Annex 1: Analytic Framework for Assessing Factors that Influence Sustainability of Uses of Wild Living Natural Resources

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Foreword

IUCN – The World Conservation Union, is an international organization whose members include governments, government agencies and national and international non-government organizations (NGOs). IUCN's Commissions provide a forum for scientists and specialists to participate. The Secretariat develops and supports a number of technical programs and represents the interests of the Union. The strength of IUCN is in its members, networks and associates which allows them to increase their capacity and form alliances that permit them to act at a local, national or global level.

The mission of IUCN is "*To influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.*". The concept of sustainability, in this mission statement refers to the use of living natural resources in reasonable proportions that fall within the capacity of the resource to reproduce. Sustainable development implies an improvement in the quality of life, while maintaining the carrying capacity of those ecosystems that sustain this development. In summary, sustainable development implies promoting the wellbeing of people as well as species, and likewise, of ecosystems. IUCN has called upon the societies of the world to use living natural resources in a sustainable manner and to equitably distribute the benefits derived from this use.

The IUCN SSC Sustainable Use Specialist Group (SUSG) has made an effort to identify the factors that influence or affect sustainability of the use of living natural resources. In order to facilitate an understanding of how this relates to other factors, during its meeting held in June 1998 in Guatemala, the SUSG Steering Committee proposed the establishment of a Committee to organize input from other discussions and develop an Analytic Framework aimed at understanding the factors that influence sustainability of uses of wild living natural resources.

The Technical Advisory Committee (TAC) was established with members from different fields and comprising specialists in sociology, economics, ecology, agro-ecology, wildlife management and statistical methodologies to work on developing an Analytic Framework to be used as a tool for project and public policy designers, implementation agencies and evaluators of projects to determine if a use is or has a probability of being sustainable. To achieve this, systems were developed to analyze economic, population, socio-political, management, and biological factors influencing uses of wild living natural resources. These factors are separated into variables with quantifiable indicators that provide a measure of the degree of sustainability of a particular use.

TAC's greatest contribution is, perhaps, to have made the effort of going beyond the local use level and to focus the analysis on the broader context in which socio-political and cultural factors directly affect those human populations that make use of the resources. Likewise, the economic factor was not addressed in relation to the value of specific uses of wild renewable natural resources to the community, but rather, an attempt was made to relate these uses to the national-global economy that undoubtedly conditions them.

[1] Citation: Zaccagnini *et. al.* 2000. Analytic Framework for Assessing Factors that Influence Sustainability of Uses of Wild Living Natural Resources. IUCN. This 2000 version was updated in November 2001. Zaccagnini *et. al.* 2001. Analytic Framework for Assessing Factors that Influence Sustainability of Uses of Wild Living Natural Resources. IUCN., is available from the SUSG web site: http://iucn.org/themes/ssc/susg/

In this regard, the inclusion of a series of ‘external’ factors, both modifiable as well as non-modifiable, within the Analytic Framework constitutes a new approach to the analysis of sustainability, which, traditionally, has emphasized local phenomena rather than taking into account the external circumstances that influence them.

TAC is aware of the fact that the development of an Analytic Framework for different regions, ecosystems and societies in which the IUCN Sustainable Use Team (formerly the IUCN Sustainable Use Initiative) and the SUSG is involved or has an interest in, is a long-term conceptual task that needs to be tested and corrected accordingly. TAC hopes that the ideas presented herein might serve as a model for this process and that these ideas result in the development of a valid and useful Analytic Framework for the different situations and contexts in which living natural resources are used.

We hope that this Analytic Framework serves as a basis for addressing this subject on a regional level, where these ideas can be tested.

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March 2000

1. Introduction

As we begin the 21st Century 'globalization' is dominating every sector of society. And whilst we have made great strides in areas such as science and technology we nevertheless face important questions:
- Will the Earth be able to sustain a human population of 6 billion and that is predicted to increase to 8 or 12 billion by the year 2050, at existing rates of resource consumption?
- Will we be able to feed this population if soil degradation and erosion continue to transform millions of acres into non-productive land?
- Is the present economic model, based on the intensive use of natural resources sustainable?
- Is an economic model that causes millions of people to suffer from malnutrition sustainable?
- What will be the impacts on future generations of global warming, a decrease in the availability of potable water, deforestation and species loss?

Given that the present and future generations depend, to a large extent, on natural resources we must find ways of using these in a sustainable manner. The challenge is to use these resources while conserving them, and that is the essence of sustainable use.

The use of natural resources is a part of the human condition. Making use sustainable is controversial and a challenge, and requires forms of control or regulation. Policies imposed by government agencies do not often work because they cannot control all users of living natural resources, as is the case with many rural populations that continue to depend on natural resources for their survival. One popular approach to managing the use of natural resources involves combining the efforts of local communities and management institutions to create models that not only guarantee the continued existence of these resources, but also satisfy the food and income requirements of the community.

Encouraging the use of natural resources as a conservation strategy is controversial because it is not self-evident. 'Use it or lose it' sounds like a oxymoron, but it is not because if people can use natural resources, they can value them, and if they value them, they can conserve them. However, uses reported as sustainable have not yet been studied systematically nor are they fully understood.

2. Background

One of the greatest challenges facing the discussion on sustainable development is to design Analytic Frameworks with easily measured indicators, for the sustainable use of living natural resources. Such Frameworks can guide use policies and technologies. Several proposals of conceptual frameworks for developing sustainability indicators exist that include macro regional evaluations (Winograd 1994) and agro-ecosystem evaluations (Viglizzo 1996, Becker 1996, Girardin *et al*. 1999). The majority of the existing frameworks include the concept of ecological, economic and social sustainability (for example Goodland and Daily 1996, Borrini-Feyerabend 1997). In many cases these three factors are incorporated as separate variables instead of interrelated factors. There are examples of sustainability evaluation in the field where these three factors are taken into account, such as the study to evaluate the sustainable use of iguanas in Cosiguina, Nicaragua (Solís Rivera and Edwards 1998) and the evaluation of sustainability in the communal management of vicuñas in Perú (Lichtenstein *et al.* 1999).

One of the first IUCN publications on this subject, *An Initial Procedure for Assessing the Sustainability of Uses of Wild Species* (IUCN SUSG 1996), asks questions such as: Why, who, when, what and how, to evaluate the sustainability of living natural resources. Shortly after this publication the IUCN Sustainable Use Initiative (now the IUCN Sustainable Use Team) produced *Factors that Influence Sustainability* further developing an understanding of the diverse factors that influence sustainability of the use of living natural resources centering the analysis not only on biological factors but also on those factors related to human beings (for example, institutional factors, factors related to different ecosystem uses, methods of use, *etc*.). This document was referred to in the publication *Sustainable Use: The Quest for Independent Variables* (Martin 1997) that attempted to develop a framework taking into account the factors that influence use and their interactions. This document described a set of 14 variables, analyzed the effects of their direct or indirect interactions and outlined a model that attempted to estimate the probability of a use being sustainable or not. IUCN then published the *Sustainability Barometer* (Prescot-Allen 1997), which does not refer specifically to the use of resources but rather strives to evaluate the sustainable development of a region or population, and tries to integrate social, economic and institutional aspects with environmental aspects taking into consideration a group of indicators for each of these components.

A working group was established at the SUSG Steering Committee meeting in 1998 (Antigua, Guatemala) to redesign the Analytic Framework, that was first hinted at in *An Initial Procedure for Assessing the Sustainability of Uses of Wild Species*. The Framework would be redesigned in terms of a supply, demand and control model to promote better understanding of the factors that affect sustainability of uses of wild renewable resources. This document recognized that the search for sustainability is a process of continuous improvement in management and recommended the use of monitoring systems within an adaptive management strategy that would allow for adjustments leading to sustainability. Although social and economic factors are mentioned, it is recommended that only the biological factors be monitored in order to determine the extent to which a use is sustainable.

In the present Analytic Framework, biological, economic and social factors are again taken into account as in previous papers and socio-political institutional factors are added. Sustainable use is presented within biological diversity conservation principles as in previous papers (*e.g.*, *Report for the workshop on the ecosystem approach* UNEP/CBD/COP/4/Inf.9 1998, *Principles of sustainable use within an ecosystem approach* TAC 1999, *Indicators for monitoring biodiversity: a hierarchical approach* Noss 1990). External factors that influence use are also included (for example structural poverty and foreign debt) given that these also affect the probability of a use being sustainable. Equity is considered an indispensable requirement for sustainability.

3. Methodology

This analysis was undertaken by the Technical Advisory Committee (TAC) of the IUCN SSC Sustainable Use Specialist Group (SUSG). Members of TAC received and contributed bibliographies addressing methods of evaluating use sustainability, and academic papers providing background information. The bibliography was supplemented by readings proposed by members of the team. The group held six meetings and had other exchanges in which each member contributed additional information from their particular field of expertise. Consensus was sought among the committee members in striving to reach an interdisciplinary understanding of the subject. This Analytic Framework is the result of integrating the input from these different fields of expertise.

4. Analytic Framework

4.1. Rationale

The purpose of developing this Analytic Framework is to promote a better understanding of the factors that affect sustainability of the use of living natural resources. This understanding relates to the application of a methodology based on the interaction of different factors that comprise this model. This interaction assumes a multidisciplinary approach that allows for an empirical characterization of the sustainable use of living natural resources from biological, ecological, social, economic, political, cultural and historical points of view.

Although the results of this multidisciplinary experience are very general, this approach provides a non-reductionist view of this subject. Sustainability is not perceived as an isolated experience of the use of living natural resources by an individual or community, but rather as the result of the interaction of several factors for which an understanding is sought. For example, if we impose many restrictions on the quality of the environment and natural resources, especially those which strict preservationists frequently impose for a healthy environment, it is likely that the environment will be sustainable in ecological terms but that the human population or the society will not (even within a low-level consumer economy). Strong and numerous restrictions may not only lead to a degree of stagnation but also to a setback in the level of productivity. If this setback were felt at the basic necessity level (food, housing, health), there would be an intrinsic contradiction between the sustainable use of a renewable natural resource and sustainable economic and social development.

Sustainability is not perceived, therefore, as a ‘state’ but rather as a dynamic process towards which one strives. Likewise, external factors (both modifiable and non-modifiable) such as natural disasters, political factors, structural poverty, or a country’s foreign debt, that may promote violence and political instability, have been included in the Analytic Framework to provide greater realism, and to take account of change as part of a historical process, as well as the changing needs of ecosystems and societies.

The TAC model assumes an ongoing evaluation of the situations regarding the use of living natural resources as they relate to a series of factors that favor or hinder the sustainability of different types of use. Using this model one cannot affirm that sustainability is guaranteed if factors ‘x’ or ‘y’ appear in a specific form. In countries with great political, economic and social instability and with a strong impact of ‘external’ factors, the level of uncertainty is greater, and therefore, the possibility of reaching sustainability within the system is smaller.

Compared to previous Analytic Frameworks, this model follows a supply and demand approach to focus on the more comprehensive relationship of ‘society and nature’ addressing the complexity of interactions among factors that influence the use of wild renewable natural resources. It is within this framework that richer and more complex relationships develop, that go beyond addressing only those economic aspects related to the appropriation and use of natural resources.

In the discussions held by TAC, the ‘supply of nature’ was addressed by looking at its ‘production’ cycles. These cycles have determined and continue to determine the use that certain societies make of a resource, providing them with a model for this interaction also. TAC discussed whether or not a resource could be used sustainably in a non-sustainable society. For example, are sustainable uses possible, in the long-term, in inequitable societies in which the users of the resource have no input into the decisions regarding the distribution of the profits derived from this use? Because TAC chose to address these subjects from a broad perspective in which social, cultural and political aspects were defined as factors, it was concluded that certain basic principles and values, such as **equity**, defined as **the rights and full participation of civil society**, are indispensible conditions for sustainability. Equity is not considered a purely ethical problem, but rather an economic problem. The lack of equity entails a cost to society. In societies with excessive inequality there is a cost associated with maintaining social order (Reca and Echeverria 1998) and the systems of resource use that result from that social order. Sustainability, as understood by TAC, refers to uses of wild living natural resources by societies in which equity is a fundamental value.

4.2. Description of the Analytic Framework

The Analytic Framework is based on four suites of factors:

- Those related to the usable living natural resources.
- Those related to the user population.
- Those related to institutional, cultural and political conditions in which the use occurs.
- Those related to the economic conditions in which the use takes place.

The combination of biological, social (characteristics of the user population; status of institutional, cultural, and political conditions) and economic conditions promote sustainability. These conditions and their interactions affect or influence the probability of a specific use being sustainable. The sustainable use of a natural resource will be determined, to a large extent by the type of interaction between these different factors within different contexts.

A series of variables can be described for each factor. The indicators of each variable will allow us to characterize (quantify and qualify) behavior as it relates to the sustainable use of living natural resources. In this document an attempt is made to include those indicators that we consider to be most widely applicable, however, we are aware that some of these indicators cannot be used in certain sustainability analyses and that, for other analyses, it may be necessary to include other indicators not included herein. Therefore, the lists provided are not truly exhaustive.

The probability of a use being sustainable is also affected by factors that are not taken into consideration in the model developed by TAC. These are variables such as poverty, foreign debt, natural disasters and social, political and economic conflicts that, under certain circumstances, interact with variables included in the model, changing the conditions under which a sustainable use can be made of a natural resource.

Box 1: Sustainability indicators.

Sustainability indicators must be scientifically valid, realistic and useful for management purposes (Becker 1996). It is important that they be easy to measure, subject to surveys and suited to the level of aggregation of the system being analyzed.

Not all indicators are necessarily pertinent to measuring sustainability for every use. There may be important indicators that are not included when evaluating a particular use of a natural resource, because there are no universal indicators. Specific indicators will vary according to the use regime being studied, the scale of the activity or the type of use being evaluated, the type of access, the availability of data, *etc*.

Sustainability is a process and as such it varies with time, but time is not considered here as a factor. Its inclusion in the Analytic Framework is implicit, given that the majority of the factors that are considered can affect sustainability over time. In the present Analytic Framework, at a given time, the factors that determine sustainability can change and, according to the situation, may have a positive or negative effect on sustainability.

4.2.1. User Population Factor

The user population is defined as that portion of the human population that directly use or harvest living natural resources. The characteristics of the user population and its relationship to the sustainable use of wild natural resources are represented by aspects of population dynamics, including mobility and the perception of the benefits derived from the use of natural resources. This perception relates to the position each individual holds in society, to the system of land ownership and access to resources, to population income and also to awareness expressed as forms of consumption.

The Analytic Framework takes into account the dynamics of a user population as it relates to the use of a resource: Populations grow, shrink, move or abandon a resource, lose access to a resource, are expropriated from their land, *etc*., creating a specific population dynamic. This dynamic has an important effect on the sustainability of a use of a resource.

Table 1: Criteria and indicators of the User Population Factor.

Criteria	Comment	Indicator
1. Population dynamics according to gender, age, and place of residence and ethnicity.	Indicators provide a means to evaluate the pressures placed on ecosystems by the user population.	1.1. Total population according to ethnicity, gender and age.
		1.2. Total rural population according to ethnicity, gender and age.
		1.3. Vegetative growth rate according to ethnicity and gender.
		1.4. Infant mortality according to ethnicity and gender.
		1.5. Life expectancy according to ethnicity, gender and age.
		1.6. Population density per km^2.
2. Tenure of living natural resources.		2.1. Total user population that also owns the resource.
		2.2. Total user population with access to the resource (for example, tenants).
		2.3. Total population without access to the resource.
3. Population mobility.		3.1. Percentage of rural to urban and urban to rural migrations.
		3.2. Internal and external migration rates.
4. Social structure of user population.		4.1. Per capita income.
		4.2. Per capita consumption.
		4.3. Employment and unemployment rates per gender.
5. Consumption of living natural resources.		5.1. Number of people that make an extractive use of the resource.
		5.2. Number of people that make a non-extractive use of the resource.
6. Awareness and knowledge of uses of living natural resources.		6.1. Existence of traditional knowledge regarding the use of living natural resources.
		6.2. Existence of acquired knowledge regarding the use of living natural resources.
		6.3. Existence of the transfer of knowledge regarding the use of living natural resources.
7. Perception and valuation of the sustainable use of natural resources.	Perception is defined as a society's understanding of a phenomena and relates to historic experience, culture, knowledge, social position, gender and perceived needs. As such, the greater the dissemination of information regarding environmental issues, the level of informal education of a population, the level of consumer organization, and the socio-political participation of the members of a society, the greater the awareness of environmental issues and, therefore, the greater the possibility of approaching conditions that allow for sustainable use. Perception is a variable that is not easily measured, but can be expressed through different behaviors. The following are important components of this variable: (a) the effect of disseminating information regarding environmental issues within the population, (b) the information model used, and (c) the manner in which the information reaches different sectors of the population.	7.1. Existence of environmental education programs (or sustainable development programs) within public and private institutions.
		7.2. Percentage of the population that has received environmental information (or information regarding sustainable development) classified according to the means by which the information was acquired.
		7.3. Number of existing civil organizations in charge of disseminating environmental information per inhabitant.
		7.4. Number of institutional consumer education programs per inhabitant.
		7.5. Number of NGOs dedicated to consumer education per inhabitant.
		7.6. Existence of consumer organizations.
		7.7. Percentage of the population with different levels of education, classified according to gender.

4.2.2. Socio-political Institutional Factor

Each society has a particular relationship with nature, based on its religion, ethics, morals, social contract, technology available for using a resource, local economy and the prospect of exchanges with other communities.

Table 2: Criteria and indicators of the Socio-political Institutional Factor.

Criteria	Comment	Indicator
1. Promotion and implementation of sustainable use through legislation.		1.1. Presence of fiscal policies that promote sustainable use (for example, environmental taxes and subsidies).
		1.2. Absence of perverse incentives (for example, energy subsidies, industry protectionism[2])
		1.3. Interest (positive attitude) on behalf of institutions in implementing principles and legislation on equity and sustainable use.
2. Promotion of equity in policies and legislation pertaining to property, access and distribution of benefits derived from the use of living natural resources.		2.1. Existence of policies that take into account equity, tenure, access and distribution of benefits derived from the use of living natural resources.
		2.2. Existence of legislation that takes into account equity in the tenure, access and distribution of benefits derived from the use of living natural resources.
3. Participation and commitment of civil society at different decision-making levels.		3.1. Existence of a certain level of organization of the civil society that allows for its expression.
		3.2. Existence of a participatory democracy.
		3.3. Number of existing grassroots organizations.
		3.4. Number of permanent instances (institutions) at which sectors with different interests participate.
		3.5. Level of self-management of the civil society.
4. Equity in the mechanisms to distribute the benefits derived from the use of living natural resources.	Policies and legislation are expressed through mechanisms by which resource ownership, as well as resource access rights and the resulting benefits, are distributed equitably.	4.1. Degree of equity in the tenure of living natural resources.
		4.2. Degree of equity in the access to living natural resources.
		4.3. Degree of equity in the distribution of benefits.
5. Ability of institutions to implement sustainable use of living natural resources equitably.		5.1. Efficiency (rationale and operation) of institutions in implementing the sustainable use of living natural resources equitably.
		5.2. Existence of decentralized institutions.

In an ideal participatory democracy, politics and legislation reflect the aspirations of civil society in its different ethnic, cultural and ethical expressions. They also reflect the principles of sustainable use of living natural resources as agreed to and adopted at an international level (for example, by the signing of conventions or treaties such as CBD, CITES, RAMSAR, *etc*.). Therefore, if a population has established principles for the sustainable use of living natural resources, such principles and the degree of participation of the population will determine whether or not they are included in the policies of a government and translated into legislation

[2] Industry protectionism limits competitive pressure to improve efficiency and adopt new technologies and products that are environmentally and economically sustainable (Panayotou 1998).

pertaining to sustainable use. The existence of such legislation, however, does not guarantee its enforcement. This will depend on the existence and effectiveness of institutions (governments, communes, communities, NGOs, *etc*.) that enforce/comply with the requirements for sustainable use. Compliance with these requirements is closely related to government transparency, the degree of decentralization of institutions and their ability to implement policies, and the effective communication of values, knowledge, awareness, *etc*., regarding all aspects of sustainable use (technological, cultural, institutional, *etc*.). Institutions will develop the mechanisms of distributing benefits that are necessary to ensure an equitable distribution of tenure and access to resources.

The socio-political institutional factor is closely related to economic factors given that policies reflect a society's perception of the use of natural resources. Environmental quality, property rights and economic instruments are established according to the policies that regulate the type of use the society makes of these natural resources. Misguided property arrangements and certain policies (for example, 'perverse' subsidies) may lead to under-valuation of natural resources, giving consumers and producers misleading signals regarding the abundance of scarce natural resources and the environmental damage resulting from their use. Policies and legislation are a reflection of the aspirations of a society encompassing the range of its ethnic, cultural and ethical expressions.

4.2.3. Usable Living Natural Resources Factor

Usable living natural resources comprise the portion of the natural system that is used by human societies, that is, they do not encompass all biodiversity but rather only that part from which societies (both present and future) derive a benefit resulting from their use.

Natural resources can be subjected to extractive or non-extractive use. An extractive use may be made of several species simultaneously (for example, subsistence hunting of several species of animals by an indigenous community), or of one species at a time (for example, use of one tree species for wood by a forestry enterprise). Extractive use of a resource may be undertaken by only one user or simultaneously by several users. It is important to distinguish these different types of use as they relate to management and decision-making regarding the use of living natural resources and their sustainability.

A strictly non-extractive use may be made of a resource (such as for recreational purposes) or an extractive use may be made of products derived from individuals of a species (for example, the use of animal hair or wool, or of fruit from a plant). This type of extractive use is very different from the felling of trees or the culling of wild animals and should not have a major impact on the survival or reproduction of the species being used.

The diverse extractive and non-extractive uses of one or several species may alter the functional processes of the ecosystem to which these species belong. These effects may be difficult to anticipate at the outset. It is therefore advisable that, when evaluating the sustainability of each use, an analysis be undertaken of the following interactions:

- Between individuals of the species being used.
- Between the species being used and other species.
- Between the species being used and other functional processes of the ecosystem.

A list of variables at different levels of resolution is provided for this evaluation in the section pertaining to 'use at an ecosystem level' according to the complexity of the system being analyzed.

4.2.3.1.Species Resource Use

A general indicator of sustainable use of one or several species would be the continuous presence of a species above a certain abundance threshold sufficient to guarantee its future viability, not only in terms of demographic persistence but also ecological persistence (that is, of interspecific interactions). The manner in which different indicators are considered and interpreted will also depend on whether the use is of one or several species.

4.2.3.2. Use at an Ecosystem Level

Ecosystem use may be associated with several activities, which range from recreational activities to the use of the ecosystem's functions or services. For example, carbon sequestration by forests, water regulation by wetlands, and the role of tropical forests as gene reservoirs. The purpose of sustainable use is to use the resource while using and maintaining the functions of the ecosystem. From the perspective of natural resources evaluation of the sustainable use of an ecosystem as a whole may be addressed by monitoring indicators that measure the effect of disturbances (both human and natural), and the condition of the composition, structure and function and/or processes of ecological systems (based on Noss 1990). The type of indicators to be used may vary but must include at least those components of biodiversity that are considered most relevant, and that can be easily measured.

Table 3: Criteria and indicators of the Usable Living Natural Resources Factor.

Criteria	Comment	Indicator
1. Condition and population dynamics of a resource.	Abundance may be measured by estimating the number of individuals or indirectly by measuring the following variables.	1.1. Abundance of the species being used.
		1.2. Amount extracted per unit effort.
		1.3. Quality of the individuals extracted or of the attributes of interest to that particular use (for example, width of the fiber or size of the trophy).
		1.4. Demographic rates and parameters (for example, recruitment rates, changes in the age and sex structure, extinction of sub-populations).
2. Habitat condition.		2.1. Habitat quality for the survival of the species being used as it pertains to availability of food, shelter and appropriate habitat for reproduction.
3. Functional relationship between species.	The importance of this information for sustainable use is based on the fact that, when there is a relatively high degree of dependence of one species on another, such as animal-animal (predatory-prey), animal-plant (pollination) or plant-plant (epiphytic or parasitic) and this dependence is species specific to a large degree, the abundance of one of these species is conditioned by that of the other species involved.	3.1. Degree of dependence among species (for example, trophic relationships or other types of inter-specific relationships).
		3.2. Degree of specificity of the relationships (for example, the importance of a species in the diet of another, or the importance of a species of plant as a nesting support for a species of bird).
4. Pressure on living natural resources.	This variable refers to a very important element: The intensity of the pressure exerted by the human population on living natural resources. Although there are many ways of expressing degrees of intensity, depending on the type of resources and the types of societies, we have selected three indicators that, to a large extent, represent the degree of pressure exerted on living natural resources.	4.1. Extraction rate of the species being used.
		4.2. Frequency and time of year when these extractions take place.
		4.3. Characteristics of the extracted individuals (size, age, sex).

For a comprehensive list of the indicators that evaluate the impact on different levels of biodiversity complexity, see Noss (1990) and Redford and Richter (1999).

4.2.4. Economic Factor

The economic aspects of the relationship between nature and society can be expressed as the economic valuation that social participants assign to their natural resources. From the economic point of view, valuation of environmental goods and the effects of their use is a key aspect of a process targeted to the sustainable management of natural resources (Munasinghe 1994).

This valuation results from the level of perception of the costs and benefits that the use of a resource represents to a society. A full economic perception requires sufficient information about the costs and benefits, knowledge of the cause and effect relationships regarding the use of the environment, and a willingness to express this in monetary terms.

The economic valuation of environmental goods must include all the opportunities of present or future alternative uses and the value of the impacts that their use generates on the parties or sectors of the economy (externalities), as well as the values expressed by the owners or users of the resource. This valuation may be expressed to a greater or lesser degree through mechanisms for the exchange of environmental goods and services (the market, for example) that distribute private and social benefits (or costs).

If the cost-benefit relationship to the private sector (owners and users of a resource) is positive, the use of environmental goods generates an economic surplus called 'natural resource income.' at the same time.The degree of appropriation of the income by private individuals is represented, by the value they assign to this resource, and constitutes an important component of the equation that describes the total value of the resource.

mechanisms for the exchange of environmental goods and services determine indicators referred to as prices (market prices, tariffs, payments required for their use, *etc*.). These prices normally fall below the overall value society wishes to assign to the resource and are outside the economic sphere of the owner or user of the resource. These differences may be remedied by intervention measures imposed by the organized society (through government, legislative and administrative entities) such as the definition of property-rights over goods (private, public or shared), establishing rights and restrictions of the owner and rights of third parties, and economic instruments to promote sustainable use, internalize external costs and impose restrictions on specific uses.

Table 4: Criteria and indicators of the Ecosystem Level of the Usable Living Natural Resources Factor.

Criteria	Comment	Indicator
1. Ecosystem species composition.	This variable refers to the diversity and variety of the ecological system at every level of complexity (landscape, communities-ecosystems, populations-species). Diversity indicators should represent both richness and relative abundance.	1.1. Landscape diversity.
		1.2. Community and ecosystem diversity.
		1.3. Population-species diversity.
2. Ecosystem structure.	Ecosystem structure refers to what is known as the architecture of the ecological system.	2.1. Degree of landscape, community and ecosystem heterogeneity and connectivity.
		2.2. Habitat structure and conservation status (vegetation, physiognomy, foliage stratification, *etc*.).
		2.3. Micro and macro population structure (spatial distribution, age structure, *etc*.).
3. Pressures on the ecosystem.	Together with possible alterations to the architecture of the ecological system there are alterations of an ecosystem's ecological processes. We have chosen two indicators of ecological system functional status.	3.1. Degree to which basic ecological processes have been altered (nutrient cycling, energy flow, erosion, *etc*.).
		3.2. Degree to which specific ecological processes of particular importance have been altered (*e.g.,* population extinction, degree of alteration of pollinating relationships, *etc*.).
4. Natural disturbances and human pressure on the ecosystem.	This variable encompasses the most important variables that determine changes to the ecological system. Many of these changes are intrinsic to the ecological system, but others represent the influence of external factors.	4.1. Extent and temporal frequency of natural disturbances (for example, floods) and the pressure caused by humans (for example, felling of woods, induced fires, land conversion for other uses).

Table 5: Criteria and indicators of the Economic Factor.

Criteria	Comment	Indicator
1. Relative importance of the environmental resource to the society as a whole.	The information and social perception of the relative importance of an environmental resource to the society as a whole is expressed as the economic value assigned to this resource. Each society has a particular relationship with nature and will therefore have a particular perception of an environmental resource and the resulting value will be different.	1.1. Total Economic Value (see text below).
		1.2. Relationship between Total Economic Value and price (see text below).
		1.3. Existence and quality of economic instruments (see text below).

4.2.4.1. Total Economic Value (TEV)

TEV expresses the theoretical value of each resource unit, whether or not it is an environmental good or service. It incorporates valuations at different levels (use, option, stock) and incorporates externalities (positive and negative) generated by its use (or lack thereof).

Although the existence of values on the use (or non-use) of environmental goods is recognized, assigning monetary values is not an easy task. Methods have been developed to value environmental goods and services that are not available on the market, taking into account observable behaviors (travel cost method), imitating similar markets (proxies) or by asking a specific population to provide a direct valuation (contingent valuation).

The purpose of any of these methods is to obtain an estimate of the population's willingness to pay for biodiversity, that is, estimate demands that allow one to estimate the social price of the good.

This quantification can be made by simple calculations of the 'shadow price' or reference price (Boardman *et al*. 1996). More complex methods may be used such as a complete cost model which takes into account the marginal social opportunity cost and incorporates marginal costs of production, use (present value of future costs that must be faced by society as a result of the present use of the resource) and external costs (Panayotou 1998).

Full cost pricing requires that all costs to the user (present, future, internal and external) incurred by society throughout production and consumption be incorporated and covered by the price of the good or service. This method presents to the user the same cost as that faced by society and provides an appropriate signal of the relative scarcity of the resource and an incentive to save and use the resource efficiently.

Box 2: Marginal social opportunity cost.

MSOC = MPC + MUC + MEC.
MSOC = Marginal social opportunity cost.
MPC = Marginal production cost (for example, the opportunity cost of labor, capital, energy used in production).
MUC = Marginal user cost (future opportunities lost because of a reduction of the resource resulting from its present use).
MEC = Marginal environmental cost (for example, damages inflicted on other individuals, activities or the environment as a result of this activity).

TEV = (0,...,)

A greater or more complete index of the TEV means greater possibilities of sustainability of the use of this resource.

The TEV method has some shortcomings especially those related to conservationist opinions regarding the position of economists. For example, there are environmental goods that can only be valued but to which no quantifiable value can be assigned (Tolba 1991).

- *Relationship of TEV/Price*

Market prices or tariffs do not necessarily express the entire value assigned by society. The difference between the TEV and the 'price' established by an exchange mechanism, defines an indicator that expresses an explicit and monetary recognition of the social value of the resource.

$$0 < \frac{P}{TEV} = 1$$

The closer the price is to the TEV, the closer the coefficient approaches the unit value. This means that the price represents the social value of the resource, which therefore allows us to ascertain that the mechanism for the exchange of the good has made a complete and correct assignation of its value, resulting in satisfactory (or maximum) levels of sustainability from the economic point of view.

4.2.4.2. Existence and Quality of Economic Instruments

The application of economic instruments by a society is a mechanism by which environmental costs, or the cost of depleting a resource not represented by the assigned price, can be internalized. This would lead to the efficient use of resources and minimize waste.

Economic instruments include a variety of measures (Panayotou 1998).

1) **Property rights** (land titles, mining rights, custodial rights, licenses, patent development rights, *etc.*).
2) **Market creation** (exchangeable emission or effluent permits, exchangeable land permits, exchangeable harvest quotas, *etc.*).
3) **Fiscal instruments** (pollution taxes, land use taxes, property taxes, *etc.*).
4) **Financial instruments** (financial subsidies, soft loans, green funds, *etc.*).
5) **Charges, bonds and deposit systems** (environmental performance bonds, waste disposal bonds, environmental accident bonds, *etc.*).
6) **Liability systems** (legal liabilities, liability insurance coverage, *etc.*).

Property rights granted by land market instruments may be in the form of land titles and land use rights. A market for exchangeable land use permits may be created, fiscal instruments such as property taxes and taxes on the use of the land may be instituted and financial instruments may include incentives to conserve soil, such as loans. In the case of forests, property rights may be communal, a market may be created by concessions or bids, fiscal instruments may include taxes or royalties and financial instruments may include incentives for reforestation (Panayotou 1998).

The existence of such economic instruments in a society is a qualitative indicator of social maturity regarding the use of the environment.

4.2.5. External Factors

In addition to the four central internal factors that influence sustainable use there are others that though no less important, have not been included among the primary relationships for methodological reasons. We refer to them as external factors and have subdivided them into modifiable and non-modifiable factors.

4.2.5.1. Modifiable Factors

- *Social, Political and Economic Conflicts*

Growing inequality in the distribution of wealth throughout the world, associated with lack of protection afforded to the poorer sectors of society, a lack of investment in the social infrastructure, health and other basic services, and high rates of unemployment, ethnic tension and economic crises, make it possible to predict, with a high degree of certainty, the probability of conflicts that may affect the sustainable use of living natural resources.

- *Foreign Debt*

Foreign debt of developing countries and the pressures to repay the debt increase poverty and the pressure on natural resources, decreasing the probability for the sustainable use of living natural resources.

- *Global Environmental Problems*

Local changes in the climate of a region as a result of global climatic change may affect resource productivity and the sustainability of their long-term use.

- *Structural Poverty*

Poverty in developing countries is so deeply rooted that it cannot be reversed merely by changing patterns of resource use. However, the dynamics of poverty are such that they affect the probability of living natural resources being used sustainably. The experience of the 1980s and 90s has demonstrated that impoverishment of the masses leads to socio-political instability and a fall in global economic productivity. The productivity of a system and international competitiveness appear to be linked to equity.

4.2.5.2. Non-modifiable Factors

Natural disasters such as floods, hurricanes, earthquakes, fires or volcanic eruptions may drastically alter conditions in an area, availability of resources and, as a result, the use societies make of these resources.

When analyzing a situation it is important to take into account the degree of vulnerability to external factors. For example, ecotourism enterprises are vulnerable to the political instability of the country where they operate. When terrorist outbreaks occur tourists stop visiting a region. Many uses of one species are vulnerable to market fluctuations – if the price of the product decreases, production ceases to be profitable. All experiences are vulnerable to non-modifiable factors, but in certain places there is a greater possibility of these occurring more often than in others (for example, earthquakes along fault lines).

4.2.6. Interaction of Factors

Although it is possible to ascertain the influence of individual factors on the sustainability of use of natural resources, it is their interaction that is most important in determining whether or not a use will be sustainable. For example, the existence of perverse economic incentives which result from policy failures may alone promote the over-utilization of natural resources. However, if in addition to this, property rights to the resources are poorly specified, there will be an even greater trend towards high extraction rates. If there are inadequate market controls to ensure appropriate levels of trade, there might be an incentive for poaching which would lead to overuse. Not only do each of these factors affect the probability of sustainability, but the effect of each is multiplied through their interaction.

It is possible to imagine an array of situations or cases in which internal and external factors are incorporated into the model at different levels, establishing different probabilities for sustainability. Consideration of these potential interactions would lead to a series of hypotheses that should be explored for different resource management strategies.

4.2.7. Resource Management

An analysis of the sustainability of natural resource management must be designed as a function of the interaction of the four factors described above. Sustainability is affected by a series of events, some of which are under the control of the users, others in the hands of resource administrators, others subject to market forces, *etc*. Given that these events may change with time, it is advisable to adopt flexible management practices that can be adapted in response to changes.

Adaptive management may be the most appropriate type of management to create conditions of sustainability of the use of living natural resources, precisely because they allow for the inclusion of factors related to risk and uncertainty.

Box 3: Adaptive management.

Possible indicators of adaptive management principles:

1. Existence of management programs based on historic experience and existing updated knowledge rather than postponing the development of such programs until complete information is gathered.
2. Existence of monitoring programs to evaluate the results of management from several perspectives (economic, ecological and social).
3. Use of the knowledge derived from monitoring and from understanding the dynamics of the ecological system to undertake an evaluation that would lead to corrective measures that incorporate risk and uncertainty in management practices.
4. Active participation of local players most directly involved with the resource in decision-making, adoption of measure, responsibilities and benefits.
5. Reinvestment of part of the benefits derived from the use in improving management practices.

The following indicators are also important in decisions related to public policies:

6. The existence of flexible legislation, which allows for correcting management practices.
7. An efficient administrative body that can make relatively quick decisions.
8. Sufficient interaction among the various public agencies (ministries, secretariats) when making decisions regarding management of living natural resources.
9. Sufficient awareness among decision-makers of the consequences to the society of negative environmental impacts.
10. Sufficiently trained technical personnel in public service to undertake the above mentioned tasks.

Although adaptive management holds great promise, it must be pointed out that there have been recent problems in its implementation (Halbert 1993, McLain and Lee 1996, Roe 1996, Walters 1997 in Johnson 1999). These include difficulties in developing acceptable predictive models, conflicts related to ecological values and management objectives, little consideration of non-scientific information and a lack of willingness on the part of agencies to implement long-term policies because they are considered costly and very risky.

In an adaptive management strategy there will be occasions where problems can be identified, questions regarding possible effects (natural or not) can be presented, effects on the system being used can be evaluated and measured, responses (environmental, social, *etc.*) can be predicted, differences between predicted and observed data can be verified and, on this basis adjustments can be made to policies as well as to management decisions. However, Hilborn and Ludwig (1993) point out that the adjustments needed to move towards more sustainable systems must be made rapidly and retain flexibility to avoid reaching irreversible levels of degradation.

Throughout this process, it is very clear that there are excellent opportunities for the scientific community to act at different levels within adaptive management settings, especially in regard to its role in the development and transfer of knowledge, the support of decision-making, monitoring and orienting processes directed at adjusting policies (Ludwig *et al.* 1993).

Based on the above, in considering every sustainability evaluation process, it is important to determine if adaptive management principles are being abided by within the existing uses assigned to the resource. To determine this, indicators such as those listed in Box 3 can be used.

4.2.8. Space and Time

Problems with sustainability are expressed at different hierarchical levels, both in space and time. To evaluate the sustainability of an experience it is essential to use appropriate horizons and spatial scales and it is necessary to define, in principle, the level at which the system will be evaluated (for example, local, regional or global) and for what period of time (past and future) it will be analyzed. Although there are links between the various levels, it is not known if the problems presented at a higher level are equal to the sum of the problems that exist at lower levels of the scale (Viglizzo 1996). At higher levels there is an expert knowledge of socio-economic and cultural processes, whereas at lower levels physical and biological processes prevail. This implies that different indicators must be selected when moving from one scale to another (Viglizzo 1996).

The scale that is chosen will determine the significance and the use of indicators while monitoring and analyzing the use practice. For example, the sustainable use of a resource such as wood within a forest plot will take place when the volumetric increase that is harvested does not exceed the growth rate of the forest and consideration is given to socio-economic factors on an appropriate scale. If sustainability is analyzed on a greater scale (ecosystem or basin level), in addition to individual resource indicators, it is necessary to include the behavior and interactions of the components of the system of use at the corresponding level (Winograd 1996).

Every analysis must address whether or not sustainable use is sought for all renewable living natural resources as well as the wellbeing of ecosystems at all geographical scales. Were this the case, it is inevitable that at some point and under some circumstances a situation of incompatibility would arise. An alternative would be to accept that, in order to maintain a sustainable use of some renewable natural resources and of some ecosystems, it is necessary to ‘sacrifice’ others. The solution will depend on the information gained by ecologists regarding critical structures and functions at different scales (Noss 1990) in order to determine which and to what degree and where this sacrifice should be made.

Given that sustainability is a function of a range of factors and variables, the uses that are sustainable today will not necessarily be so in the future should one or more variables change. Therefore, to have a clearer idea of the validity of a specific probability of a use being sustainable, it is important to repeat the evaluations of sustainability of the same system of use within reasonable timeframes.

5. Final Comments

It is recognized that the relationships between human societies and nature as manifested by different use strategies are multiple, changeable and varied. Biological diversity as well as the diversity of human societies makes it impossible to encompass all possible relationships in one Analytic Framework. The diversity of situations and contexts makes it very difficult to develop this Framework from a theoretical perspective and based on the perspective of only one region. Therefore, we envisage the development of this Framework as a process of ongoing reflection and creation that will lead to the development of the most appropriate tools for each particular situation. Sustainability is conditioned by time and whilst a use might be considered sustainable, if there are changes to the internal and external factors described in this Framework sustainability will be put at risk.

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