PART 2

DIMENSIONS OF SUSTAINABILITY

Chapter 3

ENVIRONMENTAL ASSESSMENT FOR SUSTAINABILITY ASSURANCE

Many reputable scientists consider that environmental deterioration may be reaching critical thresholds beyond which there could be serious and irreversible loss of functions performed by natural systems. Despite recent advances, EIA and SEA fall short of realising their full potential as a means of providing greater environmental sustainability assurance (ESA) to development decision-making. ESA means that the critical resource stocks and ecological functions must be safeguarded, depletion and deterioration of sources and sinks must be kept within acceptable levels or safe margins, and losses of natural capital must be made good (Sadler, 1996a). This definition also encapsulates the conditions necessary for environmentally sustainable development (ESD). It is also in keeping with the World Bank operational definition of environmental sustainability of projects and activities (Box 3.1), articulated in 1991 but no longer in force as formal guidance.

Box 3.1: World Bank operational definition of environmental sustainability

1. **Output Rule:**
   Waste emissions from a project or action being considered should be kept within the assimilative capacity of the local environment without unacceptable degradation of its future waste absorption capacity or other important services.

2. **Input Rules:**
   a) Renewables: Harvest rates of renewable resource inputs must be kept within regenerative capacities of the system that generates them.
   b) Non renewables: Depletion rates of non renewable resource inputs should be set below the rate at which renewable substitutes are developed by human invention and investment.

Source: World Bank (1991)

A kit of policy concepts and tools for undertaking environmental sustainability appraisal are available and their potentials are discussed in this chapter. Four such approaches are identified in Goodland and Sadler (1996). These comprise envir onmental economics, environmental accounting, environmental assessment and sustainability principles and guidelines. Only the last two approaches are discussed in this chapter with a focus on their possibilities and limitations. Economic appraisal and its environmental dimensions are discussed separately in Chapter 4. However, when carried out together as part of a full sustainability appraisal of a proposal, these policy instruments need to undertaken as part of an overall, mutually reinforcing process for addressing environmental options and considerations of sustainable development.

3.1 Background: on the notion of limits

In utilitarian terms, environmental sustainability refers to biophysical capacity to assimilate wastes and regenerate raw materials. This is the baseline condition for sustainable development, since all forms of human activity are dependent on the maintenance of environmental sources and sinks. When these are reduced or impaired, so correspondingly are the options for development and ultimately the integrity of life support systems. By many accounts, current patterns of economic growth, based on continued or accelerated throughput of raw materials and energy, cannot be sustained indefinitely into the future and the world is moving inexorably towards the exhaustion and dispersion of a one-time inheritance of natural capital and biological diversity. From this perspective, environmental sustainability represents the baseline condition for sustainable development and it is being systematic ally liquidated, although some observors interpret the current situation quite differently (eg Ljomberg, 2003).

The notion of the limits to growth or development remains a sub-text of the sustainability agenda. Much of the discussion around this subject is coded rather than conducted openly (largely for reasons that date back to the response to the Club of Rome report (Meadows *et al.* 1972). A new analysis, 20 years later, indicates that fundamental resource and environmental trends are continuing to follow the very same trajectory that led to the initial warning of potential economic and social dislocation (Meadows *et al.* 1992). Similar warnings with regard to the health of major resource and ecological systems have been issued recently by UNEP, UNDP and the World Bank, amongst others. In some cases, resource or environmental constraints on human activities are all too clear. Example include where a fishery has collapsed or where agricultural lands are so degraded that they can no longer support food produc tion at previous levels. In many cases, however, the situation is not clear and there is considerable uncertainty or dispute surrounding the potential environmental impact of development trends, generally, or proposed plans and actions, specifically.

For present purpose, three examples will suffice to indicate the scale of concern about environmental limits or constraints on development:

Global change – human-induced change to the planet's systems and sinks is exemplified by climate warming.The capacity of the global atmosphere to assimilate carbon dioxide and other greenhouse gas emissions was once thought to be limitless. But the Intergovernmental Panel on Climate Change (IPCC) and other scientists now acknowledge that there are boundaries, even though they have yet to be translated into agreed caps and cutbacks by industrial countries (pace [??] the Kyoto Protocol, 1997). Although the environmental impacts of climate change are difficult to predict, aggregate potential changes noted by the IPCC include sea level rise, melting of the polar ice cap and alterations to arctic ecosystems (where average temperature may increase by more than 5°C).

Resource and ecological balances – there are major concerns about these balances in respect of food production, water supply [what in particular about these two?] and loss of biodiversity and natural habitat – they are considered to be precarious in many of the faster growing developing countries (World Bank 1999). Loss of biodiversity, primarily through the reductio n and degradation of natural habitat, represents the most pervasive and serious alteration to the existing ecological order. Species reduction rates are on a par with the five great extinctions of the geological past.

Decline of commercial fish stocks – according to the FAO, world fish stocks are being severely depleted by continued over-harvesting (ref?). Most of the major fishing grounds are reported to be in decline and major commercial fish species are near to or approaching exhaustion. In Canada's offshore areas, the collapse of the Atlantic cod fishery is the most visible example, but the catch of certain other species has also fallen nearly as sharply (with serious economic and social consequences, particularly in Newfoundland).

3.2 A framework for assessing environmental sustainability

The concept of sustainable development has become internationally accepted as a basis for addressing environmental issues and relating them to economic and social priorities. Basic aims and principles for implementing this approach were contained in the Rio Declaration on Environment and Development, Agenda 21 and other agreements from the Earth Summit and are updated in the Plan of Implementation concluded at the WSSD in Johannesburg (2002). With additions, these aims and principles provide a basis for defining the characteristics of environmental sustainability. They represent a first step towards a framework of criteria against which development trends, options and proposals can be assessed regarding their likely sustainability.

3.2.1 Basic concepts

Considerable work is being undertaken to define basic concepts for environmental sustainability, but, as yet, there are few widely agreed frameworks. The best way forward is to begin with certain "benchmark principles" which are robust enough for policy evaluation and to then elaborate their components. One starting point is the Brundtland definition of sustainable development (WCED, 1987).
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> "*Development that meets the needs of the present without compromising the ability of future generations to meet their needs.*"

Despite its limitations, this definition incorporates the fundamental checkpoints of intra-generational equity, or improving the welfare of all people, particularly the poor and disadvantaged; and inter-generational equity, or maintaining development options and opportunities for the generations who follow.

The principle of inter-generational equity is the omnibus test of whether or not development is sustainable. It requires that the next generation receive a stock of assets (resource potentials, created wealth, human capabilities) that is at least equivalent to our own, taking into account population growth (*sustainability rule number one*). In this context, special conditions are attached to the maintenance of natural capital by many environmental ecologists and resource policy analysts. Recently, considerable effort has been made to define environmental sustainability in operational terms. This work includes:

- the valuation of the stock of natural capital as a net measure of environmental sustainability;
- the delineation of system conditions for environmental sustainability as defined by the conservation of energy and matter and the processes of photosynthesis and cell biology;
- the delineation of boundary considerations for environmental sustainability as indicated by the main factors that determine the overall impact of human activity; and
- the identification of framework of guiding premises and principles against which the development proposals may be provisionally tested for environmental sustainability assurance.

3.2.1 Valuation of capital stocks

The first of the main avenues followed to define the concept of sustainability focuses on the value of the 'capital' stock(s) that should be passed from one generation to the next. Environmental economists have defined sustainability as improving capital stock and the range of opportunities that it represents for the next generation. In passing these on intact or adding to them, each generation meets the test of inter-generational equity (*sustainability rule number one*). The different types of capital are described in Chapter 4. Importance is accorded to natural capital depending on how relationships are interpreted and the environmental implications associated with the four levels of sustainability that can be identified (Box 3.2). Specifically, according to Serageldin and Steer (1994):

- *Weak sustainability* involves maintaining total capital intake without regard to its composition. Natural capital can and should continue to be converted into economic capital and output (goods and services) governed only be existing environmental policies, regulations and guidelines;

- *Moderate sustainability* requires that some attention is given to the level of capital as well. Natural capital is considered to be substitutable only up to certain critical limits – thresholds that are not yet known. The sensible approach is to adopt the precautionary principle to the use and conservation of natural resources;

- *Strong sustainability* means maintaining natural capital at current levels (no net loss). This implies resource losses and ecological damages resulting from development must be replaced or offset;

- *Absolute sustainability* means non-depleting and non-damaging use of natural resources. This would allow only the net annual increment of renewable resources could be used.

3.2.3 The Natural Step

The second of the main avenues followed to define the concept of environmental sustainability employs the basic laws of physics and ecology to provide a deeper understanding of nature's *a priori* conditions (or limits) for economic growth to continue indefinitely. As elaborated by Robert *et al.* (1997) [is this the same ref as in Box 3.2? – citation and dates differ??], four basic principles (or system conditions) must be fulfilled for the global population to achieve true or absolute environmental sustainability (see Box 3.2). These comprise three physical and ecological boundaries to the current path of development and a social component that is necessary to stay within them.

In brief, human conversion of energy matter (i.e. throughput of resources and raw materials) and the manipulation of ecological processes (e.g. photosynthesis) must be within the range of natural cycles and fluctuations and variations must not increase systematically (e.g. accumulation of heavy metals in soils, phosphorus in lakes, CO_2 in the atmosphere, chemicals in biota, reduction of biodiversity, soil degradation etc). These principles are pedagogical, i.e. formulated to describe what is non-sustainable and to emphasize the "sustainability gap" that has been opened by modern industrial society systematically violating fundamental laws of nature (principles 1-3, Box 3.2). Eventually, this widening gap will demand a fundamental shift in societal values (principle 4, Box 3.2) and, no less, in patterns of economic development.

Taking the Natural Step implies decreased use of fossil fuels, (principle 1), reduced flows of substances that persist in nature (principle 2) and sustainable use of land resources and maintenance

Box 3.2: Principles and system conditions for long-term sustainability

1. Substances from the Earth's crust must not systematically increase in nature. This principle deals with the exchange of materials between the lithosphere and the ecosphere (biosphere and atmosphere). It means that fossil fuels, metals and other materials must not be extracted faster than their slow re-deposition into the Earth's crust.

2. Substances produced by society must not systematically increase in nature. This principle addresses the substance chains that are produced by industrial society. It means that molecules and nucleides must not be produced at a faster rate than they can be broken down and reprocessed.

3. The productivity and diversity of nature must not be systematically deteriorated. This principle concerns the use of resources and the manipulation of ecological process. It means that society must not harvest more resources than are regenerated and maintain a surface area of nature with sufficient capacity to reprocess waste products and convert them to essential ecological functions.

4. Basic human needs must be met everywhere. This principle introduces the social component for attaining the resource metabolism defined by the three system conditions above. It means that resources and services obtained from nature must be used where they are needed most for a global population.

Source: Robert and Lathi (1996)

of high biodiversity to preserve the stability, resilience and integrity of ecosystems (principle 3). Significant progress on these fronts will be difficult, at best, and may be politically impossible in the immediate future. In reality, the emphasis of the Natural Step is on the strategies and actions that lead first to slowing and eventually stopping the continued undermining of the functions and diversity of nature (Holmberg and Robert, 1977). This position approximates to 'strong sustainability' as described above.

3.2.4 The IPAT relationship

The environmental impact (I) of human activity begins with resource exploitation and ends with pollution. The rate of 'throughput' of raw materials and living resources is a function of population (P) multiplied by affluence (A), expressed by per capita consumption. Generally, the greater the rate of throughput, the larger the environmental damage. However, technology (T) can moderate this relationship by reducing resource inputs and pollution outputs (the basis of the search for eco-efficiencies by industry). Thus, net environmental impact (I) can be summarized by the following relationship (Daily and Erlich, 1992):

Net environmental impact (I) = population (P) x affluence (A) x technology (T).

Other things being equal, environmental sustainability may be achieved by a small population living at a high level of per capita resource consumption or a large population living at a subsistence level. World population currently exceeds six billion and three-fifths live at subsistence or near poverty levels. Yet human activity is already estimated to use or pre-empt 40% of net primary productivity on land (Vitousek *et al.* 1986) - a proxy indicator of the scale of natural capital appropriation. Using this estimate, a near doubling of world population (P) and a proportionate increase in relative affluence (thereby multiplying per capita resource consumption) will place enormous pressure on resources and the environment, unless dramatic reductions in throughput are introduced by new technologies that lower resource inputs and waste outputs (see Box 3.3).

Box 3.3: The IPAT Relationship

The rate of throughput (Tp) of energy-matter determines the aggregate environmental impact (I). It does so, in accordance with the second law of thermodynamics, by converting energy-matter from a high quality (e.g. raw materials and living resources) to a low quality (waste and residuals) state. Throughput disperses the accumulated store of high quality energy matter (produced by solar energy and photosynthesis), thereby increasing entropy or disorder.

The net impact (I) of throughput (Tp) reflects three factors:

1. size of population (P);
2. level of affluence (A) or per capita consumption; and
3. state of technology (T), which is represented as a throughput intensity per unit of output.

Environmental sustainability occurs when the impact of throughput is within regenerative and assimilative capacities of natural systems. Where limits are being reached or exceeded, keeping throughput less than carrying capacity can be achieved only by one or a combination of the following factors:

- stabilise population;
- reduce per capita consumption;
- improve technology, thereby reducing throughput intensity.

Source: Goodland and Sadler (1996)

3.2.5 *Basic premises and principles for electing a standard for environmental sustainability*

Four premises of natural capital follow when the above concepts are related to the earlier discussion on resource and ecological impact of human activity:

- the 'source and sink' functions provided by natural systems are finite and irreplaceable;
- their maintenance constitutes the baseline condition for sustainable development;
- natural capital - the raw materials and ecological services that were once considered 'free goods' - is now limited in relation to the size of the world economy; and
- it will become limiting on economic and population growth where these are based on the increasing throughput of raw materials.

Once accepted, these premises provide a compelling basis for electing a "standard" of *strong sustainability* as a reference point for environmental assessment for sustainability assurance. This involves treating natural capital as valued and scarce, preferably as a general policy, but certainly in conditions where resources are threatened or species are at risk. It would require development options and proposals to meet strong sustainability rules 1, 2 and 3 (Box 3.4)):

Box 3.4: Strong sustainability rules

1. Avoid irreversible or environmentally significant changes.
2. Adopt a strict version of the precautionary principle for actions that potentially affect critical ecological functions, species or habitats.
3. Adopt the no net loss principle (NNL) to maintain natural capital at or near current levels.

Supply side principles for maintaining natural capital

4. Renewable resources should be depleted (harvested or used) at a rate equal to their regeneration.
5. Waste emissions should not exceed the assimilated capacity of the environment or cause harmful effects to human health.
6. Conserve biological diversity comprising the variability of ecosystems, species and gene pools, paying particular attention to red-listed species.

Demand side principles for maintaining natural capital

7. Apply the precautionary principle, using a strict form where there is the potential for serious or irreversible losses and weaker versions where there is not.
8. Apply the polluter pays principle to all actions that cause resource losses or environmental damage as an adjunct to the precautionary approach.
9. Give priority to anticipate and prevent strategies.
10. Reduce or eliminate environmentally perverse subsidies.
11. Avoid conversion to higher intensity uses.

Sources: complied from Sadler 1999, World Bank, 1991; UN Convention of Biological Diversity, 1992; IUCN, 1994.

3.3 Environmental sustainability principles

In order for the NNL to become operational, environmental impacts must be avoided, fully mitigated or otherwise offset by providing an equivalent or appropriate replacement for residual damage. A series of supply- and demand-side principles for sustainable development are available for this purpose. On the supply side, the emphasis is on carrying capacity, biodiversity, ecosystem integrity and similar concepts that identify limits or thresholds of acceptable change to natural and managed systems. On the demand side, this limitation is addressed by taking a precautionary approach to avoid serious environmental damage.

3.3.1 Supply side principles

As noted above, World Bank policy initially called for development options and proposals to be environmentally sound and sustainable, such that “each project effecting renewable natural resources (e.g. as a sink for residues or as a source of raw materials) does not exceed the regenerative capacities of the environment” (World Bank 1991, 51). An output guide elaborates this principle for waste emissions and an input guide addresses harvest rates for renewable resources. These guides or ‘rules of thumb’ are widely accepted and accord generally with the *World Conservation Strategy* (IUCN/UNEP/WWF 1980) and its update, *Caring for the Earth: A Strategy for Sustainable Living* (IUCN/UNEP/WWF 1991) and other documents. If applied, they go part of the way to addressing the three system conditions for sustainability described in Box 3.2 and can be adopted as the basis of *strong sustainability rules 4 and 5* (Box 3.4).

These ‘rules’ provide indicative guidance for resource management strategies but are difficult to measure or validate until environmental loss or deterioration actually takes place, as the recent collapse of the Atlantic cod fishery demonstrates. Typically, the supply-side approach estimates optimum annual rates for particular renewable resource stocks, such as fish or timber. In reality, maximum sustained yield is highly approximate because the ecology of the resource is not understood, i.e. the marine system as compared to stocks of fish. Natural and managed ecosystems are complex and dynamic, with periodic instability, random or stochastic events and surprising situations (Holling, 1991). Scientists have limited ability to predict these systemic ecological changes, or those that will occur as a result of specific development actions.

Resource managers and fisheries scientists should (or do) address uncertainty pragmatically rather than precisely, i.e. by erring on the side of conservation and forgoing maximum productivity. This strategy, inter alia, helps to ensure ecosystems have sufficient integrity (or self-organising capacity) to maintain their structure and function in the face of stress (resilience). Biodiversity is a key property of the resilience of ecosystems and its conservation constitutes *strong sustainability rule number 6*, underpinning the rules 1-5 (Box 3.4). The UN Convention on Biological Diversity provides a global framework for this purpose;. Its objectives are to conserve biodiversity at ecosystems, species and gene pool levels, to promote sustainable use of living resources and to encourage fair and equitable distribution of the benefits derived form their use. Within this framework, particular attention must be directed to ensuring no further decline in the number of threatened and endangered species as classified in the *IUCN Red Lists* (IUCN 1994).

3.3.2 Demand side principles.

On the demand-side, the precautionary principle is a key to applying the NNL principle. The use of the precautionary principle is now the international standard to guide decision-making where there is scientific uncertainty (Principle 15, *Rio Declaration on Environment and Development*). It is a powerful counterweight to address and manage downside environmental risk and constitutes *strong sustainability rule number 7* (see Box 3.4). Often, however, the operational implications of the precautionary principle are misunderstood (see Appendix 2 for further discussion).

A strict precautionary approach will avoid all actions that might cause serious or irreversible environmental damage. Weaker versions involve maintaining safe margins, requiring the use of best available technology or highest environmental standards, or applying EIA, cost-benefit analysis and other types of policy appraisal. Four interpretations of the precautionary principle are set out below. These identify how a disciplined and discriminatory precautionary approach might be undertaken in support of the NNL principle (Young 1993):

- When the cost of degradation may be serious or irreversible and/or there is little prior experience or scientific confidence about the outcome, the strict precautionary principle should be followed.

- When the cost of degradation may be serious but reversible, maintain a large safety margin and require the use of EIA and best available technology.

- As confidence with the activity increases, allow a transition to use of best available technology that does not entail excessive cost (BATNEEC).

- Finally, when the threat of environmental damage or irreversible loss is neither irreversible nor perceived to be serious, use standard rules and regulations.

In addition, there are several variants or extensions of the precautionary principle, which address the causes of environmental damage at source and thus support and reinforce the NNL principle. These may be seen as *adjuncts to strong sustainability rule number 7* (see Box 3.4) and include:

- promote "anticipate and prevent" actions which are cheaper and less risky than "react and cure", e.g. for fisheries management;
- reduce and eliminate environmentally perverse subsidies and taxes, e.g. that artificially induce development at the expense of natural habitat;
- as far as possible, avoid the unnecessary conversion of land from less intensive to more intensive use, which is pervasive cause of habitat and biodiversity loss, e.g. build on brownfield rather than greenfield sites.

Finally, the polluter pays principle should be applied such that all types of resource loss and environmental damage are internalised, e.g. in the case of loss or damage to fish habitat from timber harvesting. This represents a prescribing or triggering rule for no net loss of natural capital and constitutes *strong sustainability rule number 8* (see Box 3.4). Simply stated, all environmental losses incurred through needed economic activity require equivalent "in-kind" compensation, either like-for-like replacement of lost habitat or resource values, or, where this is not possible, a comparable offset (e.g. reforestation to sequester CO_2 emission). The application of an impact offset protocol (or an equivalent tool) for all actions taken by governments, requiring their approval or involving public investment, is necessary to implement the other strong sustainability rules

3.4 Approaches and tools for assessing the environmental sustainability of development

Recently, tools which aim to for assess the environmental impact of developments within a sustainability framework have received more attention. These include both retrospective and proactive approaches. In the first category, ecological footprint analysis is increasingly used to sharpen perspectives on the aggregate impact of human activities on an individual, city-wide or national basis; and also to examine the dramatic differences that are found between, and to a lesser extent within, developed and developing countries. Also in this category are various types of sustainability audits. These cover the environment either specifically or in part (see Chapters * and *). In the second category, EIA and SEA represent major entry points for environmental sustainability assurance as described earlier (see Table 3.1). This is an area of increasing interest and experimentation, but, in practice, they are not yet applied within explicit sustainability frameworks as described above,

Table 3.1: The evolving paradigm -- from EA to ESA and SA

Paradigm/Level/stage	Key characteristics – post Rio
First generation – project level EIA	Includes social, health and other impacts, cumulative effects and biodiversity
Second generation – SEA	Applies to policy, plans, programmes and legislation
Next generation 1– toward environmental sustainability assurance (ESA)	Applies to policy, plans, programmes and legislation
Next generation 2 – toward sustainability appraisal (SA)	Integrated or full cost assessment of the economic, environmental and social impacts of options and proposals

3.4.1 Ecological footprint analysis

The ecological footprint provides a macro framework and approach to impact accounting. It expresses the IPAT relationship as a single number – the hectares of productive land and water required to produce the resources consumed and to assimilate the wastes generated by a given population using prevailing technology (see Rees and Wackernagel, 1995; Wackernagel, 1999; Wackernagel and Rees, 1996). This figure can be used to compare the differential impact of countries on the environment or to illustrate hypothetical global ecological deficits (or surfeits), expressed in the gap between the average ecological footprint and the per capita capacity of the biosphere. For example, the ecological footprint of the average Canadian is calculated at 7.2 ha, compared to a world average of 2.4 ha and an estimated available capacity of 2.1 ha – of which 0.5 ha are biologically productive ocean space (Wackernagel, 1999).

Various methods used to calculate an ecological footprint. All tend to underestimate the size of a footprint. The total footprint of the world population exceeds the estimated carrying capacity of the Earth, a condition known as overshoot (which can continue only for a limited time). Such comparisons are instructive; a striking metaphor of the scale of our draw down of natural capital and the policy adjustments that may be needed. As an aggregated indicator, ecological footprint analysis is not a decision-making tool per se. However, it does lend itself to policy scenarios and, for present purposes, the scale of the human ecological footprint underscores the real value of natural capital.

[MORE TO BE ADDED HERE]

3.4.2 Strengthening EIA and SEA as sustainability instruments

EIA and SEA are key mechanisms for applying the framework of sustainability described above. This framework identifies supply-based principles against which development proposals can be generally tested for their conformity with criteria for achieving strong sustainability (weaker versions of sustainability may also be used). On the demand side, the precautionary principle guides the application of EIA and SEA and the polluter pays principle underpins the argument for impact compensation or remedy for residual damages. In this scheme, EIA and SEA are concerned with maintaining the capacity and integrity of natural systems rather than minimising impacts. The key argument made here is that sustainability assurance is best achieved by an impact compensation protocol that can be applied to all types of development decision-making, using EIA and SEA as front line instruments to identify and remedy environmental effects.

From this standpoint, three measures have been proposed to sharpen EA as a sustainability instrument (Sadler, 1996):

- (re)focus on environmental `bottom lines' with particular reference to environmental standards and safe margins;
- evaluate the `acceptability' of potential environmental effects against the composition and value of natural capital stock, paying particular attention to critical resources and ecological services; and
- require `in-kind compensation' for the residual impacts (i.e. those that cannot be mitigated or avoided) for all acceptable development projects and activities.

More than any other single measure, the incorporation of the 'no net loss' criterion is the single most important measure to upgrade EIA and SEA as sustainability instruments. The criterion can be readily introduced as a mitigation requirement. No net loss principles are already widely applied in fish and wildlife management; for example, in the US and Canada. Undoubtedly, this type of asset-trading and replacement will be crude and imprecise. As such, impact compensation will need to be promoted and implemented pragmatically, not least because it will be seen as onerous by proponents.

In order to convert EIA and SEA from tools for impact minimisation to instruments for achieving sustainable development, it will be necessary first to sharpen current approaches so that they better compensate for the conversion of natural capital. Environmental impacts may be thought of as a draw-down of natural capital which must be offset by an equivalent investment in resource conservation, rehabilitation or enhancement (Sadler and Jacobs, 1990). In-kind impact compensation measures as well as conventional mitigation terms and conditions should be applied to non-conforming development activities (i.e. those that do not meet the no-net loss of natural capital rule). For example, CO_2 emissions from a coal-fired generating station may be offset by carbon sequestering through forest planting, or habitat losses may be set aside by off-site rehabilitation and restoration.

The point here is not to grasp a theory of the impossible but to promote the art of the practical by creatively employing "best guess" science to implement values and actions that help guarantee sustainability. Few development proposals would go forward under a strict criterion of non-liquidation of natural capital. Natural capital, however, is an aggregate concept that refers to multi-function ecosystems rather than to single resources or specific sites. It is most appropriately operationalised at a net or programmatic level (Pearce, Markandya and Barbier, 1989) and in a bio-regional context (Sadler and Jacobs, 1990). At this scale, there is greater latitude for imaginative natural asset trading, supported and disciplined by strategic environmental assessment.

The crucial issue is how to start. We begin with three immediate practical steps:

Step I: Tiering Environmental Assessment

The concept of tiering (i.e., vertical integration) EA refers to a sequential process of addressing issues and impacts at the appropriate level of effort required for informed decision-making. To a degree, existing EA systems are tiered already. For example, screening procedures identify the level of examination necessary for different types of projects and classes of activity. In principle, extending this approach to focus and coordinate SEA and EIA as complementary processes should be cost-effective and pay sustainability dividends. Figure 3.1 illustrates key elements and relationships of this system. However, practical experience with tiering is still limited; and few jurisdictions currently apply this approach comprehensively (eg as in the United States).

Insert Figure 3.1

The tiering of SEA and EIA facilitates a systematic review of key issues including justification, alternatives and mitigation (as illustrated for energy in Figure 3.1). Each stage establishes on-going requirements and directions for the next phase of analysis. The decision-making "staircase" (the linear boxes in Figure 3.1) is framed by a portfolio of economic policies (the horizontal boxes in Figure 3.1) - which also will be subject to SEA. A comparable group of environmental policies (the vertical boxes in Figure 3.1) provides an initial benchmark against which reviews may be conducted. This framework corresponds with a disciplined, adaptive approach to EA – one that permits a certain degree of substitution of effort between different levels. In reality, the conditions for implementing a tiered approach either may not be in place, or only partially developed, e.g. integrated river basin management plans which facilitate disciplined locational trade-offs.

Step 2: Refocusing the EIA and SEA process

The following steps indicate how SEA and EIA components may be used to approach environmental sustainability (Sadler, 1994):

i) screening economic and development policies for their conformity with sustainability goals and principles;

ii) preliminary assessment of environmental costs of development programmes to identify low-impact, resource-efficient energy, transportation and other sector strategies;

iii) area-wide assessment to establish resource values and land use capabilities for regional development; and

iv) project EIA to identify in-kind compensation for natural capital losses (e.g. offsetting residual fish and wildlife losses by ex-situ habitat rehabilitation and enhancement).

Step 3: Linking EIA and Other Policy Instruments

EIA and SEA should be linked (or horizontally integrated) more closely with other policy and planning instruments. Once in place, these linkages could provide an initial basis for full cost-accounting and informed decision-making in support of sustainable development. Following the work of Costanza (1991) and others, we define this orientation as attempting to make local, short-term economic goals and actions consistent with global long-term, ecological constraints; and also recognise that this bio-centric perspective subsumes ethical questions about fairness of access to resources and distribution of benefits.

For present purposes, we emphasise three emerging instruments that promise to advance an integrated approach to environmental sustainability and also to provide a coherent context for SEA and project EA:

- national sustainable development strategies,

- bio-regional planning, and
- ecosystem approaches.

National strategies for sustainable development (NSDS)

Agenda 21 (UNCED, 1992) called for all countries to develop NSDSs. These were intended to translate the ideas and commitments of the Earth Summit into concrete policies and actions. More recently, the WSSD Plan of Implementation recommitted governments to "take immediate steps to make progress in the formulation and elaboration of NSDS and begin their implementation by 2005". It is now accepted that an NSDS should improve the integration of social and environmental objectives into key economic development processes. The OECD DAC (2001) has defined an NSDS as

> "*A co-ordinated set of participatory and continuously improving processes of analysis, debate, capacity-strengthening, planning and investment, which seeks to integrate the short and long term economic, social and environmental objectives of society - through mutually supportive approaches wherever possible - and manages trade offs where this is not possible*"

The OECD also established a set of principles for NSDSs. Building on these UNDESA (2001 a,b) established number of characteristics common to NSDSs in both developed and developing countries. These principles and characteristics can be summarised as:

- Integration of economic, social and environmental objectives;
- Coordination and balance between sector and thematic strategies and decentralised levels, and across generations;
- Broad participation, effective partnerships, transparency and accountability;
- Country ownership, shared vision with a clear timeframe on which stakeholders agree, commitment and continuous improvement;
- Developing capacity and an enabling environment, building on existing knowledge and processes;
- Focus on priorities, outcomes and coherent means of implementation;
- Linkage with budget and investment processes;
- Continuous monitoring and evaluation.

An NSDS may best be viewed as a system comprising various components:

- Regular multi-stakeholder fora and means for negotiation at national and decentralised levels, with links between them;
- A shared vision, developed through such fora, incorporating broad strategic objectives;
- A set of mechanisms to pursue these objectives in ways that can adapt to change (notably an information system with key sustainable development indicators; communication capabilities; analytical processes; international engagement; and co-ordinated means for policy coherence, budgeting, monitoring, and accountability);
- Strategic principles and locality- or sector-specific criteria, indicators and standards adopted by sectors and stakeholders, through legislation, voluntary action, and market-based instruments, etc.;
- Pilot activities – from an early stage – to generate learning and commitment.
- A secretariat or other facility, with clear authority and powers, to co-ordinate these mechanisms;

- Finally, a mandate for all these activities from a high-level, central authority such as the prime minister's office and, to the extent possible, from citizens' and business organisations.

Land use and resource planning

Land use and resource planning is a key instrument for bio-regional integration of environment and economic objectives, and by extension, the implementation of NSDS. By definition, the aim of this approach is the efficient allocation of competing demands on the resource base, and the protection of natural areas and sites of special sensitivity or significance. This is usually done through some form of zoning scheme, based on resource assessment or ecological land classification. Regional planning is undertaken at various geographic scales (approximately 1:50,000 to 1:250,000) and applied to natural unities (e.g. watershed, ecosystems), administrative jurisdictions (e.g. metropolitan areas) or some combination (e.g. forest management district). As such, this process facilitates land and resource management towards carrying capacity, optimising the mix of multiple uses, and monitoring of cumulative environmental effects.

Ecosystem approaches

An ecosystem approach is promoted in a number of countries, for example Canada and the USA. The suite of instruments that are used for this purpose span both ex ante and ex post approaches. Box 3.5 discusses four tools that are used, or are potentially applicable for, strategic level ecosystem assessment.

Box 3.5: Ecosystem frameworks and approaches used in Canadian planning and decision-making

A number of ecosystem approaches and frameworks are used to support Canadian land and resource use planning. They have a particular role and contribution in the context of EIA and SEA for sustainability assurance.

Ecological land classification (ECL) delineates and differentiates surface areas on the basis of their spatial association of natural features (e.g. climate, landforms, water, flora and fauna). The national ecological classification framework for Canada (completed in 1996) is organized as a hierarchy of 15 ecozones (major terrestrial systems). These are sub-divided into some 50 eco-provinces, nearly 200 eco-regions and more than 1000 eco-districts (or land resource areas) with a minimum size of approximately 1000 km^2. It supports an ecosystem approach to land and resource planning at a scale appropriate to purpose (see Ecological Stratification Working Group, 1996; Marshall and Schut, 1999) and supplements more specialized inventories (e.g. for soil, forests or wildlife).

State of the environment (SOE) reports bring together a large body of data and information on current trends and issues affecting the environment and natural resources (and may be seen as a retrospective and generalized form of impact statement). In Canada, SOE reports have been discontinued at the national level but continue to be issued on an ad hoc basis for major ecosystems (e.g. Boreal shield) or specific resources (e.g. water and forest health). The last national report highlighted, inter alia, the environmental changes occurring in the major ecozones (above) and described progress towards or away from environmental sustainability (Environment Canada, 1996). It provides a useful but now dated reference standard for SEA and land use planning.

Biodiversity assessment identifies 'hot spots' or areas with a high concentration of landscape or species diversity or important gaps in their representation in protected areas. In Canada, a number of studies are underway to address 'time limited' opportunities for biodiversity conservation, e.g. as outlined in a 'state of the debate' report by the National Round Table on Environment and the Economy (2003). This report emphasises the importance of planning for whole landscapes to maintain natural capital as part of resource use and development (as well as to ensure representation in protected areas), particularly in the large swathe of still intact boreal forest in Canada (see also Lee et al., 2003). In addressing threats and risks for all or part of such regions, biodiversity assessment provides early warning of potential cumulative effects and, by extension, a framework for the conduct of SEA of/for land use plans.

Ecological footprint analysis *(EFA)* estimates the area of biologically productive land and water (bio-capacity) needed to supply the resources consumed by a given population and assimilate the waste generated (using current technology). It is a proxy measure of the sum of our ecological impact, estimated as appropriated space relative to bio-capacity available nationally (14.25 ha per capita) or globally (1.9 ha per capita). This approach, for example, has been used to compare the ecological footprint of Canadian cities, which range from 6.87 to 10.33 ha per capita (Anielski and Wilson, 2003). As a macro indicator of sustainability living, EFA has gained some currency as a general policy tool (City of Toronto, 2004) but specific applications to land use planning have yet to occur.

In practice, however, the potential of regional planning as a sustainability tool remains to be fully realised (see Richardson, 1989). To that end, certain adjustments to conventional theory and practice are necessary, including:

- recognition of land as living community that requires "the exercise of an ecological conscience";
- adoption of an ecosystem approach to planning and management;
- coordination with EA and impact management; and
- specification of these changes in policy guidelines and objectives.

Recent developments along these lines are exemplified by innovations in Australia, Canada and New Zealand – three Commonwealth countries which have imported and adopted elements of the UK town and country planning system. For present purposes, the New Zealand experience is particularly instructive [thus we need to refer to a case or box here?].

[MORE TO BE ADDED]

3.5 Precautionary guidelines for integrated environmental management (IEM)

As described above, a precautionary approach is the best guarantee of environmental sustainability. It represents a form of insurance against risk, which is an event with a known or statistical probability, and a "best guess" hedge against uncertainty or indeterminacy, which is an event with unknown probability (see Appendix 2). For example, car driving involves risks which can be calculated and converted into automobile insurance rates. Living near a toxic chemical dump entails a potential health threat, (e.g. from long term "low dose" exposure) that cannot be statistically expressed. Most environmental problems are characterised by uncertainty rather than risk (Costanza and Cornwell, 1992), and are compounded by the different interpretations of the severity of threat. As noted earlier, the prudent stance is to minimise risk.

These points underline the fundamental importance of a precautionary approach to environmental law, policy and management. We elaborate three principles for institutionalising this approach:

i) establish safe minimum standards;

ii) harness the market to environmental service, to the extent possible; and
iii) enforce regulatory compliance and liability for damage.

3.5.1 Safe minimum standards

The notion of safe minimum standards to maintain the assimilative and regenerative capacity of the environment is well-established (e.g. ambient air and water quality indices). It is also recognised by resource economists as a means of avoiding irreversible environmental loss and change. Not all economists accept the main premise of putting the onus on preservation rather than development options (unless it can be reasonably proven that the use benefits foregone are unacceptably large). At issue here is the extent to which irreversible losses are or may soon become a pervasive feature of development (Pearce and Turner, 1990) and so, by definition, cannot be compensated, restored or otherwise offset (e.g. by natural recovery within 10-100 years). Exhaustible resources are a special case in this respect.

Because we are near, at or may even be transgressing, critical ecological thresholds, universal safe minimum standards need to be applied to key dimensions of environmental sustainability. The principles listed earlier are illustrative. They reflect the concept of maintenance of natural capital. Much more needs to be done to negotiate these limits and to enshrine them in national resource and environmental policies and in international agreements on global and trans-boundary concerns, such as greenhouse gases and acid rain. Despite their flaws, the conventions and accords reached at the 1992 Earth Summit and at WSSD in 2002 provide a superstructure for moving ahead internationally on IEM.

3.5.2 Harnessing the market

Once set through the policy process, safe minimum standards can be implemented using various measures, including ,but not limited to, environmental assessment. Sustainability assurance can also come from eco-efficiency regulations and incentives. Traditional "command and control" regulatory structures are under increasing attack. In their more rigid form of specifying means as well as ends, they have been discredited for some time. Market-based approaches to environmental management are now widely promoted as an alternative; notably by the private sector. So far, the main thrust is toward improved efficiency and continued technological innovation in meeting required levels of environmental quality. But there is no reason, in principle, why market incentives cannot also produce fairer distribution of resources and opportunities or support the greening of trade and taxation (see Costanza, date and ref).

In practice, the application of market-based approaches is relatively cautious, small-scale and limited mainly to the USA. There, there have been mixed results from the initial launch of emission charges, product levies, green taxes and other economic instruments (Sadler, 1992a). Recent proposals for expanding their use, especially in the United States, should further test their appropriateness for supporting environmental sustainability. A carefully watched development will be a system of tradeable permits for the Los Angeles region. This allows polluters to trade or sell the credited difference between the upper permissible and actual emission limits established under an air quality "bubble". It will demonstrate the practicality of allocating geographic and time frames for tradable credits and exchanges and enforcing of violations.

3.5.3 Regulatory enforcement and damage liability

Safe minimum standards are just that; guidelines for avoiding significant or irreversible impairment to the source and sink functions performed by natural systems. In effect, they represent the substrate or foundation of environmental sustainability which is given effect by environmental law and regulation, implemented through monitoring and enforcement, and backstopped by secured liability for loss and damage. Recently, the trend has been toward more stringent environmental legislation with stricter penalties for violations. This has been driven by problems and risks – notably an earlier generation of major industrial accidents such as Bhopal and Exxon Valdez, and the problems of so called "orphaned" mine tailings, waste dumps and other contaminated sites. Business and industry have also responded to these trends by establishing guidelines and codes of practice for environmental performance that point beyond regulatory compliance to "no regrets policies" for pollution prevention, contingency planning and life cycle stewardship.

The mining sector is making considerable efforts to address the challenges of sustainable development. The international Mining, Minerals and Sustainable Development (MMSD) project (2000-2002) was coordinated by the International Institute for Environment and Development under commission from the World Business Council for Sustainable Development (WBCSD) and on behalf of a group of the world’s major mining companies. This initiative is discussed in Chapter 11 (section 11.3). MMSD recognised the need for integrated impact assessment which “should include all significant social, economic and environmental issues”. MMSD work undertaken in North America developed a Seven Questions framework as an example of an integrated assessment framework that goes beyond ‘impacts’ (Box 11.4). The framework is intended as guidance to operators, owners, investors, insurers, communities, indigenous people, NGOs and others.

Such guidelines, codes and frameworks now need to be applied to more pervasive cumulative effects from multiple sources and activities, which cut across industry sectors and the regulation of air and water pollution. Loss and degradation of wetlands and other valued habitats are well documented cases. A customised mix of economic and regulatory instruments is needed to ensure wetlands are appropriately valued and protected for the ecological functions and services they provide (Pearce and Turner, 1990). Under the safe minimum approach, for example, a contiguous area of a high value wetland landscape would be set aside sufficient to maintain its core function. In other zones, water quality would be maintained through land use and water discharge controls. Licensing and incentive schemes could be used for this purpose, with environmental assurance underwritten by fiscal premiums for damage and legal penalties for persistent or deliberate offenders. Secured liability, perhaps through the bonding system for worst-case damage proposed by Costanza and Cornwell (1992), represents an important "bottom line" for implementing the precautionary principle. But it is not clear how this approach can be monitored and instituted for a large number of small users compared to a small number of large industries. Ultimately, the maintenance of natural capital likely requires a more flexible, conditional system of resource use and property rights.

3.6 Conclusions and recommendations

The main premises of this chapter are that:

- maintaining the "source and sink" functions of the environment constitute the enabling condition of sustainable development;

- natural capital is now constraining; and
- present rates and scales of ecological change warrant immediate action.

In the near term, we consider the following to be priorities for environmental sustainability research and development:

- substantiate the concept of maintenance of natural capital for types of near natural and managed systems, e.g. in the form of precautionary rules of thumb for substitution or restoration;

- sharpen the framework of principles and criteria of environmental sustainability, e.g. safe minimum standards, ambient air and water quality indices, and loss and health of target species;

- pilot test the demonstration of policy tools, e.g. employ facilitated negotiation to resolve issues of impact analysis and evaluation and/or assist environmental and economic trade-offs; and

- capitalise on practical opportunities for "learning by doing", e.g. designate "projects as research and management experiments", monitor and evaluate policy and planning initiatives, etc.