C. Qualitative environmental assessment

It is difficult to provide an absolute scale for an expert or professional to a relative quality value for environmental impact assessments. However, the task is made easier when there are exact figures for an environmental variable and parameters established by environmental control bodies. If environmental specialists base their assessments on their experience and on the appropriate literature, they will be able to make an adequate, logical and consistent estimate.

The quality, intensity and extent of the effects of a natural phenomenon on the environment will vary according to the force released, the sensitivity and quality of the medium receiving it, the medium's capacity for recovery, the time it takes to recover and the partial or total loss of environmental assets or services. Human activities bring with them some inevitable and irreversible environmental impacts, most obviously involving land usage. Whether for working, production, storage, access roads or service areas, such uses are all negative impacts known as loss of vital space. However, the natural environment's recovery in the short, medium and long terms will normally be brought about by its own systems of ecological evolution (natural succession, natural recovery, self-purification of water, assimilation and transformation of chemicals and pollutants in the biogeochemical cycles, the atmosphere's photochemical reactions, etc.). The aim in this case is to restore the environment's ability to absorb the effects of the natural phenomenon, particularly when it is of great intensity and duration.

Once the environmental status study has been carried out and the necessary analysis has been made (preferably with an interdisciplinary exchange of information) the environmental specialist(s) will finally be able to judge the general importance or class of the alteration in the overall system. One of the proposals for studying human developments is that an environmental impact study should use six negative and four positive assessments of the effects on any natural or anthropogenic system. These assessments are based on results that can be induced from observations, professional experience, environmental matrices or models employed and data generated by analyzing a project or by applying artificial actions to a given environment in space and time. This qualitative method can be used in the case of disasters caused by extreme natural phenomena.

This assessment, which must be impartial, should preferably be made after completion of the study of the environment's features, of the environmental inventory and of such analyses as called for by the situation or by the institutional terms of reference. The classes of negative impact are given below and summarized in Table 3.

a) Zero Impact. Insignificant or very slight, with swift environmental recovery or with minimal or very low prevention or recovery costs.

b) Insignificant or Minimal Impact. Quantifiable impact that does not affect the system's stability. Recovery in the short or medium term; problems, alterations, changes and damage are insignificant when the benefits derived from the situation are taken into account.

c) Moderate Impact. Change is marked, but restricted to a relatively limited area. Slight regional impact; short-term recovery; moderate or acceptable problems; simple and cheap mitigation.

d) Severe Impact. Very marked regional or very extensive change. Recovery in the short or medium term if appropriate mitigation measures are implemented. A high level of discomfort and inconvenience, and mitigation is costly.

e) Very Severe Impact. Very extensive, heavy and harmful consequences in the region. Possibility of partial or slight recovery at a very high cost in the medium and long term. Fewer options for using the resource in the future. In the case of developments, it signifies a permanent threat to resources, health or life.

f) Total Impact. Even though only partially damaged, the system cannot recover; destruction is total. Loss of options for using the resource in the future. Where a human development is concerned, it will be imperative to forbid its installation or operation. In a disaster situation, natural recovery can take place in the very long term (more than 25 years).

Table 3

CLASSES OF ENVIRONMENTAL IMPACT

Enviromental impact	Damage Quality	Exent of the Damage	Recovery Term	Recovery Costs
Zero	Almost non-existent	Very limited range	Immediate Very short	None
Insignificant or minimal	Slight	Local	Short	Low
Moderate	Marked	Local Limited range	Short or Medium	Medium to high
Severe	Very marked	Local or extensive	Medium or long	High or very high
Very severe	Serious and destructive	Local or extensive	Medium or long	Very high
Total	*Total or almost total*	*Local or extensive*	*Very long or irreversible*	*Incalculable*

Source: adapted from Alfonso Mata, 1995

One advantage of this method is that it becomes much easier to interpret the appraisal after inputting quantitative values, such as a hurricane's wind speed, an earthquake's magnitude, the extent of a forest fire, fish catch data or the extent of a flooded area.

Good examples of this idea are the Fujita Scale of Tornado Intensity and the Saffir-Simpson Hurricane Scale. The former classifies tornadoes as weak (F0), moderate (F1), significant (F2), severe (F3), devastating (F4) and incredible (F5). The latter similarly classifies hurricanes into categories 1 (moderate), 2 (strong), 3 (severe), 4 (very severe) and 5 (devastating). Scales have also been used to give a qualitative and quantitative idea of the El Niño phenomenon by classifying occurrences as moderate, strong, and very strong according to the average changes in the ocean's surface temperature. In the case of hurricanes, each category has different geographical zones of damage intensity, which are established using approximately the same qualitative standards. Accordingly, they can be classified into zones of moderate, strong, severe and very severe impacts.

We now provide examples of qualitative environmental assessments based on relating to the damage caused to the environment by Hurricane Georges in the Dominican Republic in 1998 and by the El Niño phenomenon in Costa Rica in 1997-1998.

Table 4 shows a breakdown by category of the areas affected by mass movements caused by Hurricane Georges in the Dominican Republic. The skill shown by the observers during field trips made to determine areas, type and depth of mass movements such as landslides, together with analysis of aerial photographs taken before and after the disaster, made it possible to estimate the percentage of the area affected and associate it with a qualitative description of the damage.

Table 4

CLASSIFICATION ON THE AREAS AFFECTED BY LANDSLIDES AND AVALANCHES CAUSED BY HURRICANE GEORGES IN THE DOMINICAN REPUBLIC IN 1998.

Category	Affected area (%)	Estimated damage
D1	10	Slight
D2	30	Moderate
D3	50	Severe

Source: Adapted from Lücke, O. & R. Mora. 1998.

Table 5 shows the characteristics of the protected areas damaged as a result of Hurricane Georges and the impact classification defined by the authorities of the affected country.[7]

7 ECLAC, *República Dominicana: evaluación de los daños ocasionados por el huracán Georges, 1998: sus implicancias para el desarrollo del país*, (LC/MEX/L.365), Mexico City, 1998.

Table 5

CHARACTERISTICS OF THE PROTECTED AREAS IN THE DOMINICAN REPUBLIC AFFECTED BY HURRICANE GEORGES IN 1998 AND THEIR CLASSIFICATIONS IN TERMS OF RELATIVED IMPACT

National Parks and equivalent reserves (1)	Affected area km²	Life zone (2) and special feature	Degree of environmental impact (3)
NP Armando Bermúdez	*766*	*S-wf and S-rf, the greatest altitudes in the Antilles*	*Moderate*
NP Cuevas de Borbón or El Poumier	*0.25*		*Severe*
NP Del Este	*430*	*S-mf, S-df, Habitat of birds and plants, solenodon and hutia*	*Very Severe*
Isla Catalina	*22*	*S-rf*	*Very Severe*
NP Isla Cabritos (Lake Enriquillo)	*25*	*S-df endangered species*	*Minimal*
NP Jos del Carmen Ramírez	*764*	*S-wf and rS-rf, larger*	*Moderate*
NP Laguna de Cabral or Rincón	*240,54*	*Turtle and endemic fish*	*Severe (flooding)*
NP Redonda and Limón Lagoons	*107,7*	*S-rf*	*Moderate-severe*
NP Los Haitises	*1375*	*S-mf, endemic species*	*Severe-very severe*
NP Mount La Humeadora	*420*	*S-rf*	*Very Severe*
NP Sierra de Bahoruco	*800*	*LM-mf*	*Minimal*
NP Sierra de Neyba	*407*	*LM-mf*	*Moderate*
Lomas de Barbacoa	*22*	*LM-rf and LM-mf*	*Moderate-severe*
NP Valle Nuevo	*657*	*LM-rf and M, source of rivers Yuna and Nizao*	*Moderate-severe*
RC Ébano Verde	*23.1*	*LM-rf and LM-mt*	*Moderate-severe*
SR Quinta Espuela	*72.5*	*LM-mf*	*Moderate*
UP Santo Domingo and Botanical Garden	*16.4*		*Very Severe*
Total	***6,796***		

Source: ECLAC, 1998
[1]Abbreviations: NP: National Park; SR: Scientific Reserve; UP: Urban Park.
[2]Life zone (in the Holdridge sense, see Appendix XIII), Tasaico 1962.
Abbreviations: S: subtropical; M: montane; LM: lower montane; mf: mosst forest; wf: wet forest; rf: rain forest; df: dr
[3]Areas affected by Hurricane Georges according to the National Planning Office of the Dominican Republic.

Table 6 shows another example of qualitative assessment, related to the El Niño phenomenon in Costa Rica in 1997-1998. This classification makes it possible to clearly define the values of the environmental services lost in the affected areas.

Table 6

MAIN ENVIRONMENT IMPACTS ON WILDLIFE PRODUCED BY THE EL NIÑO PHENOMENAN IN THE HUETAR AND CHOROTEGA REGIONS OF COSTA RICA IN 1997 - 1998 a/

Impact on	Cause	Intensity	Recovery period	Notes
Wetlands CaÒo Negro WLR	Drought	Severe	<5 years	Lower water level in lagoons and swamps
Wetlands CaÒo Negro WLR	Fire	Very Severe	<1 year	Damage to undergrowth and surrounding grass
Cedar trees in CaÒo Negro WLR	Fire	Irreversible, without spontaneous recovery	<20 years by importing species	The Maria cedar tree is unique to the Northern area. Once it has been burnt it will not recover
Riverside forests	Drought	Moderate	1 year	Late flowering, loss of fruits
Birds resident in CaÒo Negro	Fire	Very Severe	<10 years	Loss of habitat
Migrant birds at CaÒo Negro WLR	Fire	Very Severe	Unknown but could be swift	Loss of habitat
Land mammals	Fire	Very Severe	Unknown	Death of individual animals
Bats	Fire	Severe	Unknown	Loss of the habitat of a magnificent predator on insects and seed disperser
Batrachians Herpetofauna	Drying of wetlands	Moderate	Medium term	Reduce populations; smaller habitat
Threatened Ichthyofauna	Drying of wetlands	Severe	Variable	Tropical garfish (Astractosteus tropicus), a threatened living fossil.
Sea fishing	Oceanic imbalance	Severe	Variable	Fisheries displaced, greater effort. Coral reefs die
Trout breeding	Reduce currents	Moderate	Short term	Reduce flow of fresh water
Palm and undergrowth	Undergrowth burnt	Severe	Unknown	Disappearance of predators on pests

Source: ECLAC, 1998
Abbreviations: NP: National Park; WLR Wildlife Reserve

d) Classification and assessment of the effects on the environment

The next step is to classify the disaster's effects on the environment in terms of direct and indirect damage in order to make them compatible with the economic assessment methodology. Bear in mind that direct damage derives from changes in the quantity or quality of the environmental assets (environmental change): loss of soil and vegetation, loss of quality and/or quantity of water, changes in the dynamics of ecosystems and so forth. The disruption of human-made capital that prevents (or makes it more costly) the use of environmental assets is also considered direct damage: disruption of water-distribution networks or water-treatment facilities; disruption of communication networks and means of transport that make it impossible to carry out activities entailing the use of environmental goods and services; and so on. Indirect damage consists of modifications to the flows of environmental goods and services arising from a temporary inability to use the environmental resources due to the damage caused by the disaster up to restoration of natural and/or man-made capital.

Once the environmental impacts have been identified and classified into direct and indirect damage, the next step is to quantify and assess them. This is the most difficult stage of the assessment task, mainly because of time constraints, and the quality of the information is crucial.

The quantification process establishes the magnitude of the identified environmental effects: the area of burnt forest or of eroded soil, the length of beach damaged, the reduction in the volume of fishery catches, the reduced flow of water, the presence of pollutants in the water, the number of individual members of a species killed and so on. The assessment process puts an economic value on the identified environmental effects. In most cases, quantification comes before assessment, although quantification is not always necessary to assign a value to the environmental effect. In practice, different situations arise.

In many cases, neither quantification nor assessment can be carried out. For example there is rarely sufficient time available for disaster assessments to obtain quantitative information about the impact on specific species (without use value) or on other variables that form part of the ecosystems' dynamic. Also, it will only be possible to describe these impacts qualitatively, even if they can be identified and sustained. For example, in the case of fauna it is hardly ever possible to ascertain the number of affected individuals. Even if it were possible to obtain this information, it would be impossible to allocate a value to each of the affected individuals.[8] Consequently, in such a case it would only be possible to identify the environmental effect. However, if a project to introduce new individuals were planned, its cost could be used as an approximation of the value of the individuals lost.

The foregoing situation also occurs when there are changes to the landscape (variations to the coastline, for example) that have no significant effect on productive activities (for example, in the case of tourism). On other occasions, although it might be technically feasible, detailed information is not available or is of low quality. For example, it can be very difficult to determine the area of soil lost due to flood-generated erosion when the affected area is large and there are no remote sensors that might, be able to supply aerial photographs.

8 There are, for example, approximations of the existence value of endangered species, although they refer to the species as a whole and are not applicable to a specific number of individuals. The methodologies applied, as well as having been called into question, require a great amount of information.

e) Economic assessment of environmental damage

The purpose of assessing damage in this methodology is to identify the magnitude of the impact on the environmental resources and services and on the economy of the country or region affected.[9] It eventually also allows one to propose strategies and plans to restore the environment after a disaster has occurred.[10]

As mentioned earlier, there are several distinct types of environmental values. Use values apply when goods and services that contribute to people's well-being are derived from the natural resources. Non-use values are not related to any direct or indirect use and arise from the psychological benefits derived from, among other things, the mere knowledge that the resource exists (existence value) or the wish to preserve natural capital for future generations to enjoy (inheritance value). Option values are defined as the benefits accruing from the preservation of options for the use of a particular resource when there is uncertainty about either its possible future use or its future availability.[11]

There are different procedures for appraising natural assets.

- An estimate of the economic value of an environmental asset in the event that there is a market value for said goods. In this case, provided that prices are not distorted, the environmental changes can be appraised directly using market prices. If a natural resource provides several services and there is no market value for all of them, this procedure cannot be used to provide a reliable measure of the resource's economic value.
- An indirect estimate of the environmental goods for which there is no market by measuring the market prices of related economic goods (surrogate markets). The techniques used to make these estimates cannot be used to measure non-use values.
- An indirect estimate made after consulting users about the value that they ascribe to the environmental goods for which there is no market. This procedure can be used for both use and non-use values.

9 One of the problems associated with environmental assessment is the calculation of the population that suffers loss of well-being, since some of the environmental services have the nature of a general public good (e.g. the maintenance of biodiversity and the fixation of greenhouse effect gases). This means, for example, that the damage caused when a forest fire releases carbon into the atmosphere affects the entire world as well as the country directly involved. The international community has created financial mechanisms such as the Global Environment Fund (GEF) to encourage countries to implement activities that generate global environmental benefits, although they do not directly benefit from them. The method used here is to include all damage regardless of the area involved (private, national, global).

10 It is normal in environmental analysis to make this kind of assessment by measuring (in monetary terms) the costs and benefits of the environmental changes so that they can be compared with other market values. Such a comparison makes it possible to make: prior assessments of alternative courses of action that involve both environmental changes and alterations in the allocation of other economic goods (cost-benefit analysis) and subsequent assessments of the impacts of real environmental changes on well-being in order to calculate the possible compensation for damage or to assess the economic efficiency of the restoration measures.

11 Although some authors consider that the option value is a special variety of use value, others include it among non-use values.

Only a few environmental goods or assets can be measured directly in terms of their market value. Consequently, indirect procedures are commonly used to estimate them.[12]

Indirect procedures provide objective measurements of the damage brought about by different causes, and they allow one to identify and measure the physical relationships that describe the relationships of cause and effect. One such procedure is the production function method; others are based on different costs such as those of prevention, relocation, sickness, human capital and restoration. Because it is commonly used for these purposes, the restoration cost method is described in the following inserts.[13]

Restoration Cost Method

The economic benefits $\mathbf{B_t}$ derived from an environmental attribute EA (for example water of a given quality for human consumption) can be expressed as:

$$B_t = f(EA)$$

For the sake of simplicity, it is assumed that if EA = 0, then $B_t = 0$ (alternatively it can be considered that if EA = 0, the water can continue to be used, although at a higher cost since it will have to be treated in each home). If a disaster affects EA such that EA = 0, the economic damage should be measured indirectly from the present value of the lost benefits (PV). Alternatively, it can be assessed from the restoration cost C (investments required to return the water to its original quality). Assuming that the investment in restoration is "immediate", restoration is economically efficient when C □ PV, and for this reason an estimate that uses C will generally underestimate the economic damage. In principle, when C > PV, restoration should not be carried out; if it is, the economic damage will be overestimated.

Direct environmental damage is also produced when the damage to the man-made capital prevents, or increases the cost of, the use of environmental assets. This damage is mainly caused by the total or partial loss of other forms of capital, such as physical infrastructure.

The restoration cost to be considered is that of restoring the man-made capital, which is an indirect estimate of the environmental damage. As when making a direct estimate of damage, the economic benefits B_t derived from an environmental attribute EA (for example water of a given quality for human consumption) require a physical asset K (for example, the water distribution system).

$$B_t = f(EA, K)$$

12 This classification is based on the work of Pearce and Turner (1990) and Turner et al. (1995).

13 The restoration cost approach has been used often in the cost-benefit analysis of new projects and policies. In some countries, such as the United States, it is the basis for estimating damage compensation. The Integrated System of Economic and Environmental Accounting proposed by the United Nations considers this approach to be a possible method for environmental valuation. United Nations, *Integrated Environmental and Economic Accounting: An Operational Manual*, New York, 2000.

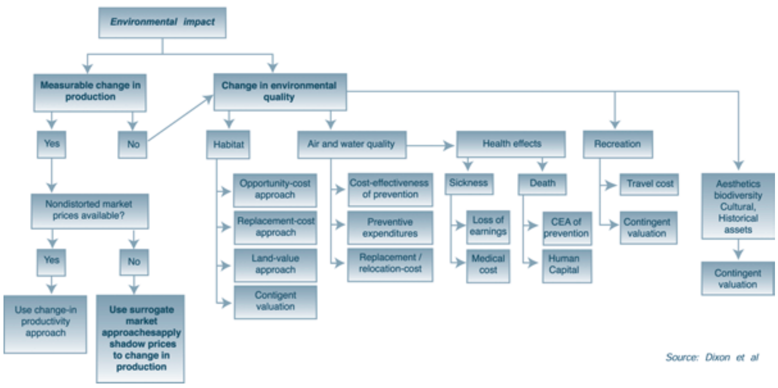
In this case, it is assumed that the disaster has not affected EA, and for simplicity it is assumed that if $K = 0$, then $B_t = 0$ (alternatively it can be considered that if $K = 0$, the water can continue to be used, although at a higher cost). If a disaster affects K such that $K = 0$, the economic damage should be measured from the present value of the lost benefits (PV). Alternatively, it can be assessed from the restoration cost C (investments required to rebuild the water distribution system). Assuming that the investment in restoration is "immediate", restoration is economically efficient when C □ PV, and for this reason an estimate that uses C will generally underestimate economic damage. In principle, when $C > PV$ restoration should not be carried out (if it is, the economic damage will be overestimated).

The other estimation methods can also be used, according to the basic information available.[14] The graph in Figure 3 shows the procedures or methods that can be used to evaluate the different types of environmental change in different situations. Because of its importance in relation to the assessment of other economic sectors, the change-in- productivity approach (or the production - function method) is shown in a box.

14 For a more detailed explanation of these methods, see Dosi, D., *Environmental Values, Valuation Methods, and Natural Disaster Damage Assessment,* (LC/L.1552-P), ECLAC, Santiago, Chile, 2000.

Figure 5

ENVIRONMENTAL IMPACT VALUATION METHODS.



Despite the use of restoration cost as a preference method, it is still necessary to assess the damage during the time taken to restore the asset. Also, there are situations in which this method cannot be used (because of the characteristics of the natural asset which has been affected, because it would not be economically efficient or because restoration is not going to be carried out). In such circumstances, when technically possible, one of the other existing methodologies will have to be used to assess the damage. The final choice of the assessment technique to be used will depend on a series of criteria and circumstances. Ultimately, the choice of technique is going to be influenced by the amount of information needed, its availability and the ability to obtain it at a reasonable cost within the time limit.

Most available techniques are inherently incapable of estimating all the value categories. For example, some of them focus on estimating a particular use value, such as the cost of travel for recreation values; hedonic prices for area environmental attribute values; or the prevention cost for values related to health risks.

Change - in - productivity approach

This approach seeks to exploit the relationship between environmental attributes and the output level of an economic activity. The underlying assumption is that when an environmental attribute enters a firm's production function, the economic impacts of environmental changes may be measured by looking at the effect on production and by valuing that effect at market (or shadow adjusted) output prices. The monetary estimates obtained in this way should not be interpreted as the "true" value measure, but as a proxy of the environmental change's ultimate welfare impacts. Under this approach, the value of natural capital is considered as resource inputs into production: land for agricultural production, forest as a source of timber, etc. If the natural resource of interest provides multiple goods and services, some of which are unmarketable, this valuation approach would fail to provide reliable measures of the resource's value. However, in the context of natural disaster damage assessment, this approach allows estimation of the environmental contribution to economic activities (agriculture, forestry, fishery) that are assessed separately.

If Y is the activity's output, ENV the environmental variable(s) of interest, and X_i (I = 1…..N) other inputs, the production function might look like this:

$$Y = f(X_i, ENV)$$

A change in ENV (e.g., an increase or decrease in water pollution) will decrease/increase output levels. Broadly speaking, when Y is a marketed good, and the observable price is not affected by relevant market-failures, this price can be used to estimate the value of a change in ENV.

This approach is closely linked to the concept of economic rent. Economic rent is the return on a commodity in excess of the minimum required to bring forth its services. Rental value of the natural capital is therefore the difference between the market price and the cost of production/extraction. For example, in the case of agricultural and livestock production, the contribution of the environmental asset (agricultural and pasture land) can be estimated as the difference between the market value of the output and the production costs. In the case of forest resources, the value of roundwood production and other non-timber goods less production costs would represent the contribution of forests to economic activity. When an environmental change produces a diminution in the natural asset productivity, it can be assessed by multiplying the output change by the current output price.

This is the simplest way of using this valuation approach. Its main caveat is that it ignores possible prices changes and this is not the case when significant and widespread changes in environmental conditions could entail non-negligible price effects. Market failures, such as open-access conditions (present in many fisheries, in which economic rent is close to zero) represent another problem for the use of this approach.

The time available and the cost make it practically impossible to make estimates based on contingent assessment methods (which are potentially capable of estimating both use and non-use values). Nevertheless, if such a study for any of the affected areas (species) existed before the disaster, then this method should be used to estimate damage.

The environmental value transfer procedure is the process by which a demand function or the value of an environmental attribute or of a group of such attributes obtained in one context is used to estimate environmental values in another context. The use of estimates from earlier studies to assess the costs and benefits of new projects, environmental regulations or other policies is common in the field of public decision-taking, and it has been formally recommended and adopted by several agencies for the economic assessment of environmental impacts.

The use of this technique is justified by the resources saved. The constraints of time and other resources that affect disaster assessments make this a particularly interesting method. Protocols exist for the implementation of this technique, which involves three major steps:

(1) Identification and selection of original studies

Once the analyst has identified the relevant ecological and economic cause-effect relationships which are believed to drive changes in people's welfare resulting from the environmental changes that are expected to occur or that have actually occurred at the study site (the "transfer context"), the analyst has to identify previous studies that can potentially quantify such changes.

Once a search of the literature or other available sources has revealed potential candidates for transfer, the analyst should evaluate their transferability and select the most appropriate one(s). Several criteria have been suggested for assessing the transferability of existing studies. Besides their scientific soundness, special attention should be paid to the original studies' relevance: that is the original study context and the transfer context should match as closely as possible. In particular, the magnitude of environmental changes and the affected "environmental commodities" must be similar; the baseline environmental conditions should be comparable; the affected populations' socio-economic characteristics should be similar.

(2) Synthesis of available information

Finding studies that adequately satisfy the aforementioned general criteria may prove difficult. If analysts are able to pick up several useful studies, however they face the problem of exploiting all the acquired relevant information in an efficient and sensible way.

The simplest approach consists of using the bundle of selected studies to get a range of possible estimates (lower bound and upper bound estimates) or simple descriptive statistics (e.g., the mean and standard error).[15] More sophisticated approaches exist, such as meta-analysis techniques.

(3) Transferring information

After identifying relevant studies and synthesizing available information in some way, the next step consists of transferring such information, in order to get cost (or benefit) estimates. This can require ad hoc adjustments to the available estimates and may entail some arbitrary decisions.

The Discount Rate

Bearing in mind that natural resources are considered to be economic assets whose values can be indirectly estimated from service flows, an assessment of environmental damage should account for the variations in these flows during the period in which they occur. To do this, it is necessary to identify the times that the loss of environmental services begins and ends, to estimate annual losses of well-being and to choose discount rate.

The use of discount rates is the subject of wide-ranging, and as yet unsettled, theoretical debate. In principle, the difficulty of choosing an appropriate discount rate can be avoided if a political decision has been taken to restore the natural capital's productivity, provided that the restoration is technically possible and is in fact carried out. However, this will only be the case when restoration is carried out immediately after the disaster and the recovery of the natural capital's productivity is also "immediate".[16] In reality, if restoration is not carried out immediately or if its execution will take more than one year, a discount rate should be used to express the cost of restoration at present values so as not to overestimate the damage. The same thing happens when the restoration is immediate but does not enable total immediate recovery of the environmental services. The three alternative scenarios shown below will make this clear.

1. The restoration (whose total cost is C) is carried out immediately (t = 0), but the capital will be recovered over time t = n. During this time, the people affected suffer annual losses of well-being B_t (t = 0, … n). In this case, the economic damage caused by the disaster will be

$$D = C + \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} \qquad (1)$$

2. The restoration is executed in time t = n and, once completed, enables the immediate restoration of productivity. In this case,

15 For example, in a study aimed at assessing the total economic value of Amazonian deforestation, Torras (2000) exploits previous studies which have focused on specific forest value categories (direct use, indirect use, and non-use values), and calculates the annual per-hectare economic loss by using the mean of the estimates from these studies. In this way the author arrives at an estimated total annual value of a representative hectare of Amazon rain forest of US$1 175 (1993 prices). Although the methodology employed is quite crude, the paper provides valuable information about a large number of empirical studies in developed and developing countries aimed at estimating forest values.

16 Although this situation is unlikely to be found in reality, there are similar situations, such as when restoration consists of cleaning debris from a beach used for recreation.

$$D = \frac{C}{(1+r)^n} + \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} \quad (2)$$

3. Finally, the restoration is carried out in time t = n, but recovery of the asset's productivity will take t = n+s. In this case,

$$D = \frac{C}{(1+r)^n} + \sum_{t=0}^{n+s} \frac{B_t}{(1+r)^t} \quad (3)$$

Most of the conceptual problems related to the discount process –intergenerational equity, uncertainty about future preferences and uncertainty about the discount rate itself– can be avoided if the recovery phase is not "too long".[17] In this case (short - term environmental damage), the personnel in charge of the disaster assessment should use a "standard" discount rate, such as (for example) that used for cost-benefit analysis of public projects.

Other approaches can also be used. For example, Kunte, A., et al (1998) used a discount rate of 4% for estimating the value of natural capital as resource inputs into production of the countries of the world.
Kunte, A., K. Hamilton, J. Dixon and M. Clemens. *Estimating National Wealth: Methodology and Results; Series Indicators and Environmental Valuation of the World Bank* (paper circulated to encourage thought and discussion), Washington, 1998.

3. Estimating the environmental damage

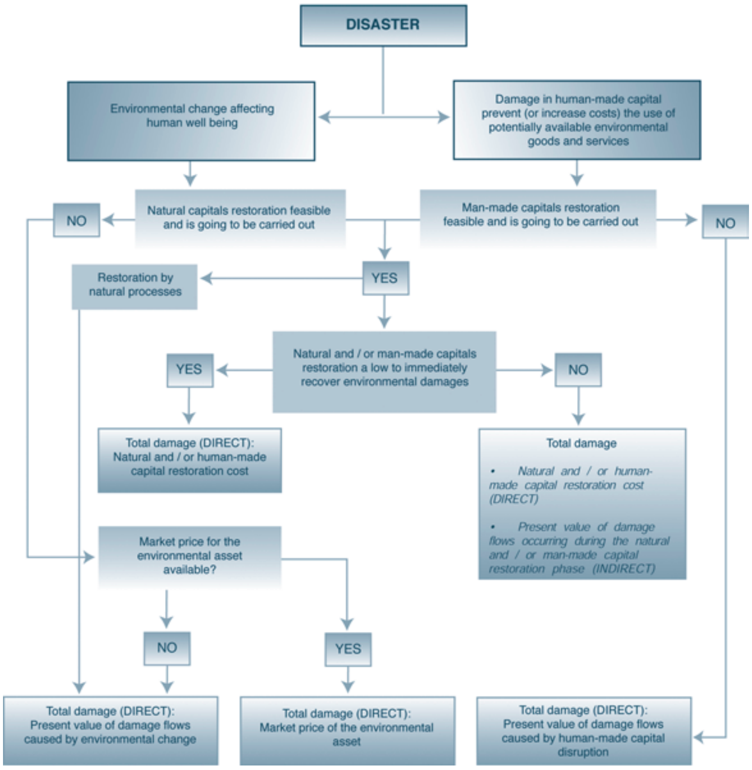
When making preferential use of the restoration cost method to assess damage, the environmental specialist should remember that there are differences between the restoration of a natural asset and the restoration of man-made capital.

First of all, it may not be technically possible to restore the natural asset. Second, when it is possible, it may take more time to restore the natural capital than the man-made capital infrastructure. Third, unlike man-made capital, natural capital is sometimes restored by natural processes, provided human intervention allows. This is the case, for example, of some types of forest after a fire or of the sandy beaches on some islands following the erosion caused by hurricanes or tropical storms. In this last case, there is no point in making an assessment by applying the restoration cost, and other methods will have to be used. The following graph illustrates the procedure for making an economic assessment of environmental damage.

17 The longer the restoration stage, the more difficult it is to identify a suitable discount rate. Therefore, the Principle of Caution advises a downward adjustment of the "standard" discount rate. However, it is not easy to say how much the rate should be reduced.

Figure 4

PROCEDURE OF ECONOMIC ASSESSMENT OF ENVIRONMENTAL DAMAGE



The definitions of direct and indirect damage, the direct and indirect ways of estimating damage and the calculation methods described previously should be borne in mind when studying the following specific examples of damage caused to different environmental assets and services.

a) Damage to the air

The air is often affected by the pollution caused by natural events, such as volcanic eruptions, as well as that caused by human activities. It is clearly not feasible at present to ascribe a value to pure air for human consumption. Any definitive alteration in air quality can only be estimated indirectly by calculating the cost of air cleaning programmes that might be undertaken (restoration cost). These are not normally put into effect to counteract natural disasters, but are used in the case of urban environmental degradation caused by human activities. In this sort of case, the assessment will be based on the annualized investments required to implement the clean-air projects.

The indirect damage resulting from temporary air pollution can be measured according to the corresponding increase in economic flows (higher current expenses) required for health and defensive expenditures throughout the period needed to re-establish normality.

A theoretical example of this situation would be a volcanic eruption that pollutes the air in a city and reduces visibility for interurban transport in the zone of influence. The air would only be cleaned naturally with the passing of time (probably by the action of rain), so it is not feasible to assess direct damage. However, it is possible to determine the resulting indirect losses during a three-month period, which is the time required for the situation to return to normal, by measuring the higher costs of medical care for the population, the cost to the population of buying masks (to avoid respiratory problems) and the increased costs derived from the use of longer, more expensive routes to carry people and goods (because of transportation difficulties). The tourism sector might also be affected by a lower flow of visitors. These types of indirect damage will, however, have been assessed under the health, transportation and tourism sectors.

b) Damage to water resources

There are two types of damage that can occur: changes in the quantity and quality of the water (natural asset) and damage or destruction of water works and distribution systems (man-made capital).

The assessment of direct damage is different in each case. In the first case (reduction in the quality or quantity of water), it is usually difficult to ascribe a value to the damage caused to the asset. Nevertheless, an assessment can be made indirectly based on the annualized investments needed to construct water purification/cleansing works or systems. In the second case (damage to man-made capital), the direct damage can be estimated through the cost of rehabilitating or reconstructing the existing systems, whether these supply water for human or industrial consumption, electricity generation or agricultural irrigation.

Calculations of indirect damage in the case of pollution are based on the higher operating costs and lower income of the existing treatment plants, as well as on the defensive expenditure incurred by private individuals (e.g., the purchase of filters) and on the increased cost of providing the population with medical care. If water works or distribution systems have been affected, the indirect damage is also assessed according to the higher costs and lower income of the companies providing the service.

An example of this is damage caused by increased silting in rivers due to heavy rains in a catchment area where water is collected for human and industrial consumption. Assessable direct damage is the cost to the water treatment plant of repairing the works in the catchment area and cleaning its equipment. Investments in forestation to protect the catchment area can also be included under this heading. Indirect damage, on the other hand, includes the increased cost of operating the plant because more energy is needed to pump water from further away, as well as the fall in income due to reduced billing during the time needed for its restoration, when the plant is either unable to operate or capable of only limited operation.

In the case of floods that damage agricultural irrigation systems, the direct damage would be equal to the cost of restoring or replacing the irrigation systems, while the indirect damage would be equal to the present value of the difference between the market value of production and the production costs during the time that the repairs or reconstruction are being carried out.

When there is drought or insufficient water to meet needs, direct damage is not assessed. However, the production that will not be obtainable during the drought in the agricultural and livestock, industrial and commercial sectors (including services), as well as the increased costs and reduced income experienced by the providers of services such as electricity and drinking water, is assessed as indirect damage.[18] As in the case of air pollution, much of this damage will already have been assessed in the infrastructure, health and agricultural sectors.

c) Damage to the land and seabed

The land can be permanently or temporarily affected by the action of a natural or anthropic event. In some cases, the impact may be positive, as when deposited materials have the medium-term effect of making the soil more fertile or when unexpected rains make production possible in areas that are normally arid.[19]

In the case of a negative impacts, direct damage can be assessed directly by taking the market value of the affected land, provided that this is not economically distorted. Alternatively, it can be assessed by calculating the present value of the farm production less the production costs (economic rent) that would no longer be obtained. In the case of repairable damage, the direct damage can be assessed as the cost of restoring the affected area through, for example, soil conservation projects. In the case of irrigated land its value implicitly incorporates the value of water.

18 See, for example, the case of the losses caused in Central America by the drought of 2001, in ECLAC, L.510/Rev.1, february 12, 2002.

19 This would be the case of the soil that received deposits of ash with a high mineral content from the Chinchón volcano in Mexico and, as a result, became more productive. A similar situation occurs with extensive areas of normally dry land in Ecuador that become productive temporarily because of the action of unexpected rains caused by the El Niño phenomenon.

In the case of land used for housing and human settlements, the assessment of the direct damage to the natural asset is based directly on the land's commercial value (in fact, urban land fits better in the concept of constructed capital). The assessment of the damage caused to the man-made capital (infrastructure and services) is based on the restoration or replacement value. These assessments are normally included in the housing and human settlement sectors.

During a natural disaster such as a hurricane, the waves that are generated by the intense winds will often have a significant impact on the seabed and marine ecosystems. The waves interact with the seabed and can cause considerable reshaping, which extends to the shoreline. The impact may be positive, as in the case of sand brought to the shoreline from offshore reserve areas, a process known as cross-shore sediment transport.

In the case of beaches, pieces of land or buildings for recreation or tourism that have been flooded, silted up or covered by debris deposits, the assessment of direct damage will be based on the cost of clean-up and the cost of beach restoration (including sand refill) when such measures are economically feasible. This damage assessment may have been made in the tourism sector.

Where soil rehabilitation is technically and economically feasible, the assessment of indirect damage should be based on the present value of the difference between the market value of the output crops and crop production costs during the period required for the rehabilitation. If a natural event makes production feasible in areas that are normally arid, the new production should be deducted from the losses to determine the event's net effect. This assessment is normally made in the agricultural sector. Given that farm production is the first link in a chain, it is also necessary to estimate the fall (or rise) in industrial production and in the commercial sector's sales resulting from the fall (or rise) in farm production.

Disaster-induced indirect damage related to the housing and human settlements sector is normally assessed under that sector. Indirect damage to tourism should be assessed as the income that will not be received during the time that the beaches are being rehabilitated. This figure forms part of the damage assessment of the tourism sector.[20]

d) Damage to biodiversity

Some disasters have extremely negative impacts on forests and vegetation. Fires, droughts, hurricanes and heavy rains are capable of causing permanent or temporary damage to large areas of forests and mangrove swamps.

20 Likewise, tourism sector income that cannot be generated because of direct damage to roads and other means of communication (although tourism installations have not been damaged) should also be considered as indirect damage.

The assessment of the direct damage in such cases can be based on the commercial value of wood and non-timber products in natural forests or plantations that are in production less the production, costs (economic rent). In the case of natural woodlands not being exploited for their timber,[21] the direct damage can be assessed indirectly by calculating the value of the environmental services (such as sequestration and storage of carbon, conservation of biodiversity and regulation of the water cycle) and goods (such as firewood and non-timber products when these are exploited) that will be unobtainable for a long period (the length of the period should be defined by the environmental specialist).[22] Mangrove forests provide environmental goods and services such as timber, fisheries and other species habitat, maintenance of estuarine water quality and shoreline protection. If actions are planned for the recovery of forests, mangroves swamps or urban parks, the assessment of direct damage is based on the restoration cost.

An example of this is provided by the Costa Rican forests that were damaged by fire during the drought caused by El Niño in 1997-98. Since they were expected to recover naturally, direct damage was assessed based on the present value of the forest services that would not be obtainable during the recovery period.[23]

When forests and mangrove swamps are only partially or temporarily affected, the assessment of indirect damage should be based on the present value of the environmental services that will be unobtainable during the period needed for the assets to recover. If the assets are totally lost with no possibility for recovery or if restoration is deemed a very long-term proposition, indirect damage should not be assessed.

It is not normally feasible to make an assessment of direct damage in the case of wild animal species, whose loss reduces biodiversity.[24] However, where repopulation is planned, the cost can be used as in indirect way of assessing the damage. A similar situation occurs with loss or direct damage caused to the coral formations that are mainly found on Caribbean coasts. Hurricane waves can damage coral reefs, as the horizontal and vertical action of the waves can break off pieces of coral. After such an event, and in cases where coral damage has been reported, it may be necessary to carry out an underwater video reconnaissance, or to rely on local dive professionals to estimate the aerial extent of damage.

21 In the case of protected areas, another way of valuing damage in natural forests not used for timber extraction is through the opportunity cost of preservation (the foregone benefits from converting them to pasture or agricultural land). This value must be considered as the minimum value of the protected area.

22 Some countries have mechanisms for payments of environmental services that permit a direct approximation of the value (partial or total) of services associated with forests.

23 ECLAC, 1998, *The* El Niño phenomenon in Costa Rica in 1997-1998; Assessment of its impact, and rehabilitation, mitigation and prevention needs in light of climatic *change,* (LC/MEX/L.363), Mexico City

24 In very special cases. direct damage to certain wild species could be estimated when there is a market for products or hunting licenses (sport or traditional). However, while a commercial value could be assigned to a specimen of the species (a partial approximation to its total economic value), estimating the affected population is more problematic.

In this case, it would also be possible to make the assessment indirectly on the basis of the environmental services (coastal protection recreation, fishing, biodiversity conservation) provided by the coral reefs as ecosystems.[25] The main difficulty with this method lies in estimating the chances of natural recovery and the length of time that it will take.

As the waves travel over the reefs to shore, they often uproot seaweed beds. An example of this was recorded in Belize in the Inner Passage between the mainland and the cayes, after Hurricane Keith. That event uprooted hundreds of hectares of seaweed beds, which were seen floating on the surface of the sea in large mats. Assessment of the value of this ecosystem can be linked to the cost of seaweed replanting programmes, evaluated on a per hectare basis; another option is the estimation of the sand producing potential of the seaweed beds and the subsequent valuation of the beach enhancing potential of this sediment.

Where damage is caused to the coral formations and emblematic species that attract tourists, it is possible to base an assessment of indirect damage on the income that will not be obtainable by the tourism sector during the time that it will take to recover the former environmental conditions.[26] However, this can only be done when the activities are identifiable in economic terms (e.g., lower takings from entry fees to land and marine parks; less income for recreational diving businesses).

e) Environmental damage by man-made capital disruption and overlap with other sectors

As indicated above, environmental damage can arise from man-made capital disruption (disruption of water distribution networks and roads, loss of buildings such as hotels, etc.) that prevents the use of environmental goods and services. Restoration cost of man-made capital is the way to estimate this direct environmental damage. Under thisapproach, it is necessary to distinguish two situations:

(1) When man-made capital is closely and exclusively linked to the use of environmental goods and services, man-made capital restoration cost can be considered as a proxy for environmental damage. This is the case of water distribution networks that allow the use of water or roads that are only used for recreation in natural areas (for example, inside a national park).

25 Reviewing work done in assessing reef value in Australia, Aruba and Jamaica may assist in assigning a monetary value to the damaged reef. Valuation rates can vary from US$7 500 per hectare to US$500 000 per hectare, depending on the location of the reef and its role in the overall ecosystem. Recent work on coral reef valuation includes the importance of coral to the pharmaceutical industry. Restoration actions (such as coral transplantation) are sometimes carried out.

26 A concrete example of this is the case of the Caribbean island of Anguilla, whose coral formations and beaches have often been swept by the wave of hurricanes and tropical storms in recent years, negatively affecting tourism occupancy rates after such events. See ECLAC, 1995, *The macro-economic effects and reconstruction requirements following hurricane Luis in the Island of Anguilla,* (LC/MEX/L.289 and LC/CAR/L.462), Mexico City.

(2) In many cases, however, man-made restoration cost also encompasses the use of non-environmental goods and services such as infrastructure (e.g., roads) used for trade or human transportation, but not exclusively linked to recreation. Hotels in nature areas allow for both nature-based recreation and other goods and services (food, lodging, fun, etc.). In these situations, human restoration costs include the present value of both environmental goods and services, and non-environmental goods and services. Consequently, this approach can overestimate environmental damage.

Something similar happens when estimating indirect damage, for example when environmental damage temporarily prevents tourist activities. In this case, only part of the tourist expenses can be considered exclusively "environmental" and it is not always easy to segregate this component. One instance in which it is possible to determine a specifically environmental component is via entry fees charged to enter protected areas or taxes used for environmental protection; these can be used as a proxy for the environmental contribution to the economic activity. However, a deeper exploration of such damage could be very difficult.[27]

Thus, in both cases (direct and indirect environmental damage), it may be difficult to isolate an accurate figure for environmental damage distinct from that of other sectors. This will depend on the available information. This problem is partially overcome (in terms of taking into account all environmental damage) when considering that most environmental damage is already considered in the assessment of other sectors (agriculture, tourism, infrastructure, health, etc.).

To summarize, the following figure shows the different situations in which environmental damage assessment can be divided.

27 The approach for estimating the economic rent generated by the environment in tourist activities is through the difference between the market price (for example, room rate per night) and the hotel production costs (salaries, inputs and other expenses, including a normal rate of return of the investment). Hotels located in places with special landscapes can charge higher prices than others with less favored locations. The same occurs within a hotel; rooms with the best views are more expensive.

Table 7

DIFFERENT TYPES OF ENVIRONMENTAL DAMAGE ASSESSMENT

Direct and indirect environmental damage
I Without monetary valuation. Damage described or qualitatively assessed.
II Monetary valuation. Environmental damages not included in the assessment of other sectors.
III Monetary valuation. Environmental damages included in the assessment of others sectors. They can be easily isolated from other sectors.
IV Monetary valuation. Environmental damages included in the assessment of other sectors. It is difficult,if not impossible,to isolate them from other sectors.

Monetary assessment of environmental damage is limited to the situations described in boxes II and III in the figure. The amounts obtained in box II will be added to the estimations of other sectors to get an overall assessment of direct and indirect damages. The summ of boxes II and III, will provide a clearer idea of the damage suffered by the environment and facilitate a comparison with other sectors. However, when arriving at overall figures of damage, the amounts of box III must be separated to avoid double counting.

The following table shows the types of environmental damage classified according to the different categories described above and the sectors in which they are most likely to have been included.

Table 8

TYPES OF ENVORONMENTAL DAMAGES AND OVERLAP WITH OTHER SECTORS

Direct and indirect environmental damage	
I Without monetary valuation. Damage described or qualitatively assessed.	
II Monetary valuation. Environmental damages usually not included in the assessment of others sectors. (i) Environmental damage usually that is assessed on the basis of the cost of environmental restoration, especially when the conservation of de affected environmental asset is the responsibility of the country's environmental bodies. This is usually the case with protected natural areas and (ii) environmental damage that is assessed by variations in the flows of goods and services for which there are no clearly established markets (e. g., environmental services provided by forest; such as the sequestration of atmospheric carbon or regulation of the water cycle). The most common damages included in this category are: ī Loss of environmental services linked to the damage of ecosystems such as forest, mangroves, coral reefs, etc. ī Damage to the infrastructure of protected areas (roads, signposts, research centers, etc).	
II - III Monetary valuation. Damages in which the frontier between environment and other sectors assessments is not very clear. It could depend on the organization of the assessment team or on the institutional organization of the country affected.	Sectors in which environmetal damage could have been assessed
ī Damage to infrastructure and equipment related to environmental sanitation, such as dumps and garbage collection and treatment facilities and equipment ī Restoration of urban parks	Water and sanitation sector and/or housing and human settlements
ī Lower earnings from protected areas (terrestrial or marine parks) entry fees ī A fall in taxes used for environmental protection (e. g.,additional airport or hotel taxes that are levied on foreign visitors in certain countries)	Tourism
III - IV Monetary valuation. Environmental damages usually included in the assessment of other sectors. Isolating environmental damage depends on the availability of information. ī Loss or loss of quality of agricultural and pasture land ī Loss or agricultural and forestry production ī Loss of fish catch	Sectors in which environmetal damage have been Agriculture and Fishing sectors
ī Water distribution problems caused by contamination, disruption of distribution in infrastructure and/or availability ī Health problems linked to changes in environmental conditions	Health, drinking water and sewage sectors
ī Losses related to the tourism sector	Tourism
ī Changes in energy production and distribution caused by environmental changes (e. g.,silting of dams or disruption of distribution networks) ī Loss of sub-soil assets (e. g.,oil spill)	Energy sector
ī Relocation of houses exposed to new threats ī Diminution of house values caused by environmental changes (including changes in landscape)	Housing and human settlements
ī Problem in transport (terrestrial, maritime and fluvial) caused by landslides, floods, silting of ports and rivers, etc. ī Changes in environmental conditions that demand restoration actions (e. g. water courses divert demending to undertake drainage actions).	Infrastructure: communication and transport sector

When the summary is prepared, the global specialist or analyst must ensure that there has been no double counting, so that all comparisons made later (for example, with the GDP of the affected country or region) will be valid and give a true picture of what really happened because of the disaster.