of stewardship practiced affects the level of ecosystem resilience. Exactly how equity affects stewardship and how specific stewardship practices affect resilience is still a matter of research. Definitions of equity, stewardship practices, and environmental resilience reflect a combination of local context, appropriate incentive structures, and adaptation to environmental change. The goals of equity and stewardship are commonly considered to be inconsistent with efficiency in environmental management. In a departure from the usual approach, Young and McCay (1995) look at efficiency-driven, market-based property rights systems and evaluate them for their ability to accommodate equity, stewardship, and resilience, in the design of adaptive and flexible management regimes -- after considering a number of different types of property rights systems for a variety of resources. Chichilnisky and Heal (2000) emphasize that the most attractive feature of markets is efficient allocation of resources, requiring minimal intervention once an appropriate legal infrastructure is in place.

Several studies demonstrate the difficulties of crafting equitable schemes that promote better stewardship and resilience for the conservation of natural resources. Gadgil and Rao (1995) examine the incentives for managing biodiversity contained in India’s folk traditions of nature conservation. They focus on the efficiency and equity gains possible through reestablishing conservation approaches based on positive incentives to local communities. This attractive option is contrasted with current unsuccessful regulatory methods that are too centralized, sectoral, and bureaucratic. Zylicz (1995) analyze the conflict between conservationists and a municipality in Northeastern Poland. Parts of national parks are being claimed by previous landowners who feel they were not reimbursed fairly, there are private or communal enclaves left within park boundaries, and neighboring landowners protest against development constraints due to the park’s existence. The fate of nature depends on the ability of conservationists to demonstrate economic benefits from investing in natural capital, to prevent degradation.

Parks and Bonifaz (1995) examine the the joint use of environmental resources, by looking at the inconsistencies of short-term commodity production with long-term environmental sustainability in open-access Ecuadorian mangrove–shrimp systems. They identify incentives to maximize short-term profits through shrimp mariculture, which have led to destruction of larval-shrimp habitats as mangrove ecosystems were converted to shrimp ponds. Gottret and White (2001) describe integrated natural resource management (INRM) in Latin America. The complexity of INRM interventions requires a more holistic approach to impact assessment, which combines the traditional "what" and "where" factors of economic and environmental priorities, with newer "who" and "how" aspects of social actors and institutions.

4.2.4 Traditional knowledge

The documentation and use of traditional ecological knowledge is now an internationally accepted practice. At an even deeper level, many “modern” concepts like “Gaia” and “deep ecology” have basic roots in ancient philosophies – e.g. the contribution of eastern thinking is documented in Daniels, (2005), Hall (1989), Hargrove (1989).

Here we focus on how long-standing systems of environmental resource management and their use of traditional ecological knowledge are yielding insights into current resource management problems. Cicin-Sain and Knecht (1995) review data on reconciling systems of traditional knowledge with modern approaches to the management of natural resources. They analyze implementation challenges that both regional and national-level entities will face as they endeavor to enhance the role of indigenous knowledge and participation.

The last 10 years have seen increase in the conservation projects incorporating indigenous and local knowledge into environmental monitoring projects. Danielsen et al. (2009) review several different types of locally-based monitoring approaches defined by their degree of local participation, ranging from no local involvement (with monitoring undertaken by professional researchers) to an entirely local effort (with monitoring undertaken by local people). Locally based monitoring is especially relevant in developing countries, where it can: (a) lead to rapid decisions to solve key threats affecting natural resources, (b) empower local communities to better manage their resources, and (c) refine sustainable-use strategies to improve local livelihoods.

Ecosystems are complex adaptive systems, and their governance requires flexibility and a capacity to respond to environmental feedback (Levin 1998, Berkes et al. 2000, Dietz et al. 2003). Carpenter and Gunderson (2001) stress the need for continuously testing, learning about, and developing knowledge and understanding in order to cope with change and uncertainty in complex adaptive systems. Knowledge acquisition about complex systems seems to require institutional frameworks and social networks nested across scales to be effective (Berkes et al. 2003).

Knowledge of resource and ecosystem dynamics and associated management practices exists among people of communities that, over long periods of time, interact for their benefit and livelihood with ecosystems (Berkes et al. 2000, Fabricius and Koch 2004). The way such knowledge is being organized and culturally embedded, its relationship to institutionalized, professional science, and its role in catalyzing new ways of managing environmental resources have all become important subjects (Kellert et al. 2000, Gadgil et al. 2000, Armitage 2003, Brown 2003, Davis and Wagner 2003). It has been suggested that the management and governance of complex adaptive systems may benefit from the combination of different knowledge systems (McLain and Lee 1996, Johannes 1998, Ludwig et al. 2001). Some attempt to import such knowledge into the realm of scientific knowledge (Mackinson and Nottestad 1998), while others argue that these knowledge systems are culturally evolved and exist as knowledge–practice–beliefs complexes that are not easily separated from their institutional and cultural contexts (Berkes 1999). There are those who question the role of traditional and local knowledge systems in the current situation of pervasive environmental change and globalized societies (Krupnik and Jolly 2002, du Toit et al. 2004), while others argue that there are lessons from such systems for complex systems management, which also need to account for interactions across temporal and spatial scales and organizational and institutional levels (Barrett et al. 2001, Pretty and Ward 2001), and in particular during periods of rapid change, uncertainty, and system reorganization (Berkes and Folke 2002).

The use of traditional and nontechnical knowledge by itself, in combination with modern scientific knowledge, and in the restoration of previously established property rights, is explored in several case studies. Pálsson (1995) considers the use of practical knowledge obtained by Icelandic fishing skippers in the course of their work, exploring how fishermen's knowledge differs from that of fishery scientists, and how the former could be brought more systematically into the process of resource management for the purpose of ensuring resilience and sustainability. A study of Cree Indians from the Canadian subarctic is presented by Berkes (1995), who analyzes the evidence regarding the distinctions of the local indigenous knowledge from Euro-Canadian, science-based wildlife and fishery management knowledge. The understanding of traditional knowledge for resource management has remained elusive, not only for development policymakers, but also for scholars engaged in such research. Traditional knowledge may be used to reestablish claims to former rights (Ruddle 1995). For the New Zealand Maori, traditional property rights have been recognized by customary law. The codification of existing rights and customary laws within a system of statutory law in various cultural settings is a contemporary process in many nations in the Pacific Basin, which might provide useful precedents for application worldwide.

Long et al. (2003) reveal that myths, metaphors, social norms, and knowledge transfer between generations of the White Mountain Apache tribe facilitate collective action and understanding of ecosystem dynamics, and provide a cultural foundation for adaptive management and modern ecological restoration. Watson et al. (2003) argue that traditional ecological knowledge serves an important function in the long-term relationships between indigenous people and vast ecosystems in the circumpolar north, and can contribute to understanding the effects of management decisions and human-use impacts on long-term ecological composition, structure, and function. Ghimire et al. (2004) assess variation in knowledge relating to the diversity of medicinal plant species, their distribution, medicinal uses, biological traits, ecology, and management within and between two culturally different social groups living in villages in northwestern Nepal. Devkota (2005) describes how traditional knowledge embedded in Nepalese forest communities enhances natural, social and economic simultaneously, and provides a practical example of strong sustainability. These local groups are not only meeting their present demand for natural resource services, but also seeking to increase their socio-economic and environmental resources for the future.

Becker and Ghimire (2003) show the important role of organizations such as NGOs, in bridging traditional knowledge and scientific insights, and in providing social space for mobilizing a synergy between traditional knowledge and western knowledge for sustaining ecosystem services and biodiversity in a Ecuadorian forest commons. Milestad and Hadatsch (2003) analyze the potential for organic farming in the Austrian Alps to flourish under the Common Agricultural Policy of the European Union in relation to the farmers' perspectives on sustainable agriculture, and whether or not organic farming and traditional practices are capable of building social–ecological resilience in the area.

4.2.5 Mechanisms linking humans and environmental resources

Linkages between humans and environmental systems operate in different ways according to their structure, the systems they link, and the process by which the linkage is made. Some linkages are constructed by the informal observation of environmental characteristics on the part of users, and the gradual evolution of behavioral response. Others are established as more rapid responses to change. In cases of environmental overuse, linking mechanisms are often weak or absent, cutting off the interaction between environmental condition and human response. The particular structure of a linking mechanism reflects the economic, social, and ecological context in which it is established. The structure determines what information will be monitored, how it will be monitored, and what will be done with the information once acquired. The key question is whether the governance system promotes or even allows behavioral adaptation to environmental change. Linkages affect both ecosystem and human system adaptation and evolution through the type of feedback allowed.

Folke and Berkes (1995) present a systems view of social and ecological interactions, which stresses the need for active social adaptations to environmental feedbacks and the use of traditional ecological knowledge. Particular attention is paid to the lessons that can be learned to assist in the design of more sustainable resource management systems -- improving their adaptiveness and resilience. Chopra (2001) describes the management of natural resources and the environment for livelihoods and welfare based on three empirical studies in India, to show that the endowment of social capital may be measured by how well individuals cooperate across the traditional division of institutions (state, market and non-market).

Berke and Folke (1998) look at management practices based on local ecological knowledge and offer the following guiding principles for designing management systems that build resilience in social-ecological systems: (1) "flow with nature," (2) enable the development and use of local ecological knowledge to understand local ecosystems, (3) promote self-organization and institutional learning, and (4) develop values consistent with resilient and sustainable social-ecological systems.

Nested forest tenure systems, fisheries, and joint farming–forestry systems, help to determine the function of linkages. Mexican resource tenure systems function as “shells” that provide the superstructure within which activities are developed and operate (Alcorn and Toledo 1995). Such shells are linked in very specific ways to the larger “operating system” in which the shell is embedded. The best course of action for promoting ecologically sustainable resource management is to support existing structures. Hammer (1995) focuses on the links between ecological and social systems in Swedish fisheries, especially in the Baltic Sea. He compares traditional small-scale and current large-scale management systems, in terms of how they promote linkages between social and ecological systems, and finds that large-scale systems are more vulnerable because of their failure to process ecosystem feedbacks. Pauly et al. (2002) discusses the evolving unsustainable fishing practices worldwide and looks at methods of creating sustainable world fisheries.

Social-ecological linkages help to analyse the broader parametric effects of fishing on the whole biotic and environmental system (Wilson and Dickie, 1995). The fundamental cause of overfishing lies in the social institutions that either cannot grasp the complexities of biological interactions, or have insufficient means to control the inputs. This institutional difficulty, combined with the uncertainty characterizing marine systems, suggest the appropriateness of a multilevel governance system that captures the social–ecological linkages on different scales. Pradham and Parks (1995) look at how the interactions between forests and subsistence agricultural systems in Nepal's villages are influenced by the activities of rural farming communities that depend on the forest for various subsistence products. Past government efforts to protect forest resources by excluding local communities have resulted in the opposite effect. Destruction of the social–ecological linkages at the local level has resulted in village residents perceiving forests as open-access resources, and this has led to further environmental degradation. Sastry (2005) examines the spatial dimensions of making development more sustainable in the mountainous Western Ghats region of India, from the economic, social and environmental perspectives. He proposes an integrated model which promotes three distinct forest ecosystems to operate at three different altitudes where three separate socioeconomic systems operate. The model helps to rejuvenate forests while maintaining ecological balance – based on the "unity in diversity" approach. Satake and Iwasa (2006) use a Markov model of social-ecological coupling to show that myopic decisions by private landowners will push entire landscapes towards agricultural use, although the forested state is more socially optimal. A long run management view and enhanced forest recovery is the remedy.

4.2.6 Poverty, population and natural resource use

Linkages among poverty, population and natural resource use are discussed here in the context of property rights. A broader discussion is provided in Section 2.3.5. The population policy literature reflects the current view that previous successes in family planning directed at the supply side of population growth, cannot be sustained without paying serious attention to reducing both the demand for births and the momentum of population growth (Bongaarts, 1994). Proposed policies include establishing formalizated systems of property rights to resources, in addition to education of women to enhance economic standing, and incentives to postpone childbearing to later years (Bongaarts, 1994; De Soto, 1993).

Dasgupta (1995) finds that population growth is in varying degrees linked to poverty, to gender inequalities in the exercise of power, to communal sharing of child-rearing, and to an erosion of the local environmental–resource base. These linkages suggest that population policy should contain not only measures such as family planning programs, improved female education, and employment opportunities, but also other measures to alleviate poverty, and provide basic household needs.

Jodha (1995) shows how poverty affects resource use behavior based on desperation. He argues that the current unsustainable pattern of resource use in the Himalayas is due to the replacement of traditional conservation-oriented resource management systems with more recent extractive systems. He examines the driving forces underlying this shift and discusses ways to restore some of the beneficial properties of the traditional systems.

Munasinghe (1997) shows that oversimplifying the complexities of the poverty-population-resource use linkage, could lead to inequitable and unwarranted conclusions. He argues that under appropriate circumstance, people may be considered a social resource that would complement and strengthen the natural resource base, and enhance economic prosperity – see Section 2.3.5. Grima (2003) examines agricultural practices in fragile lands and hill areas, to better understand the trade offs among development, poverty alleviation and sustainable use of natural capital.

4.2.7 Lessons learned and conclusions

Both general principles and specific social and ecological context play a crucial role in the design, implementation, and maintenance of property rights regimes for environmental resources.

Governance Systems: General principles of governance were discussed in relation to matching the scale and complexity of ecological systems with property rights regimes, ensuring that sets of rules are consistent across different levels of authority, distributing authority to achieve representation and contain transactions costs, and coordinaing between jurisdictions. Specific properties of governance were presented for limiting air pollution, managing a fishery, and enforcing regional environmental regulations.

Equity, Stewardship, and Environmental Resilience: General principles were discussed in terms of the relationship between equity, stewardship, environmental resilience, and efficiency in property rights regimes designed for a range of environmental resources. Specific interactions were analysed in the contexts of traditional systems for maintaining biodiversity in India, changing property rights to national parks in Poland, and mangrove–shrimp production systems in coastal Ecuador.

Traditional Knowledge: General principles of traditional knowledge were discussed in terms of the interaction between international environmental policy on the use of traditional knowledge and the implementation of local-level resource management systems that use traditional knowledge. Specific properties of traditional knowledge were presented in the contexts of practical knowledge about fishing in Iceland and Canada, and the restoration of Maori property rights in New Zealand.

Mechanisms linking humans and environmental resources: General principles of mechanisms that link humans to their environment were discussed in terms of their structures and the processes by which they allow humans to observe environmental change, adapt their behavior to reflect environmental change, and create knowledge in the process. Specific properties of linking mechanisms were presented in the contexts of forest tenure systems in Mexico, fisheries management in Sweden and elsewhere, and the interaction between agriculture and forestry in Nepal.

Poverty, population and natural resource use: General principles of the connection between population and poverty were discussed in terms of the intermediate linkages of gender equality, child-rearing practices, women's education, and general employment opportunities. Specific properties of the population–poverty connection were presented in the context of the relationship of population growth to poverty and unsustainable forest use. Simple generalizations may lead to wrong conclusions, because the poverty-population-resource use nexus is complex.

The diverse papers discussed in this section are woven together by a common thread -- the interaction of social and ecological systems through property rights to produce environmental outcomes. They show how the ecological context shapes human organization and behavior, and the human context in turn shapes ecological organization and response. The structure of governance, values of equity and stewardship, traditional knowledge, linking mechanisms, and conditions of poverty and population all form a part of that context. The analysis of property rights regimes confirms that the co-evolutionary path which humans and their environment follow (see Section 2.3) is indeed determined by the interaction of socioeconomic and ecological contextual elements.

4.3 ENVIRONMENTAL AND SOCIAL ASSESSMENT

Sustainable development assessment (SDA) used in the project cycle includes economic, social and environmental elements (Chapter 2). Economic (and financial) assessment relies on cost-benefit analysis (CBA) – see Sections 2.4.2 and 3.2.1. Below, we examine the other two key components of SDA, environmental and social assessment (EA and SA).

4.3.1 Environmental assessment (EA)

Most nations and donor agencies now incorporate environmental assessment (EA) into their decision making.

EA process

The EA process is a part of sustainable development assessment (SDA), to ensure that development options under consideration are environmentally sound and sustainable and that any environmental consequences are taken into account early in project design. In recent decades, EA has been adopted by most countries and international agencies, and evolved into a comprehensive instrument for making development more sustainable.

The breadth, depth, and type of analysis in an EA depend on the nature, scale and environmental impacts. The process (a) evaluates the potential environmental risk and impacts of a project in its area of influence; (b) examines project alternatives; (c) identifies ways of improving project selection, siting, planning, design, and implementation by minimizing, mitigating or compensating for adverse environmental impacts, as well as by enhancing positive impacts; and (d) follows up on managing environmental impacts during project implementation (World Bank, 1999).

EA examines the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and cultural property); and transboundary and global environmental aspects, in an integrated way. It also takes into account the variations in project and country conditions; the findings of country environmental studies; national environmental action plans; the country's overall policy framework, national legislation and institutional capabilities related to environment and social aspects; and obligations of the country under relevant international environmental treaties and agreements.

An EA should be initiated as early as possible in the project processing and should be integrated closely with the economic, financial, institutional, social and technical analyses of a proposed project (see Box 3.1). EA is most effective when preliminary findings are made available early in the preparation process. At that time, environmentally desirable alternatives (sites, technologies, etc.) may be considered, and implementation and operating plans can be designed to respond to critical environmental issues in a cost-effective manner. Later actions such as making a major design change, selecting an alternative proposal, or deciding not to proceed at all with a project, can become very expensive. Even more costly are delays in implementation of a project because of environmental issues, which were not considered during the design stage.

A range of instruments can be used to supplement the EA requirement: Environmental Audit, Strategic Environmental Assessment (SEA), Hazard or Risk Assessment, and Environmental Management Plan (EMP). Other complementary approaches like environmental cost accounting and life cycle assessment are used mainly in the private sector. EA procedures may also be applied to development activities broader than specific projects – e.g. an SEA can be adapted to regional or sectoral scales and used to assess impacts of sectorwide programs, multiple projects or development policies and plans. A regional or sectoral EA can reduce the time and effort required for many project-specific EA's by identifying issues and existing data in advance, or by eliminating the need for project-specific EA.

The process involves an analysis of the likely effects of a project or policy on the environment, recording those effects in a report, undertaking a public consultation exercise on the report, taking into account the comments on the report when making the final decision, and informing the public about that decision. The EA implementation plan should provide for frequent coordination meetings and information exchange between EA and feasibility study teams. Most successful EAs have thorough mid-term reviews. Most major concerns arise within the first months, and the rest of the EA period focuses on mitigating measures.

Implementation and supervision

Supervision ensures that measures to mitigate anticipated environmental impacts, to monitor programs, to correct unanticipated impacts, and to comply with any environmental conditionalities are implemented adequately. Procedures for startup and continuing operation of the project will normally specify these agreements as well as measures to protect the health and safety of staff. Proper staffing, staff training and procurement of spare parts and equipment to support preventive, predictive and corrective maintenance are also necessary elements of implementation.

Supervision could be carried out through a combination of the following: reports required on compliance with environmental conditionalities, status of mitigating measures, results of monitoring programs and other environmental aspects of the project; oversight by line agency with responsibility for the sector, and/or by environmental management, land use control, resource conservation, or permit-issuing agencies at the local, regional or national level; early warning about impending unforeseen impacts; supervision missions to review implementation of environmental provisions, corrective actions taken to respond to impacts, and compliance with environmental conditionalities, including institutional strengthening components; and site visits environmental specialists or consultants as required to supervise complex environmental components or respond to environmental problems.

Reporting on the environmental aspects should cover key data (e.g. violations of pollution standards), descriptions of impacts observed, progress on mitigating measures, the status of monitoring programs (especially those for detecting new impacts), progress on institutional strengthening, and adherence to environmental conditionalities.

At the conclusion of a project a project completion report is prepared and submitted, including a description of impacts that actually occurred, whether or not it was anticipated in the EA report, and evaluations of the effectiveness of mitigating measures and of institutional strengthening and training. The World Bank (1991) provides a checklist of major items.

Environmental auditing

Environmental audits have been developed as an instrument to analyse existing conditions at and around a specific site, the environmental risk it may cause, the environmental liabilities, and the degree of compliance with environmental standards and legislation. Users of such information are the companies themselves, customers, commercial banks, other lending institutions, local and national governments, and the general public. Environmental audits help to reduce environmental and public health risks, and assist in improving environmental management.

Environmental audits provide reliable environmental information on industries and other types of enterprises, in response to increasing public concern over the quality of the environment and stricter environmental legislation. It can be viewed as a 'snapshot' of the environmental situation at a given site. Audits can provide important input to the EA's analysis of baseline conditions, consideration of alternatives, and development of a mitigation plan for the existing impacts. Criteria may be based on local, national or international environmental standards, national laws and regulations, permits and concessions, internal management system specifications, corporate standards, or guidelines of organizations such as the World Bank (World Bank, 1995).

The environmental audit primarily uses existing documentation of the institution being audited, interviews with managers and personnel, and observation of practices at the facility. Spot checks in the form of tests and samples are often done to verify company compliance and the accuracy of information provided by the company.

Strategic environmental assessment

Strategic environmental assessment (SEA) is a promising approach to ensure that strategic-level policymaking takes account of sustainability principles (Wood and Djeddour, 1992). A number of countries have recently introduced elements of this approach, and more appear likely to do so. To date, however, practical experience with SEA of policies, plans and programs is limited, with critical issues yet to be resolved, such as the proposed scope of the approach, its role and relationship to other policy instruments in decisionmaking; and the appropriateness of relying of the methods and procedures of project EA. SEA overlaps with the analysis of economywide policies and the environment (see below).

Wood and Djeddour (1992) review the advantages of introducing SEA from two viewpoints: overcoming the limitations of conventional project EA; and promoting more integrated approaches for assessing and evaluating the sustainability of development policies, programs and plans.

Ecological and economic considerations must be treated on the same level and at the same time in decisionmaking. To promote the sustainomics principle of making development more sustainable (MDMS), all development options and activities must be adjusted to and be consistent with the "carrying capacity" of the global biosphere and regional ecosystems. Often, scientific understanding is inadequate to permit predictions of whether and when significant thresholds will be crossed (i.e. the point at which cumulative stress of use and activity will cause irreversible change or structural breakdown in natural systems (Kay 1991).

SEA extends the principles of EA to cover the development policies and plans that govern the conversion and depletion of natural capital. This basic approach must be coordinated with other strategies and instruments for environment-economy integration, including analysis of links between economywide policies and the environment (Chapters 3, 7, 8 and 9).

SEA may be seen as a means of incorporating sustainability. It is a process can help to: instill and integrate environmental goals and principles into the highest levels of policymaking; ensure that economic and fiscal agencies are responsible and accountable for the environmental consequences of their choices and actions; and promote long-term changes in attitudes and assumptions about economic growth.

Economy-wide policies and the environment

Since economy-wide policies (both macroeconomic and sectoral) have pervasive, powerful and long-lasting effects throughout a national economy, their environmental impacts need to be assessed. This is a complex exercise, described in Chapters 3 (see Section 3.7), 7, 8 and 9.

4.3.2 Social assessment

Social assessment (SA) is an important element of sustainable development assessment (SDA) – see Section 2.4.2. SA focuses on people, who are both the reason, and a resource for sustainable development. Culture, societies, and organizations are the foundation on which development programs rest. Peoples' varied needs, beliefs and expectations are factors which shape their response to development activities. In the past, these factors were often analyzed separately, and some key issues were overlooked.

The sustainomics framework recognizes that integrated, systematic social analysis can help ensure that projects are more sustainable and feasible within their social and institutional context. The sustainable development triangle in Figure 2.1 emphasizes that stakeholder participation in the selection and design of projects can improve decision making, strengthen ownership, and include poor and disadvantaged groups.

Social Assessments (SA) first emerged in the 1970s as a means to assess the impacts on society of development schemes and projects before they go ahead. It has since been incorporated into the formal planning and approval processes in many countries, in order to assess how major schemes may affect populations, groups, and settlements (Barrow, 2000).

IAIA (2003) states the following: "Social assessment includes the processes of analysing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions. Its primary purpose is to bring about a more sustainable and equitable biophysical and human environment."

Social assessment provides a framework for incorporating participation and social analysis into the design and delivery of projects (World Bank, 1995). SAs are carried to: (a) identify key stakeholders and facilitate participation in project selection, design, implementation, monitoring and evaluation; (b) ensure that project objectives and incentives are acceptable to all intended beneficiaries, and that social differences are taken into account in project design; (c) assess the social impact of projects, and determine how adverse impacts can be avoided, minimized, or substantially mitigated, and positive impacts maximized; (d) develop capacity to enable participation, resolve conflict, permit service delivery, and carry out socially sound mitigation measures; and (e) make projects more sustainable by strengthening the right institutions, overcoming constraints, and making micro-macro links.

SA's may also be included in poverty assessments and other economic and sector studies. SAs involve consultations with stakeholders and affected groups and other forms of data collection and analysis. Formal studies need to be carried when social factors are complex and social impacts are significant. Where there is considerable uncertainty due to lack of awareness, commitment or capacity, SAs can contribute to the design of projects which build on experience and are responsive to change.

The degree of stakeholder involvement needed also influences assessment design. In some cases stakeholders simply provide information and no further interaction is foreseen, but often projects are improved when issues are jointly assessed and agreed, or beneficiaries are given the responsibility for identifying problems and empowered to find solutions. Where local participation in project design and implementation is expected, participatory data collection and analysis can help build trust and mutual understanding early in the project cycle. Stakeholder Analysis involves the identification of key stakeholders; interests, influence and power; liability and risks; plan for stakeholder participation. It is important that findings be discussed with affected people to ensure that conclusions and recommendations are appropriate. Many methodological tools can be used when conducting SAs including quantitative surveys, qualitative methods such as beneficiary assessment, and participatory processes and workshops (World Bank, 1996b). It is the task of the SA team to identify which concepts apply and what methods and tools should be used to provide decision-makers with operationally relevant information.