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Indicators for biodiversity assessment in Costa Rica

J. Camacho-Sandoval [a,*], H. Duque [b]

[a] *Escuela de Ciencias Agrarias, Universidad Nacional, Heredia 3000, Costa Rica*
[b] *CENICAFE, A.A. 2427, Manizales, Chinchiná, Caldas, Colombia*

Abstract

Indicators used by the "Harmony with Nature" chapter of the "4th State of the Nation Report" (SOTNR) for monitoring biodiversity in Costa Rica were reviewed in order to assess its value as a monitoring tool. They were compared with the framework and indicators proposed by the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the Convention on Biological Diversity of which Costa Rica is a party. The SOTNR included state, pressure and use-response indicators for four different types of ecosystems: forest, marine-coastal, freshwater and agricultural systems. However, very few indicators related to species and genetic level were available. More information and indicators for forest and agricultural systems existed than for other types of ecosystems. Some indicators — ecosystems quantity, population density or infrastructure — were not desegregated by type of ecosystem. A main limitation of the report was the non-availability of ecosystem quality indicators. Suggestions are made for the inclusion of a fuller set of indicators to ensure that impact and sustainability can be monitored comprehensively at different levels of scale.

Keywords: Biodiversity; Indicators; Ecosystems sustainability

1. Introduction

During the last few decades there has emerged a strong concern for the environment at the world level. Related to these concerns it is possible to mention at least three milestones: the Bruntland Report, the Rio Conference on the Environment and Agenda 21 all of which relate development to the environment. Many others could be named. The reasons that support this concern are related to an unquestionable fact: degradation of biological natural resources and all its implications.

In order to understand this situation the main causes of environmental degradation should be mentioned. Although there are different points of view there is unanimity in recognizing that increasing human population and related anthropogenic activities can be the most important factors damaging the environment.

Since 1972, at the Stockholm Declaration of the United Nations Conference on Human Environment, an increasing concern for the need for environmental impact assessment of anthropogenic activities has been considered by governments, non-governmental organizations and by civil society in general. Environmental impact assessment has become an "emerging principle of international law" (Convention on Biological Diversity, 2000) and a compromise for countries which signed the Rio Declaration. Related to biological diversity, the signatory countries of the Convention on Biological Diversity (1992) agreed to "introduce appropriate procedures" for environmental impact assessment.

Many different approaches are available for assessing impact of human activities on the environment

* Corresponding author. Tel.: +506-277-3947; fax: +506-261-0035.
E-mail address: camachoj@sol.racsa.co.cr (J. Camacho-Sandoval).

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as well as for evaluating project performance. These approaches are considered from the point of view of disciplinary or multidisciplinary perspectives, for different kinds of users such as policy makers, scientists, NGO officers, project leaders, donors or farmers, for different levels of scale — local, national, regional or global levels — and for short- and long-term issues.

The objectives of this work are to review alternative frameworks and indicator sets for monitoring biodiversity in order to select the most comprehensive alternative and to evaluate how the indicators used in Costa Rica fulfill the selected framework.

2. Frameworks for environmental issues assessment

A comprehensive review of frameworks related to environmental issues was made by Murcott (1997) who established five framework categories as functions of the type of interacting factors. The first four categories comprise interactions between human–environmental factors, environmental–economical factors, human–economical factors and whole human–economical–environmental factors. The fifth category considers aggregated indices for different kinds of indicators.

Within environment–human–economy interaction frameworks, one of the more frequently used is the pressure–state–response (P–S–R) model, which takes into consideration the actual state and trends of natural resources as well as factors or conditions related to such trends and their response to different kinds of intervention. This model has been adopted by some important groups and organizations like the World Bank, United Nations Commission on Sustainable Development and the Organization for Economic Cooperation and Development and has thus become the dominant model (Murcott, 1997). A quite similar framework, specifically applied to agricultural systems, has been proposed with a DSR structure, it means driving force equivalent to pressure, state and response (OECD, 1997).

More recently, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the Convention on Biological Diversity (1999) proposed a PSR model that included a comprehensive set of indicators of biological diversity, in order to assist governments to "design, initiate, and/or improve their national monitoring programs", in accordance with the objectives of the convention.

A first feature of the SBSTTA proposal is the adoption of the ecosystem as the basic monitoring unit. They suggest six kinds of ecosystem: forest, marine-coastal, freshwater, mountain (Tundra), dry areas and agricultural systems. A second feature is the establishment of a baseline that could be used as a general or universal benchmark or comparison base for monitoring biodiversity changes. Two dates are proposed as baselines; 1993, because the convention entered into force on that year and a large amount of data could be available; and a pre-industrial baseline, in order to look at long-term trends.

Costa Rica developed some initiatives in order to monitor its national biodiversity. The main one is the "Harmony with Nature" chapter of the "4th State of the Nation Report" (SOTNR) — (Proyecto Estado de la Nación, 1998), an annual independent report supported by the National Council of Presidents of State Universities, the Ombudsman Office and the United Nations Development Program. Another initiative is the "National Strategy for Conservation and Sustainable Use of Biodiversity" (Ministerio de Ambiente y Energía, 2000), which includes a chapter on "The Costa Rican Biodiversity: Summary of the Actual Situation", which is a synthesis based on the SOTNR. The former gives the most comprehensive collection of indicators for the specific assessment of natural resources and biodiversity. Alternative sources of information are available in Costa Rica to analyze biodiversity, but the reason for focusing on the SOTNR included its periodic publication, a key issue for monitoring — and the fact that it is a compendium of many primary sources.

PSR indicators form the dominant models widely used for environmental issues assessment. Since the SBSTTA model is a PSR one, and since it emerges from an agreement between parties of the "Convention on Biological Diversity" and because of its completeness and quality of proposed indicators, it will become the standard reference, at least for those countries that are members of the convention. Since Costa Rica is a signatory of the convention, the SBSTTA proposal is adopted in this paper as a reference model to analyze the adequacy of indicators used by the "Harmony with Nature" chapter of the 4th SOTNR

for monitoring biodiversity at the national level in Costa Rica.

3. Indicators for biodiversity assessment

No matter which framework approach is used, indicators are key tools in biodiversity and natural resources assessment. No universal agreement on indicator choice or necessary properties exists. Some authors restrict indicators to "quantitative measures" (Convention on Biological Diversity, 1997) yet some important or interesting features of biodiversity and natural resources are of a qualitative nature.

As pointed out by UNIQUAIMS (1998) "it is not difficult to define indicators: what is difficult is to choose those which introduce simplicity into assessment of a situation yet represent impact and sustainability precisely". This leads to the need to define criteria to choose and evaluate indicators. Some authors have proposed selection criteria to choose indicators (Convention on Biological Diversity, 1997; Riley and Alexander, 1998; Interagency Working Group on Sustainable Development Indicators, 1999; Riley, 2000). The SDI group proposed six general and four specific selection criteria. General criteria include properties that must be fulfilled by any possible indicator. These criteria are:

- To represent an issue that is important to sustainable development.
- To be understandable to a general audience.
- To be quantifiable.
- To be based on available data.
- To be national in scope or relevant to an issue of national concern.
- To be scalable to different levels.

At least one of the specific selection criteria must be fulfilled by any indicator candidate, whose criteria are:

- capacity to reflect changes in important endowments;
- reflects an issue that could have significant costs or benefits for current or future generations;
- reflects an issue that could be addressed for a period of time;
- reflects an issue that involves thresholds beyond which small changes could potentially lead to irreversible effects.

Other desirable features of indicators may be: first, to quantify and simplify information in such a way that its importance is clear; second, to be able to detect changes in time and space; third, to have scientific credibility; fourth, to be able to be represented in diverse ways to address different audiences. And two final desirable features are to have the capacity to distinguish natural and man-made changes and to be easy to understand (Convention on Biological Diversity, 1999).

Other valuable properties of indicators are: universality (applicable to many areas, situations and scales of measurement), portability (repeatability and reproducibility), sensitivity to change, be operationally simple and inexpensive, already in existence with historical data and be of wide international use (Riley, 2000). Finally, indicators may be weighted using different schemes, may be aggregated to different levels for different types of data, and may be suitable for statistical analyses (Riley and Alexander, 1998). An additional issue arises related to indicators, that is the need for standard methods and protocols to ensure that indicators measure really what the users want to measure and allow fair comparisons of indicator trends for different moments, places, systems or scales.

The SBSTTA proposal includes state, pressure and use-indicators (Table 1). Within the first group, two types of indicators are considered, ecosystem quantity and ecosystem quality. Quantity indicators relate to self-regenerating and man-made ecosystem areas. Ecosystem quality indicators are proposed at three levels: the ecosystem itself, the species level and the genetic level. At the first level, habitat fragmentation/conversion and species richness indicators are included. At the species level, indicators of change in abundance or distribution of selected species and threatened species are considered. At the genetic level, indicators are related to replacement of indigenous crops or animal races by alien ones. With respect to pressure indicators, they are grouped into six types: population density, harvesting/use-indicators, infrastructure, pollution, alien/invasive species and climatic change indicators. Additionally, two groups of pressure indicators named as indicative reserves are

Table 1
Indicators proposed by the SBSTTA report and indicators used by the "Harmony with Nature" chapter of the SOTNR

SBSTTA proposal indicators	SOTNR indicators
State indicators	
Ecosystem quantity	
Habitat	
Self-regenerating	Land covered by natural and secondary forest
Man-made	Annual reforestation rate
	Annual deforestation rate
	Natural forest and reforested areas under fiscal incentives
	Area changes from forest to other uses
	Area changes from other uses to forest
	Grasslands areas
	Cultivated areas for different crops
Ecosystem quality (ecosystem level)	
Habitat fragmentation/conversion	
Native vegetation fragmentation	
Wetland drainage and filling	
Conversion of coastal areas	
Erosion	
Irrigation	
Species richness	Number of new plant, mammals and insects species described during the year on protected areas
Species level	
Changes in abundance and distribution of a selected core set of species	Inventory of plants used by people in a small native reservation in the country
Threatened species	
Percentage of total species of certain taxonomic groups	
Percentage of endemic species threatened	
Threatened species in protected areas	
Genetic level	
Replacement of indigenous crops	
Replacement of land races with few imported one	
Pressure and response indicators	
Population density	Total population
In/adjacent to key habitats	Total population by sex
In/adjacent to protected areas	Total urban and rural population
	Population density
	Birth rate
	Mortality rate
	Child mortality rate
Harvesting/use-indicators	Total timber volume extracted
Production totals	Total timber volume extracted per hectare
Export totals	Annual volume of forest products exported
Import totals	Annual value of forest products exported
Local processing capacity	Total marine resources captured
Domestic consumption	Using artisanal methods
Catch/effort	Using industrial methods

Table 1 (*Continued*)

SBSTTA proposal indicators	SOTNR indicators
Changes in proportions of commercial species	Overall total by year Total hydroelectric generation Hydroelectric generation (as percentage of total electric generation) Annual yield per hectare for 24 crops National annual meat yield National annual milk yield National annual poultry (broilers and eggs) yield Organic crops area Organic products volume exported Number of farmers involved in organic agriculture
Infrastructure	Total annual national investment on housing
Road and transportation networks	Total investing in housing (as percentage of NGP)
Dams	Number and percentage of house-owners by gender
Rate of housing development	Number of houses classified by its basic services for urban and rural areas
Pollution	Total fertilizer used
Soil quality	Pesticide importation per year
Water quality	Changes in water volume utilized/unit of coffee processed
Air quality	Particle concentration in water in coffee processing Concentration in air of: carbon monoxide, nitrogen dioxide, lead, ozone, suspended particles and suspended particles with diameter greater than 10 μm
Alien/invasive species	
Percentage of habitat colonized by invasive species	
Percentage of protected areas colonized by invasive species	
Climatic change	
Indicative reserves	
Habitat management	
Percentage of protected (IUCN 1–3)	Forest protected area
Percentage of protected (IUCN 4–5)	Changes in total protected areas in the country by year
Percentage of managed for production	Changes in private ownership of protected areas
No. of fires/area burned per year	
Special habitats	
Percentage of remaining	Total forest area
Percentage of protected	Protected forest area
Use-indicators	
Ecosystem goods	
Total amount harvested per species and grand total over time	Total timber volume extracted
	Total timber volume extracted per hectare Annual volume of forest products exported Annual value of forest products exported Total marine resources captured Using artisanal methods Using industrial methods Overall total by year

Table 1 (*Continued*)

SBSTTA proposal indicators	SOTNR indicators
	Total hydroelectric generation
	Hydroelectric generation (as percentage of total electric generation)
	Annual yield per hectare for 24 crops
	National annual meat yield
	National annual milk yield
	National annual poultry (broilers and eggs) yield
	Organic crops area
	Organic products volume exported
	Number of farmers involved in organic agriculture
Ecosystem services	Annual estimation of stored carbon areas where fiscal incentives are applied
Total and per kilometer carbon stored within forest per country	Number of foreign and/or local visitors to national parks per year

included. They are habitat management and special habitat indicators. Finally, ecosystem use-indicators are related to ecosystem goods and services.

4. Indicators used by the "SOTNR"

Indicators used by the "Harmony with Nature" chapter of the SOTNR are presented in Table 1. They were related to the structure of the core set of indicators of biological diversity proposed by the Convention on Biological Diversity (1999), i.e. the SBSTTA indicators.

The SOTNR included state and trend, pressure and use indicators for six different types of ecosystem: forest, marine-coastal, freshwater, mountain (Tundra), dry areas and agricultural. Tundra and dry area systems were excluded from the SOTNR because they are not heavily represented in Costa Rica. More kinds of indicators were available for forest and agricultural systems than for the other types of ecosystems and they predominated in the SOTNR report.

4.1. State indicators

This type of indicator is intended for monitoring losses or gains in ecosystem quantity or quality and the relative number of threatened and extinct species in time. The SBSTTA proposal suggested measuring these indicators at the ecosystem level. They involve ecosystem quantity and quality indicators.

4.1.1. Ecosystem quantity indicators

The SOTNR included indicators for both self-regenerating and man-made areas for some of the habitat types. Related to forest ecosystems the following were considered: land covered by natural and secondary forest, annual deforestation and reforestation rates, forest areas involved in fiscal incentive programs (including natural forest management, natural forest protection and reforestation) and area changes from forest to other uses as well as area changes from other uses, agriculture mainly, to forest. For agricultural systems some quantity indicators were also included in the report such as change in size of grasslands and cultivated areas for the main crops throughout time.

4.1.2. Ecosystem quality indicators

The SBSTTA proposal includes quality indicators at three levels: ecosystems, species and genetics. The proposed indicators at the first level include habitat fragmentation/conversion (fragmentation of native vegetation, wetland drainage and filling, conversion of coastal areas, erosion and irrigation) and species richness. Related to this former issue, the SOTNR only included the number of new species described during 1997 for plants (78 species, 4 subspecies and 2 varieties), mammals (a new dolphin specie) and insects (39 new species for Pimplinae, 172 for Ichneumonidae and 7 for Cicadellidae). Most of these findings were related to protected areas.

At the species level, the SOTNR only included an initial inventory of plants used by people in a small

native reservation in the country. No indicators at genetic level were considered.

4.2. Pressure and response indicators

Pressure indicators reflect which factors are affecting biodiversity now and in the future. The main focus is on anthropologic factors but climatic changes and species migration (importation) are also considered. Six types of pressure and response indicators are proposed by the SBSTTA report as follows.

4.2.1. Population density

The SBSTTA suggests specific population density measurements in, or adjacent to, key habitats and in, or adjacent to, protected areas.

The SOTNR included, in its statistical compendium, some demographic indicators like total population, total population by sex, total urban and rural population, population density, birth rate, mortality rate and child mortality rate. Total population was desegregated by sex and for rural and urban zones. No demographic indicators for specific ecosystems were available and most of them were for the national level.

4.2.2. Harvesting/use indicators

The SBSTTA proposes production, import and export totals as well as local processing capacity, domestic consumption, catch–effort and changes in proportions of commercial species indicators. Some harvesting/use-indicators for different types of ecosystems were available in the SOTNR. With respect to forest ecosystems, SOTNR indicators included total and per hectare timber volume extracted (m^3) and volume and value of forest products annually exported by destination country. Related to marine-coastal ecosystems the indicators available were total marine resources captured by artisanal methods, total captured by industrial methods and overall total by year. For freshwater ecosystems, indicators given were total hydroelectric generation ($GW\,h^{-1}$) and total hydroelectric generation as percentage of total electric generation. All of them were reported at the national level.

Harvesting/use-indicators for agricultural ecosystems in the SOTNR involved annual yield per hectare for about 24 different crops, including crops both for exportation and for domestic use, total annual meat, milk and poultry yields (broilers and eggs) at the national level. The report also included cultivated area, the number of farmers involved and export volume of organic agricultural products.

4.2.3. Infrastructure indicators

The SBSTTA report proposes road and transportation networks, dams and rate of housing development. The SOTNR included national gross investment on road networks and some data related to housing that included: first, the total annual national investment on housing and as percentage of GNP; second, the total and percentage of house-owners categorized by gender and by province; third, the number of houses classified by the conditions of their basic services for both urban and rural areas, which seem to be indicators closer to “housing development”.

4.2.4. Pollution indicators

The SBSTTA proposal suggests pollution indicators related to soil, water and air quality. The chapter of “Harmony with Nature” report did not include specific indicators for soil and water pollution but it considered total fertilizer used, pesticide and other agrochemical volume importation per year as well as overall total volume imported per year (in terms of commercial product). A specific mention of water quality related to coffee processing was made in the report in terms of both changes in water volume utilized by unit of coffee processed and concentration of particles with diameter greater than 0.75 mm on residual water. Related to air quality, the report included some information from the main urban area of the country that comprises the four main cities. Air quality indicators for this region were: concentration of carbon monoxide, nitrogen dioxide, lead, ozone, suspended particles and suspended particles with diameter greater than 10 μm. Reference points were used for air quality indicators and threshold concentration values (maximum allowed concentration) for the main air pollution agents were included.

4.2.5. Alien/invasive species and climatic change indicators

The SBSTTA report indicators for alien/invasive species are percentage of habitat or percentage of protected areas colonized by invasive species. In the case of climatic change, the indicator proposed by SBSTTA, is mean temperature change per grid

cell of 50 km × 50 km within a 20-year period. The SOTNR did not include any indicators for these issues.

4.3. Habitat management indicators

The SBSTTA proposal uses percentage of protected areas for two categories, in accordance with the IUCN classification for protected areas management (IUCN, 1998). The first group includes strict natural reserves, wild natural areas, national parks and natural monuments. The second group comprises habitat/species management areas and marine and terrestrial protected landscape.

The chapter of "Harmony with Nature" of "4th State of the Nation Report" included the forest protected areas (ha) involved in different fiscal incentives programs per year, at regional level. The report also included changes in total protected areas in the country by year and changes in private ownership of protected areas. No specific changes for each type of ecosystem were mentioned.

4.3.1. Special habitats indicators

The SBSTTA proposed-indicators are percentage of remaining area and percentage of protected area of each type of habitat related to country area. The SOTNR only included indicators for forest ecosystems, being total forest area and protected forest area.

4.4. Use-indicators

Two kinds of use-indicators are proposed by the SBSTTA report. Ecosystems goods, includes total volume harvested by species, and overall total over time. Ecosystem services includes the indicators total and per square kilometer carbon stored within forest per country.

4.4.1. Ecosystem goods indicators

Some of the pressure indicators considered by SOTNR were listed again as ecosystem goods indicators. That was the case for harvesting/capture indicators in relation to forest, marine-coastal, freshwater and agricultural ecosystems used by the report and mentioned above. Most of them were reported at the national level exclusively.

4.4.2. Ecosystem services

The SOTNR included an annual estimation of stored carbon areas where fiscal incentives are applied. A useful indicator included in the report was the number of foreign and/or local visitors to national parks per year. This is a very important indicator for the country since tourism and eco-tourism are becoming one of the main economic activities.

5. Adequacy of indicators used by SOTNR

How did the indicators used by the "Harmony with Nature" chapter of the "4th State of the Nation Report" fulfill the Convention for Biological Diversity recommendations, specifically those of the SBSTTA proposal?

5.1. General considerations

A first issue that must be considered is related to the objectives of both, the SBSTTA proposal and the SOTNR. The SBSTTA aim is to develop a set of indicators "as a tool for adequate management of biological diversity at local and national levels, for regional and global overviews of the status and trends of components of biodiversity, in the context of the ecosystem approach and the three objectives of the convention" (Convention on Biological Diversity, 1999). The SOTNR main objective was to make information available to the Costa Rican society to allow it to appreciate reality and, on this basis, to address its future actions in specific fields, including environmental issues. It is evident that the SOTNR objectives were of a more general scope and consequently, less detailed information must be expected. The SOTNR was not intended specifically to substitute national reports to the Convention on Biological Diversity. Nevertheless, the "Harmony with Nature" chapter of the SOTNR is the most important report on environmental issues at national level and more comprehensive than the "National Strategy for Conservation and Sustainable Use of Biodiversity" on biodiversity issues.

A second concern was related to information availability and costs. The SBSTTA proposal could be considered as an ideal framework to monitor biodiversity and other environmental issues but information available in most developing countries to match such a pro-

posal completely is limited, even in Costa Rica, where biodiversity, natural resources and environment are of high priority for government and society. Full implementation of the SBSTTA proposal at the national level could be very expensive for such countries because data gathering and recommended technological devices have high costs. Finally, the last version of the SBSTTA proposal emerged in 1999 and the SOTNR was first published in 1995 and may require updating. Nevertheless, the SOTNR met some of the SBSTTA suggestions as discussed below. Some of the indicators recommended by SBSTTA and omitted by SOTNR until now, could be included in future reports if data are available, or plans could be made to gather new data.

A question that arises is whether the SOTNR scope and structure could be modified to meet the SBSTTA proposal in future versions? Since some of the SBSTTA recommendations are included in the SOTNR, the recommended indicators could be conveniently included in future modified reports for any country or region. This would lead to an international framework where international regional comparisons on the same basis would be possible.

5.2. Considerations of specific indicators

Related to quantity indicators, a first feature of the SOTNR was that information only for forest and agricultural ecosystems was included. Costa Rica has important marine-coastal ecosystems, mangrove areas, for example, on both Pacific and Caribbean sides of the country, as well as important wetlands ecosystems. Some information exists about areas covered for such ecosystems (Savitsky et al., 1998), but no quantity indicators for this kind of ecosystem were included in the report. Mountain (Tundra) and desert ecosystems are not present at important levels in Costa Rica, so no indicators for such habitats were considered.

Quality indicators were a weakness of the report. At ecosystem level no quality indicators for habitat fragmentation/conversion were considered. The species level as well as the genetic level should include indicators for changes in abundance and distribution and indicators for threatened species and for replacement of indigenous crops or animal races. Yet they were not included in the SOTNR.

An opposite situation is found with pressure/response indicators. Related to population density and infrastructure, an important number of indicators were considered as mentioned above but such indicators were not desegregated in relation to the different types of ecosystems or social layers. On the other hand, some harvesting/use-indicators were available for the main ecosystem types in the country. Air pollution indicators were restricted to the main urban area of the country. Indicators for other areas and ecosystems as well as water and soil pollution indicators were not mentioned. The same was true for alien/invasive species and climatic change indicators. In the former case, meteorological data are available in the country. Habitat management and special habitat indicators are unavailable for most ecosystems except for forest ecosystems as mentioned above. Finally, use-indicators as suggested by SBSTTA, were available in the SOTNR for most types of ecosystem.

5.3. Methodological considerations

For none of the indicators did the SOTNR report identify the need for an explicit baseline except for the air pollution indicators. In this case, the maximum allowable concentration for six pollution agents, based on international standards, were used as threshold values. Taking into account that SBSTTA suggests year 1993 as a baseline and that the first “4th State of the Nation Report” was published in 1995 with data from 1994, the former year could have been adopted as a baseline. No references to methodological aspects for data collection and analysis were found, but almost all data came from primary or secondary sources. The document itself revealed that the first limitation of the report is related to quality, continuity and availability of data. Since the report is published every year and the staff responsible for the “Harmony with Nature” have changed and could change in the future, it is necessary to establish quality control standards for data sources, collection procedures and analyses, in order to make fair comparisons over time. The SBSTTA proposal suggests methodological approaches for most types of indicators that could be adopted by the SOTNR project.

The SOTNR compiled well the valuable information dispersed in many sources and, in this way, achieved its aim of making information available to Costa Rican society. It could be interesting to try a more in-depth analysis of data available in the

SOTNR to identify indicator redundancies, to reduce problem dimensions with minimal loss of information, to identify actual trends and transitory noise, to test relationships between indicators to get a better understanding of the situation and to choose key indicators to represent more information in a simpler way. Some experience exists in the country in relating electric energy consumption to garbage production at the household level, for example, and which is being used to estimate costs of garbage deposition by municipal enterprises. It could be possible to explore some new perspectives using information available in the SOTNR with modern statistical methods.

Most of the indicators in the report met some of the quality criteria established by the different groups cited above. Among others these criteria include being related to relevant issues, quantifiable, based on available data, understood by different kinds of users, having national scope, suitable to reflect changes, being universal and portable. More difficult to evaluate and meet are criteria related to scalability, and suitability for different weighting schemes and aggregation. Some of the quantity, pressure and use-indicators were suitable for different scales, aggregation and weighting schemes since they were defined in terms of spatial and time units, usually per hectare and year, respectively. Others were defined in terms of monetary value that could be transformed to a yearly basis or to an international money standard for comparison purposes.

6. Conclusions

The SOTNR is a useful tool for monitoring biodiversity in Costa Rica. It could be improved in future editions by incorporating indicators of ecosystem quality as suggested by the SBSTTA, mainly for the more fragile ecosystems; forest, wetlands and marine-coastal areas. It is convenient to define detailed standard protocols for data gathering and analysis and promote their use by research and monitoring organizations in the country whose results were considered by the SOTNR, in order to ensure data consistency and fair comparisons in time and across regions or countries. Some suggestions on data gathering are recommended in the SBSTTA proposal but no mention is made of data analysis procedures. Powerful statistical methods are available for analyzing complex and multidimensional issues that could be appropriate for biodiversity data. There is some valuable information on biodiversity issues available in the country and this was not included in the report. An exhaustive and updated inventory of such information sources would be very valuable.

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