Handbook

for Estimating the Socio - economic and Environmental Effects of **Disasters**

Economic Commission for Latin America and the Caribbean
ECLAC

Section Five

Overall effects of damages

I. ENVIRONMENT

1. General considerations

As is well known, a people's quality of life and well-being depends to a great extent on the state of the environment. Ecosystems provide a range of goods (such as food, water, medicines and energy) and services (such as the dilution and transformation of waste, the regulation of the water cycle, carbon sequestration, the maintenance of biodiversity and recreation) that sustain and satisfy human life (see Table 1).

From an economic perspective, natural resources are considered assets (natural capital) from which goods and services are derived that help increase people's well-being. From this point of view, natural resources have a use value.[1] Natural heritage can also generate values unrelated to any direct or indirect use. These non-use values 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).

Extreme events are part of nature, and ecosystems have evolved with them. For example, many ecosystems have adapted to occasional wildfire favored by drought: phyrophytic species in these ecosystems actually require fire for proper germination. Riverine habitats and ecosystems are often dependent on annual floods. When these events occur in remote areas without human intervention, they are not considered disasters.

However, where natural and human systems interact, qualitative and/or quantitative environmental change that detracts from people's well-being can result from extreme natural phenomena.

1 Direct use values derive from the consumptive use (for example, the use of firewood) or non-consumptive use (such as tourism activities) of natural resources. Indirect use values, also known as functional values, can be described as the benefits indirectly enjoyed by people as a result of the primary ecological function of a given resource. For example, the indirect use value of a wetland can derive from its contribution to the filtration of water used downstream.

For example, a hurricane can cover a beach with debris and prevent its recreational use; flooding can lead to contamination by wastewater; drought might affect the survival of an endangered species. Such environmental change can be permanent or temporary. A volcanic eruption with lava flows can result in irreversible changes in the landscape; however, changes in the atmosphere caused by the same eruption, such as pollution by the gases released, are temporary. Changes in people's well-being might arise from the temporary or permanent inability to use environmental goods or services, or the increased costs of their enjoyment without there being environmental change. For example, the destruction of a path leading to a beach might prevent (or make more costly) its recreational use even if the beach did not undergo environmental change.

Table 1
GOODS AND SERVICES PROVIDED BY ECOSYSTEMS

Ecosystem	Goods	Services
Agroecosystems	Food crops Fibre crops Crop genetic resources	Maintain limited watershed funtions (infiltration, partial soil protection) Provide habitat for birds, pollinators, soil organisms important to agriculture Build soil organic matter Sequester atmospheric carbon
Forest ecosystems	Timber Fuelwood Drinking and irrigation water Fodder Nontimber products (honey, fruit, spices, plant medicines, hunting, etc.) Genetic resources	Remove air pollutants, emit oxygen Cycle nutrients Maintain array of wathershed functions (infiltration, purification, soil stabilization) Maintain biodiversity Sequester atmospheric carbon Moderate wether extremes and impacts Generate soil Provide for aesthetic enjoyment and recreation
Freshwater ecosystems	Drinking and irrigation water Fish Hydroelectricity Genetic resources	Buffer water flow (control timing and volume) Dilute and carry away wastes Cycle nutrients Maintain biodiversity Provide aquatic habitat Provide transportation corridor provide for aesthetic enjoyment and recreation
Grassland ecosystems	Livestock (meat, leather, etc.) Water for human consumption and irrigation Genetic resources	Maintain array of wathershed functions (infiltration, purification, soil stabilization) Cycle nutrients Remove air pollutants, emit oxygen Maintain biodiversity Generate soil Sequester atmospheric carbon provide for aesthetic enjoyment and recreation
Coastal ecosystems	Fish and shellfish Fishmeal (animal feed) Seaweeds (for food and industrial use) Genetic resources	Moderate storm impacts (mangroves; barrer islands) Provide wildlife (marine and terrestrial) habitat Maintain biodiversity Dilute wates Provide harbours and transportation routes Provide for aesthetic enjoyment and recreation

Source: World Resources Institute (2001)

In Latin America and the Caribbean, national accounts do not yet expressly include most environmental assets and services. In other words, environmental accounts have not yet been included in the national accounts of countries, although some of the value of environmental services is included in the statistics of such sectors as agriculture, and tourism. Consequently, damage assessment methods in the past did not include estimates of the effects of disasters on the environment. Nevertheless, such estimates can be made by way of a series of indirect procedures.

Our proposed methodology of environmental damage assessment takes into account several major constraints, such as the scarce time available for carrying out the assessment, the lack of information on affected ecosystems and the paucity of markets for most environmental services. Moreover, environmental economics has only recently developed as a subdiscipline within economics, with much room for innovations and improvements in tools and methodologies for environmental valuation.

To undertake such an analysis, concepts must be defined in line with the ECLAC methodology and applied to the specific case of the environment, its assets and its services. Environmental capital or assets are made up of the ecosystems that provide society and economies with environmental goods and services. To assess the effects of a disaster on natural capital, one can begin by separating its components: physical medium (soil, water, air, climate); biotic medium (human beings, flora and fauna); perceptual medium (landscape, scientific and cultural resources); and interactions among the above-mentioned media. Thus, the environmental changes caused by a disaster can produce direct damage to such assets or to works built to take advantage of them; they may also lead to indirect losses when the related environmental services are reduced, diminished in quality or made more expensive.

Direct damage to the environment can be estimated as the value of the assets affected. If there is permanent destruction, direct damage can be considered to be close to the commercial value of the assets when a market exists for them. When there is no such market and a reversal of the environmental change is deemed appropriate, the direct damage can be approximated by estimating the cost of rehabilitating or recovering the assets. For example, if agricultural land is completely destroyed and restoration is not deemed appropriate (whether for technical or economic reasons), the direct damage will be the value of the land. If there is hillside erosion, direct damage can be estimated based on the cost of stabilizing the slopes through soil conservation works.

The presence of values not associated with use of the environment (such as existence values) and the lack of markets for many environmental goods and services pose theoretical and practical obstacles to conducting any economic valuation. When a value cannot be assigned to assets for the estimation of direct damage, estimates must be made by indirect means. For example, the direct damage to soils caused by mudslides can be estimated as the agricultural or forestry production precluded for a period sufficiently long to constitute a total loss. When damage to assets can be recovered naturally over a given period, the value of the damage can be estimated indirectly by measuring the amount of the environmental services the assets will not provide over the period required for recovery.

The many and varied cases of harm or damage must be analyzed individually to define or choose the method for estimating both direct and indirect damage to environment. These are described in the sections below, broken down into the procedures for each of the assets or resources mentioned above. Bear in mind that most of the damage estimated in this way will already have been measured or determined under the different social or economic sectors, and care must be taken not to count them twice at the moment of the damage review.

2. Assessment procedure

To carry out the economic assessment of the impact of a disaster on the environment, the environmental specialist must follow a procedure of successive stages in close co-operation with the sectoral specialists and the macroeconomist. Those stages are as follows:

i) Description of the environmental state before the disaster, representing the baseline for assessment;

ii) Identification of the impacts of the natural disaster on the environment;
ii) Qualitative environmental assessment;
iv) Classification of the effects on the environment;
v) Economic valuation of the environmental impact; and
vi) Overlap with other sectors.

The following sections describe each of these stages.

a) Description of the state of the environment before the disaster

To properly attribute the effects that really are due to the disaster, the pre-existing environmental situation must be appraised.[2] This stage consists of collecting, classifying and describing the environmental conditions involved (resources, natural or artificial systems, biodiversity) specific to the area in question and other areas included within the perimeter officially recognized as affected.

Apart from serving to correctly attribute the effects of the disaster, this process contributes to the analysis of possible links between the scale of the damage caused by the disaster and environmental deterioration prior to the event. For example, in the assessment of the damage caused by Hurricane Mitch in Central America (October 1998) it was established that the severe effects of the rains were aggravated by the previous actions of humans and previous disasters (The El Niño phenomenon of 1997-1998), such as deforestation and the loss of plant cover on slopes, inappropriate land use and the presence of human settlements in such risk areas as flood plains and mountainsides. The comparison of the effects of an extreme natural event between areas with greater and lesser degrees of environmental deterioration highlights the role played by the state of the environment in mitigating or intensifying damage.

Basic information to be collected. The environmental specialist will use a series of elementary steps, duly recording information, in a log or protocol and noting the date and source. These records serve not only for his or her own information but also to enable follow-up and application in similar, later assessments. This method must be based on the following steps:

Gather and collect basic material and bibliographic sources relevant to the problem and area in question, employing personal, library and institutional databases, primary, (books, official reports by independent institutions, NGOs, international institutions, United Nations institutions, foreign-aid banks, private enterprises) and secondary sources (newspaper and magazine articles, Internet sites, etc.);

2 In the case of long-duration disasters (such as droughts), the baseline will be represented by the closest approximation possible to what would have been the situation without a disaster. If the comparison is made with the situation before the disaster, effects due to another type of cause could be attributed thereto. If, for example, the area affected by forest fires is being assessed in the context of a drought, the area affected by forest fires in a normal year must be taken into account (if the information is available). The difference between these two values is what should be attributed to the drought.

Access directories of government institutions and NGOs that list contacts, project heads, spokespersons or ad hoc representatives that are relevant to the study of disasters;

Establish a plan of personal interviews (see following step), in coordination with relevant and appointed national contacts;

Meet with people in positions of responsibility, appointed technical specialists and other figures with knowledge and responsibilities or information relevant to the case in question;

Access laws and regulations while assuring familiarity with the legal framework of the country, state or region in environmental management, environmental control, watershed management, environmental conservation, and biodiversity, as well as in emergency prevention, institutional coordination and preparation, and reconstruction in general (works, infrastructure, environment);

Prepare a plan and guide field studies of affected areas and, if possible, of unaffected and/or pristine areas;

Conduct field interviews with officials, government spokespersons and community leaders while appraising other on - site studies or existing assessments;

Indicate how those factors for which no information exists were studied and quantified by the expert or group of advisers; and

Determine the steps to be followed to improve information and valuation.

Desk study. The desk study and assessment are carried out day by day, before and after meetings with the other specialists participating in the damage assessment, using the information available up to that moment. The first condition for an appraisal of the environmental quality of the area or district affected by the disaster is having access to good, sufficient and reliable information. The availability of quality information depends mainly on the country affected. The following should be used:

Environmental profiles and natural histories;
Reports on past disasters and preliminary reports on the disaster in question;
Maps of potential and actual wildlife and plant life areas, and of potential and actual land use;
Geological and geomorphological maps and reports;
Maps of weather and hydrogeological conditions;
Geographic information systems (GIS) at scales of 1:200,000 and 1:50,000 for large areas and several watersheds; in some cases a 1:10,000 or 1:5,000 level is appropriate; and
On - site, aerial or satellite photographs or films, relief maps (detailed logs must be kept of field trips to affected areas and to similar unaffected areas for purposes of comparison).

All this material will enable reasonably accurate definitions of the state of the environment before and after the disaster occurred. Gathering this information will allow the environmental specialist to undertake the comprehensive qualitative and quantitative study.

Definition of the areas and aspects of greatest interest. An initial screening should determine the points of greatest interest or importance, so that analysts can focus research and assessment on what is most representative of the problem. This is necessary because the time the group of specialists has available for the assessment is almost always very limited by mission cost considerations and the urgent need for post-disaster information. The scope of the study is almost always established within the first two or three days of the mission, after the most important environmental characteristics of the affected area and the probable impact have been taken into account.

If an environmental study group is available, each specialist should concentrate on the environmental variables in his or her professional field; their results can be combined later. A list or basic framework of systems, habitats or species important to each wildlife region (including protected areas that were affected) should be prepared. The most representative ecosystems and their pre-disaster level of environmental service provision (for example, water production CO_2 sequestration, biodiversity, ecotourism) must be taken into account. The chosen variables must be measured on site within the areas of influence in accordance with the behavior patterns and structure of the system where the phenomenon arose, thereby providing a general framework or scenario of the state of the environment.

The characteristics or value of the environment in question must be determined in line with the most important qualities and properties of natural resources, species and/or environmental services.[3] When determining the quality of ecosystems and environmental services, one must consider at least the following:

Unique or unusual land formations;
Protected areas or ecosystems (official or private);
Wildlife areas strategic to a region;
Areas important for the maintenance of natural systems (egg-laying, hatching, birthing and breeding areas; water collection areas, vital support systems) located outside of the country or region in question;
Areas important for the maintenance of species useful to agriculture, fish-farming, animal raising, and so on;
High-quality or unique communities of endemic plants or animals;
Communities of plants or animals that can be used for repopulation and ecological restoration;
Rare or unique habitats;
Biological corridors;

3 Inserts can be used to highlight questions of special interest. For example, in the assessment of the effects of Hurricane Keith in Belize (2000), an insert was included on the main characteristics and human pressures of one of the most important ecosystems in the region: The Meso-American reef system. See ECLAC, *Belize: Assessment of the Damage Caused by Hurricane Keith, 2000: Implications for Economic, Social and Environmental Development,* (LC/MEX/G.4 y LC/CAR/G.627), Port of Spain, Trinidad and Tabago, 2000.

Highly diverse biological communities;
Highly productive habitat (woodland, wetland, estuary, reef, etc.);
Refuge habitat for rare or endangered species;
Habitat for species that need large territories;
Area of seasonal importance to the feeding or reproduction of one or more species;
Areas that maintain a wild bank of domesticated species;
Habitat of great scientific or educational value;
Habitat of traditional importance for the provision of fuel, fabrics, food, construction materials or traditional medicine;
Areas of historic, cultural, religious or archaeological interest; and
Micro/meso/macro areas of aesthetic, landscape and recreational value.

b. Impacts of the disaster on the environment

The different types of natural hazards involving dynamic forces that change the earth's surface can be classed into two well-defined categories. First, internal geodynamic phenomena are governed by endogenous geophysical forces and processes that are part of the earth's crust; these include seismic and plate-tectonic activity, intra-plate activity, and volcanism. Second, hydrometeorological phenomena are mainly governed by extensive macroclimatic or global tropospheric processes, such as trade winds and monsoons, inter-tropical convergence, Hadley and Walker circulation, the El Niño (ENSO) phenomenon, polar fronts, tropical waves and storms, hurricanes and tropical cyclones. This group also includes dynamic processes with a local or focal influence related to the meso- and microclimate, such as tornadoes and waterspouts coastal, convective or orographic storms lightning storms. Some of these phenomena develop in the stratosphere (e.g., ozone layer).

Table 2 Summarizes the effects that natural phenomena can have on the physical, biotic and perceptual environments.

Table 2

THE EFFECTS OF LARGE-SCALE NATURAL PHENOMENA ON PHYSICAL, BIOTIC AND PERCEPTUAL ENVIRONMENTS

Phenomenon	Effects		
	On the physical environment	On the biotic environment	On the perceptual environment
Volcanic eruptions	Air pollution from gas emissions; Changes to course of rivers, beach erosion and coastline alterations; Rubble and mud flows caused by snow and ice or by collapse of volcano walls; Contamination of water bodies; Fires; Earthquakes and tidal waves.	Ill effects on human health: From the energy released From environmental changes such as air pollution (discomfort in mucous membranes, eyes, skin, respiratory system) and water pollution; Loss of vegetation and wildlife due to fires, avalanches and acid rain; Loss of habitat; Extensive ecological imbalance.	Drastic changes to the landscape (barren, desolate landscapes and loss of agrological mosaic) with los of aesthetic characteristics.
Earthquakes	Land and mudslides on mountains, cliffs and coastal bluffs due to effects of vibration; Large land movements on hillsides with high water table saturation; these can lead to damming and alter the course of waterways developments that can produce further avalanches; Elevation or subsidence from earthquakes; Environmental damage from effects on basic service infrastructure, such as water, electricity, gas, hydrocarbons (spills and fires or explotions of hydrocarbons and chemical products, etc.).	Ill effects on human health; From the energy released; From environmental changes such as air and water contamination from spills and fires; Damage to the vegetation cover of areas affected by landslides and avalanches.	Changes to the landscape due to landslide zones with loss of vegetation cover; More significant and even permanent changes can occur such as the appearance and disappearance of bodies of water.

Table 3

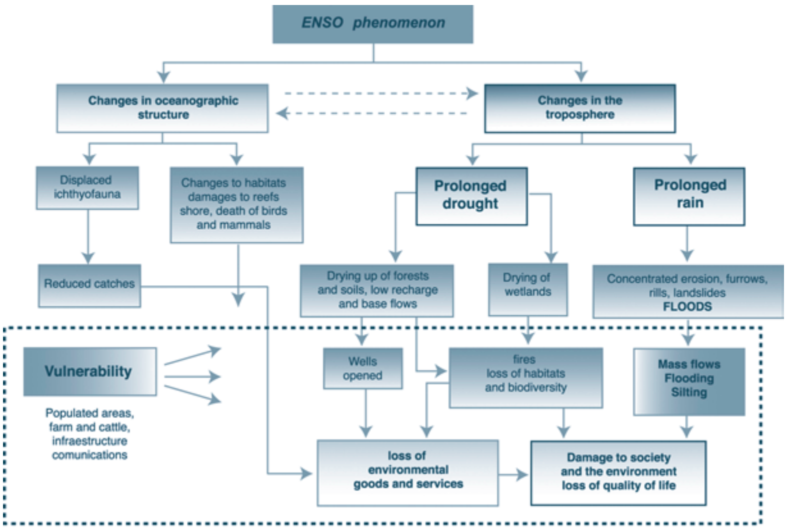
THE EFFECTS OF LARGE SCALE NATURAL PHENOMENA ON PHYSICAL, BIOTIC AND PERCEPTUAL ENVIRONMENT

Phenomenon	***Effects***		
	On the physical environment	On the biotic environment	On the perceptual environment
Tidal wave	Ï Flooding of coastal zones; Ï Intrusion of salt water in surface and subsurface bodies of water; Ï Water contamination due to chemical spills.	Ï Ill effects on human health; Ï From the impact of the wave; Ï From environmental changes water contamination and salination; Ï Damages to coastal plant and wildlife from the impact of the wave and salt water flooding.	Ï Significant affectation of the coastal landscape; Ï Possibly more significant and even permanent changes such as the appearance and disapearance of bodies of water.
Floods *(of climatological, oceanic or other origin)*	Ï Erosion, soil destabilization and landslides; Ï Sedimentation and washing of rubble and detritus into adjoining lands and bodies of water; Ï Possible damming and subsequent avalanches; Ï Contamination due to spills of water and sewage treatment tanks and the collapse of sewer and plumbing systems; Ï Contamination from chemical spills.	Ï Ill effects on human health Ï From the energy released Ï From environmental changes such as water contamination; Ï Effects on plant and animal life from the energy released, physical changes and effects from chemical contamination; Ï Loss of vegetation cover; Ï Loss of habitat.	Ï Washing downstream of sediment and obstruction of natural drainage systems can cause changes, possibly permanent, to the course of water bodies and alter the coastline.
Landmass shifts	Ï Erosion, soil destabilization and loss, and landslides and avalanches Ï Sedimenatation and washing of rubble and detritus into adjoining lands and water bodies; Ï Possible damming and subsequent avalanches.	Ï Ill effects on human health principally due to the energy released; Ï Landslides of forested land and destruction of vegetation cover; Ï Twisting and bending of trees (where reptation occurs).	Ï Drastic changes to the landscape, mostly localized.
Hurricanes and cyclones	Ï Coastal erosion, changes to the granulometry of beaches and bathymetric changes brought on by tides and oceanic turbulence; Ï Changes to geographic characteristics; Ï Erosion, landslides and avalanches caused by rains; Ï Instrusion of salt water into surface and subsurface bodies of water.	Ï Death and migration of animals; Ï Splitting and falling of trees due to winds; Ï Loss of coastal vegetation (mangroves), marine plant life and physical damage to coral reefs.	Ï Drastic changes to the landscape due to loss of vegetation and alteration of the coastline; Ï See Floods.
Drought	Drying out and cracking of the soil; increase in the susceptibility of the soil to erosion and degradation; Decrease in the surface water reserves subsurface water table, increase in the temperature of water bodies, loss of capacity to dilute contaminants; well salination may occur in coastal zones due to over exploitaton; Drying up of wetlands;	Loss of vegetation cover due to drying up of vegetation cover and associated forest fires; Loss of biodiversity due to drying up of wetlands (often these are the habitat of species in danger of extinction and are part of the routes of migratory birds) and forest fires; Other ecological imbalances (such as death of pollinating birds and insects);	Drastic changes to the landscape due to loss of vegetation;
ENOS Phenomenon	See Floods and Droughts;	The appearance or increase in the incidence of some illnesses (malaria, dengue and others) is associated with the ENOS Phenomenon; Changes in the oceanographic structure, disappearance of phytoplankton, displacement and death of ictiofauna, death of coral populations; See Floods and Droughts;	See Floods and Droughts;

A figure with the causal linkages of the main impacts on the environment can be highly illustrative, as may be seen in the following two figures for the 1997-1998 ENSO phenomenon in Costa Rica[4] and the floods and landslides in Venezuela[5] in 1999. As with the description of the state of the environment before the disaster, inserts can be included as needed to deal with specific impacts. For example, in the assessment of the impact of Hurricane Mitch in Nicaragua, an insert was included on what happened at the Casita volcano;[6] in the case of the disaster in Venezuela, an insert was included on the environmental problems caused in the Port of La Guaira when containers storing chemicals were washed away.

Figure 1

LINKAGE OF THE IMPACTS ON THE ENVIRONMENT CAUSED BY THE EL NIÑO PHENOMENON OF 1997 - 1998 IN COSTA RICA



4 ECLAC, *Fenómeno de El Niño en Costa Rica durante 1997-1998: evaluación de su impacto y necesidades de rehabilitación, mitigación y prevención ante las alteraciones climáticas,* (LC/MEX/L.363), Mexico City, 1998.

5 ECLAC, *Los efectos socioeconómicos de las inundaciones y deslizamientos en Venezuela en 1999*, (LC/MEX/L.421/Add.1), Mexico City, 2000.

6 ECLAC, *Nicaragua: evaluación de los daños ocasionados por el huracán Mitch, 1998: sus implicaciones para el desarrollo económico y social y el medio ambiente*, (LC/MEX/L.372), Mexico City, 1999.

Figure 2

DETAILED STRUCTURE OF THE DISASTER GENERATED BY THE FLOODS AND LANDSLIDES IN 1999 IN VENEZUELA