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Panorama of the environmental impact of recent natural disasters in Latin America and the Caribbean

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This document was prepared by the Inter-Agency Technical Committee on the basis of the mandates of the Eleventh Forum of Ministers of the Environment of Latin America and the Caribbean (Lima, Peru, March 1998). The work was carried out by the Economic Commission for Latin America and the Caribbean (ECLAC) and the United Nations Environment Programme (UNEP) as the lead agencies. The purpose of the document is to provide the Forum with support for discussing and approving courses of action in the sphere of the Regional Action Plan for the period 2000-2001.

Summary

Is the world turning into a more dangerous place? Is the frequency or magnitude of natural threats growing? Is human society becoming more vulnerable to the effects of some of the natural phenomena? If so, what is the reason behind this increased vulnerability?

This report provides some key background to help explain the problem of natural disasters in an integral way, considering the relationship between man and nature. The climate and geological characteristics of Latin America and the Caribbean make this region more prone to extreme natural phenomena. Furthermore, people are increasingly convinced that the earth's warming is escalating the intensity and frequency with which hydro-meteorological phenomena occur. On the other hand, the region's economic development model has not been linked to a sustainable land planning that would take into account natural risk criteria, ecosystem load capacity or sound management of natural resources (and their potential use). This, in association with demographic growth, poverty and unplanned location of human settlements in marginal areas exposed to natural risks, has contributed to a situation of geo-biophysical unbalance, increasing the region's vulnerability to the environmental impacts that extreme natural events may cause. This situation could be observed during the recent natural disasters that affected Latin America and the Caribbean, such as the El Niño Oscillation (97-98) that affected the majority of the countries in the region, especially the Andean countries in South America; Hurricanes Georges and Mitch that in 1998 affected the Caribbean and Central America respectively; and the intense rains and severe landslides in Venezuela, most recently.

This situation calls for a re-thinking of responses to natural disasters, in order to reduce vulnerability and the impact of future events. Those responses should be directed more towards the prevention and mitigation of the environmental impact of natural disasters than the rehabilitation and reconstruction of elments damaged by the disasters. Such refocusing may help to mitigate, and perhaps avoid, the large number of damages and victims that result from disasters, and may also help to obtain the maximum benefit out of the scarce resources avilable.

This document focuses only on disasters of natural origin, not on man-made disasters like explosions, fires, chemical spills, etc. It presents also an estimation of the direct and indirect costs of the impacts that El Niño and hurricanes Georges and Mitch had on infraestructure and natural resources. To produce such socio-economic estimation of damages, ECLAC applied a methodology that is still under development, particularly in what refers to the evaluation of environmental goods and services after the natural events have affected them.

There is no standard methodology to assess the socio-economic and environmental impact of natural disasters. Valuation is, without doubt, critical and relevant to estimating total damages, replacement costs, cost-benefit and cost-effectiveness in allotting resources to prevent and mitigate the environmental impact of natural disasters.

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I. A conceptual approach to natural disasters

It is important to bear in mind the conceptual differences between natural disaster, natural threat, physical event or natural phenomenon, dangerous event, disaster risk, vulnerability and environmental risk.

The concept of natural disaster

Man's life on the planet develops in a framework of permanent interaction with the planet's natural systems. A natural disaster takes place due to the inadequate relation between people and such systems. Natural risks are perceived by man as extreme natural events that pose a threat to man's life and property.. A natural disaster is the realisation of the perceived risk. It is man whom, upon occupying high-risk areas, set up the potential damage for a natural event to occur. Consequently, an extreme natural event acquires the connotation of disaster only when man and/or his activities and goods are involved (P. Larraín and P. Simpson-Housley, 1994).

A natural disaster is a dangerous event that causes environmental effects or alterations (physical, biological, social, economic), and these are of such magnitude that the ecosystems and/or society are unable to tolerate them without witnessing their basic functioning elements and dynamic balances being destroyed.

A disaster is always a social product where the physical phenomena do not necessarily determine the outcome. Political, social, economic and environmental factors are combined in such a manner that they undermine a society's and its ecosystem's capacity to support new tensions. (Ball, 1979).

In this context, a natural disaster is defined as an extreme relationship between physical phenomena and a society's structure and organization. During those extreme relationships, a population's capacity to absorb, dampen or avoid the negative effects of an event, is surpassed.

According to ECLAC (1999), "the impact of a natural disaster on development include events of dramatic, sudden and unforeseeable nature, which cause numerous deaths, suffering and affliction to a society or to an important portion of it. It temporarily alters the community's vital lines and daily operation systems of the community". The large amount of material damage such events cause, make difficult the normal functioning of economies and that of the society as well.

Physical Event or Natural Phenomenon, Natural Threat and Dangerous Event

In general, a physical event that does not affect people is considered a natural phenomenon, not a natural threat. . A natural phenomenon happening in a populated area is a dangerous event and thus, it is considered a natural threat. Natural threats are, therefore, "environmental elements that are dangerous to man and that are caused by forces external to him"(Burton, 1978).

The concept of environmental risk

In disaster-related terminology, risk is defined as the combination of vulnerability and the estimated probability of an occurrence. This is the basis for decision-making in a condition of uncertainty.. Other concepts such as environmental risks and disasters have the advantage of including natural and human dimensions (Smith, 1996). For example, water flow problems can be exacerbated by climate fluctuations ––such as increases in storm frequency– and human activities –such as drainage of soils and deforestation.

On the other hand, environmental risks could be ameliorated if using proper technology; for example, early warning systems based on satellite technology can greatly reduced the loss of lives caused by a tropical cyclone. These interactions have led us to recognize the presence of certain hybrid elements in the resulting risks, in which there exists some degree of overlap between environmental, social and technological processes.

Traditionally, the classifications of environmental risk are based on geophysical processes and they emphasise a single impact element, such as wind or storm. But in practice, the most severe risks are of a synergic nature; i.e. winds with rain cause tree-falling, which in turn lead to rivers being blocked, floods or landslides.

The environment vulnerability concept

Not all phenomena generate a crisis that can be called a disaster. For a disaster to take place, it will depend upon the vulnerability of the affected areas. . Vulnerability is "the condition in which a population is exposed to, or is in danger of being affected by a man-made or natural phenomena, called a threat. A threat caused by a natural event is an external factor. " (ECLAC, 1999).

The Expert Group on Climatic Changes (IPCC, 1995), defined vulnerability as "the degree to which climate can be damaging or hazardous", depending on the system's sensitivity and capacity to adapt to new conditions. In this context, sensitivity is defined as the system's degree of reaction to climatic changes; while vulnerability refers to both the system's degree of reaction to climatic changes and the climate changes per se, which could be damaging or hazardous to the system. Vulnerability also refers to the capacity of a system to adapt to a new condition, which will vary depending upon the magnitude and velocity of changes.

Adaptability refers to the degree it is possible to adjust a system's practices, processes and structure in light of the predicted or real climate changes (IPCC, 1995). The most vulnerable systems are those who are more sensitive to climate changes while their adaptation capacity is lower. Vulnerability increases as the capacity of a system to adapt diminishes.

In global warming, vulnerability, as seen through any scale used to measure it, varies considerably because the existing uncertainties in current climate models, which are yet to be resolved. In any case, there is no consensus about the meaning of vulnerability, within a context of climate change, and how to measure it. Widely accepted indicators that identify all aspects of vulnerability and are measurable and persistent through time are unavailable

The different definitions show the variety of opinions and perceptions there are about vulnerability; they are based on the areas affected or on the processes that may cause disasters.

Because of the region's geologic, climatic and bio-geographic features, the most common environmental threats in Latin America and the Caribbean are earthquakes, volcanic eruptions, storms or hurricanes, sudden floods, soil instability, landslides and (forest)fires. The areas located along the Pacific Ocean arepart of the so-called "ring of fire". This ring is formed by several volcanoes (most of them active) linked to tectonic faults along the coasts and at the bottom of the ocean.. This situation determines a permanent seismic and volcanic activity throughout the Andean region, making people and settlements in those areas highly vulnerable to those natural events.

In turn, small insular Caribbean states are considered to be "highly vulnerable to sea level rise and global warming and, particularly, to a possible increase in hurricane frequency due to climate changes". (ECLAC, 1999b)

Countries have different capacity to resist similar natural phenomena. There is a close relationship between the threat of a phenomenon to a region, the region's vulnerability and the risk that may exist. The risk of a region to be affected by a disaster is defined as the outcome of calculating the threat of a certain potential action, as a function of the vulnerability of that region. Therefore, the risk of a country or region to be affected by a natural event will be determined by the magnitud of the threat and the country's (or region's) vulnerability to that threat..

The environmental vulnerability of a region implies evaluating the susceptibility or resistance of the area to disasters that may be caused by natural phenomena. And the capacity of a region to resist or ameliorate the impact of a disaster is related to the provision of environmental services based on the natural resources available in that region; such as well-preserved ecosystems (particularly forests, basins, etc.).

Human intervention can increase the frequency and severity of natural disasters, and may also give rise to natural threats in places where there were none before. This can happen upon modifying the (natural) environment through construction, inadequate management and use of the environment, or destruction of ecosystems without taking into account the geophysical processes and the existing ecological relations that , in themselves, can naturally lessen the impacts from extreme natural events. In this sense, the (economic) development model is being applied throughout the region has not given enough importance to the development and application of land planning policies and instruments (based on environmental sustainability criteria) that can help to prevent this kind of risks.

The environmental vulnerability of the region to extreme natural events, constitutes a vital dimension for the future development of Latin America and the Caribbean. Therefore, it is important to have proper methodologies to assess vulnerability and mechanisms to reduce it; strengthening, at the same time, the capacity of the region to confront natural phenomena with the least possible economic, social and environmental losses.

Only recently have environmental considerations been incorporated into the analysis of natural disasters. Incorporating this dimension significantly underscores the issue of vulnerability and its importance in the planning and development processes of our region.

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II. Types of natural disasters, impact on the environment and infrastructure. Environmental considerations in the natural disaster management cycle

In the last decades, the most important natural phenomena (according to their world-wide recurrence) have been: floods, tiphones and hurricanes, wind and snow storms, heat waves, cold fronts, thunder-storms landslides and avalanches, tsunamies, earthquakes, hail, frost, drought, and sand and dust storms.

Statistical analysis of catastrophes of natural origin shows that, in the last century, hydro-meteorological type of disasters have increased in frequency while geological ones (seismic, volcanic) have maintained their historical levels.

Table I shows the relations between natural disasters and environmental vulnerability (expressed as: effects on the geomorphology and the ecology, damages on infrastructure, and consequences on agriculture and forestry –production sectors).

Table 1. Types of disasters and their effects on geomorphology and ecology, infrastructure, and agriculture and forestry

Type of Disaster	Geomorphologic and Ecological Effects	Effects on Infrastructure	Effects on Agriculture and Forestry
Earthquakes	Tremors and fissures. Land slides Liquefaction Underground settling and collapses. Avalanches and landslides. Changes in water courses.	Damage to constructions. Damage to roads, bridges, levees and cannals. Damages to pipelines , posts and cables. Undermining and burying of structures. River embankment causing local floods. Sinking of structures and buildings. Underground constructions are affected. Damage and destruction of urban infrastructure (networks, streets, equipment and furniture). Destruction of hazardous waste storage tanks.	Losses in affected areas due to landslides, avalanches or liquefaction. Temporary loss of irrigation systems. Localized losses of plants, and vegetative and forest covers..
Hurricanes, Typhoons and Cyclones, Tropical Storms	Gales and constant winds Flooding(due to heavy rains, swelling of rivers and rivers braking their banks). Landslides Avalanches Soil erosion Sedimentation of rivers Damage to coral reefs	Damage to buildings Interruption, rupture and/or collapsing of distribution lines Damage to bridges and roads due to landslides.	Loss of vegetative cover, tree-falling, crop damage (especially to gramineous). Erosion affects root crops and tubers. Change in natural and man-made drainage systems. Soil sedimentation, salinization, contamination and erosion.
Droughts	Soil drying and cracking; loss of the vegetative cover. Exposure to wind erosion. Desertification. Fires	Does not provoke major effects	Loss of crops and vegetative cover. Erosion and forest damage. Sand and infertile soil deposits. Crop cycles altered. Development of dry climate, drought-resistant vegetation, thorn bushes and cactacea.
Floods	Erosion	Loosening of building	Destruction of crops, alteration of

Type of Disaster	Geomorphologic and Ecological Effects	Effects on Infrastructure	Effects on Agriculture and Forestry
	Soil over-saturation, distabilisation and landslides Sedimentation	foundations and piles. Burying and sliding of infrastructure and constructions Sedimentation and blockage of cannals and drainage systems..	crop types and harvest cycles. Damage located in lands, planting and forest areas. Increased moisture improves soil quality in some areas, turning them into productive ones (if only temporarily).
Tsunamis and Earthquakes	Floods Salinization and sedimentation in coastal strips Pollution of water streams and water tables.	Destruction of buildings , bridges, roads, irrigation and drainage systems.	Damage to crops (harvest) Destruction of coastal plantations. Alteration of coastal fauna cycles Fishing is affected.
Volcanic eruptions	Fires, loss in vegetative cover. Deposit of incandescent material and lava. Deposits of volcanic ash. Landslides Liquefactions Ice melting and avalanches Mud flows	Destruction of buildings and other infrastructure. Collapsing of roofs due to deposits of volacanic ash. Buildings are buried. Fires Cannals, bridges and lines of transmission (above and underground) are affected. .	Wide-spread defoliation. Damage to vegetative and forest covers. Fire in areas close to the volcanic eruption. Crops are buried; productive lands are damaged due to sedimentation, pollution and landslides. Fire in plantations. Deposits of volcanic ash on undamaged soils may increase soil fertility in the long run.

Source: Adaptado de Frederick C. Cuny, Disasters and prevention, Oxford University Press, Nueva York, 1983.

The disaster management cycle: environmental considerations

In order to reduce physical, social, economic and environmental vulnerability, and to decrease the impact of extreme natural events, strategic frameworks to face natural disasters, are needed. Such frameworks should take into and incorporate environmental variables into the different phases of the disaster management cycle (ex-ante and ex-post).

The absence of rules and regulations (or their enforcement) to order the establishment of human activities in high-risk areas, combined with the progressive deterioration of the environment due to human activities, are one example of a situation contributing to an increase in the impact of natural disasters.

The strategic framework of the disaster management cycle (see **Figure 1**) forsees that prevention, mitigation and preparation measures be introduced in the restauration, reconstruction and definition of policies for national development, in order to ameliorate the impact of future disasters.

The disaster management cycle can be divided in six major phases: response, recuperation, development, prevention, mitigation and preparedness. The first three phases correspond to the so called ex-post state; i.e. the response that is given after a disaster takes place, such as humanitarian aid (including life-saving activities), reconstruction of basic infrastructure (roads, hospitals, houses). The second three stages correspond to the so called ex-ante phase, i.e. those measures intended for the prevention and mitigation of the impact of a disaster.

With the exception of the "response phase" immediately after a disaster hits (which is basically of emergency and humanitarian aid nature), all the other phases should take into account environmental variables, particularly the three ex-ante phases. Together, those three phases reflect the degree of prepardness of a community to face a disaster.

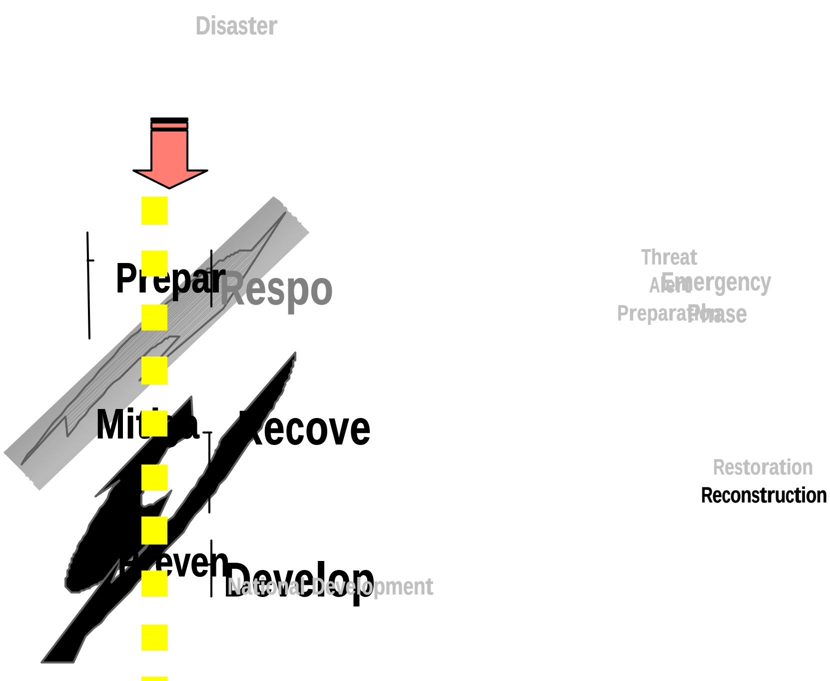
Similarly, ECLAC divides the ex-post stage in three phases: emergency reponse, rehabilitation and recuperation (immediate or after a transition period), and reconstruction (ECLAC, 1991). In this approach, the processes of mitigation and reduction of vulnerability and risk, are associated with the reconstruction phase.

Thus, the emergency phase covers the time just after the catastrophy occurred. Life saving is the priority in this phase. During this stage, different groups like police, health brigades, transport, communications, power, and water concentrate on repairing basic services, under the coordination of emergency response authorities.

The rehabilitation or transition period covers the time it takes to restore the main services and the most essential social infrastructure; i.e. building temporary housing and reestablishing transportation and basic public services. Measures taken during this phase are aimed at assisting the affected communities to return to "normal" labor life.

The reconstruction phase covers the time needed to replace physical infrastructures, services and production systems damaged during the disaster. Such replacement implies an improvement relative to the previous conditions (new standards to mitigate vulnerability and reduce risks). This could be in the form of design improvement, activity and housing relocation, current housing reinforcement, and a general improvement in the level of institutional preparation and prevention. Integrating environmental aspects in this stage of the process is fundamental to achieve reconstruction plans that can ensure lower impacts (or none) of possible future natural disasters.

Figure 1. The disaster management cycle



In many ocassions, reconstruction plans do not necessarily take into account environmental variables and factors to the extent necessary; thus running the risk of repeating mistakes, many of them fatal since there is cummulative effect of most of those factors, rendering the pre-existing environment more vulnerable to the impact of new disasters.

Disaster prevention and environmental issues should be included in the development agenda of the countries, with the aim of converting them to State policy. The agenda should be holistic, encompassing economic and social themes, and have a strong scientific foundation.

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III. The environmental vulnerability of the region to natural disasters

The pressing need to consider environmental vulnerability as a fundamental variable when planning the sustainable development of the region, is an issue of social relevance. Environmental vulnerability must be taken into account in all future regional, national and local activities.

Unplanned human settlements and activities, alongside the continued population growth and the persistance of high poverty levels (particularly in rural areas) are factors that are reflected in an increase of the region's environmental vulnerability to natural disasters; as it has been observed through the devastating effects of the disasters that hit our region. Earthquakes and hurricanes, and the recurrence of "small", located disasters" caused by mudslides, avalanches and landslides, have brought about significant devastation to people and infrastructure, increasing the poverty's vicious circle.

The recent disasters caused by El Niño and La Niña, Hurricanes Georges and Mitch , in the Caribbean and Central America, the earthquake that struck the Armenia region in Colombia, and more recently, the floods, torrential rains and landslides in Venezuela, all show the close relationship that exists between (geographic) space and land use and ocuppation pressures exerted by the population.

Human activities carry different types and levels of environmental impacts (anthropogenic impacts), such as conversion of natural forests for agriculture and livestock production, the over-exploitation of mountain-sides for subsistence agriculture, and the construction of roads and infrastructure; most of the time without properly considering environmental protection or land planning as to ensure an environmentally sustainable management of the territory.

Experts agree that rapid and unplanned urbanization increases the risk to natural disasters. Demands on land to accommodate the growth of cities, force the use of land that is innapropriate for urban use and most often located in high-risk areas. Rapid growth means a building upsurge, which oftentimes are ill-constructed or improperly maintained. The obstruction of natural drainage systems, the location of industries and hazardous wastes in urban areas, all expose the population to ulterior dangers. These elements, among others, are seen as additional threats when disaster hits. If these situations are not reverted, future catastrophes will take a larger number of lives and will inflict even more material damage. A first step towards the reversal of this situation, is clear political commitments, at the national and local levels, to ensure safer cities.

In summary, in the region there is a combination of physical and socioeconomic factors that increase its environmental vulnerability. Natural disaster prevention and mitigation is the new institutional challenge. Sound land use/land planning (both rural and urban), appropriate soil conservation techniques, environmental restoration, environmental impact assessments (and the introduction of mitigation measures) of builings and infrastructures, will all contribute to the sustainable mangement of natural resources and, therefore, the sustainable development of the region.

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IV. Estimation of the environmental impact of natural disasters in some countries of the region

Table 2 shows some of the environmental impacts and characteristics of recent natural disasters, includin affected population and total damages per country.. Examples include: El Niño in the Andean Area (Peru, Colombia, Bolivia, Ecuador), affecting Chile's fishing and aquaculture industries, and causing forest fires in Mexico; Hurricane Mitch – affecting Central America, particularly Honduras, El Salvador, Nicaragua and Guatemala; and Hurricane Georges, affecting the Caribbean, especially the Dominican Republic.

Table 2. Latin America and the Caribbean: disasters between 1997-1998.
Type of event, affected population and total damages

Date	Place	Type of event	Affected Population		Total damage (millions of 1998 US$)		
			Muertos	Damni-ficados directos	Total	Direct *	Indirect *
1997-1998	Costa Rica	El Niño (floods, drought; abnormal time-periods)		119,279	93	51	42
1997-1998	Andean Community	El Niño	600	125,000	7,694	2,784	4,910
		Bolivia (drought and floods)			537	217	320
		Colombia (drought)			575	57	518
		Ecuador (floods and changes in sea water: temperature and level)	286	29,023	2,939	863	2,076
		Peru (floods and changes in sea water: temperature and level)			3,569	1,644	1,925
		Venezuela (droughts)			73	3	70
1998 (sept. 22-23)	Dominican Republic	Hurricane Georges (98 knots winds or 170 km/h)	235	296,637	2,193	1,337	856
1998 (october 23-november 4)	Central America	Hurricane Mitch (144 knots winds or 285 km/h at its peak; +600 mm precipitation)	9,214	1,191,908	6,008	3,078	2,930
		Costa Rica	4	16,500	91	54	37
		El Salvador	240	84,316	388	169	219
		Guatemala	268	105,000	748	288	460
		Honduras	5,657	617,831	3,794	2,005	1,789
		Nicaragua	3,045	368,261	988	562	425
1999 (January 25)	Colombia	Earthquake affected cooffee plantation areas (5.8 degrees in Richter scale; epicenter close to Cordoba, Department of Quindío).	1,185	559,401	1,508	1,391	188

* The effects of natural phenomena are classified into direct damage (wealth) and indirect damage (goods and services)

Source: ECLAC 1999. "Latin America and the Caribbean: Natural disaster impacts on development, 1972-1999" pgs. 37-38.

A. Analysis of the El Niño phenomenon (1997-1998) and its environmental impact in some countries of the region

The El Niño/Southern Oscillation –a global phenomenon– is an interaction between the ocean and the atmosphere that produces fluctuations in surface temperatures and air pressure over the Pacific Ocean; during which, cold and hot episodes (known as El Niño and La Niña respectively) alternate. (IDNDR, 1999). When a hot fluctuation takes place, the atmospheric pressure is lower than normal in the tropical Western Pacific, and higher than normal over Indonesia and Australia. This is known as "El Niño". When a cold fluctuation takes place, the atmospheric pressures reverse. Such situation I known as La Niña. . These phenomenaoccurs at 2-7 year intervals and starts during summer time, in the Southern hemisphere. Their key features are abnormal ocean surface and atmosphere conditions for about 12-22 months.

Characterization of the environmental effects of El Niño phenomenon

The El Niño phenomenon has repercussions in most of the planet. El Niño has four types of environmental effects (see Annex I : Model to identify threats derived from El Niño):

a) Changes in ocean characteristics: temperature, salinity and average sea level, affecting the composition and distribution of pelagic species.

b) Excessive precipitation in coastal areas of ocean-bordering countries such as Peru, Ecuador and Chile; as well as in Brazil, Panama and some areas in Central America.

c) Precipitation deficit in Colombia, Venezuela, Mexico, Central American countries, and –at least in 1998– in Chile and Bolivia.

d) Changes in cloudness and solar radiation leves, which cause an increase in the atmospheric temperature.

Environmental Impact of El Niño on Andean Countries [(1)]

Since 1997, a new El Niño heat event began. Its intensity has surpassed the 1982-1983 phenomenon. The scientific community has ranked it as the most intense phenomenon of the 20th century. The South American countries on the Pacific Rim, especially Ecuador and Peru were particularly hard hit (ECLAC, 1998).

According to information of the Andean Promotion Corporation, the 1997-1998 El Niño phenomenon modified the hydrological cycle of the Andean region, causing water excesses in different areas of Bolivia, Ecuador and Peru, and water deficits in large areas of Bolivia, Colombia and Venezuela, and significant modifications in the characteristics of the Pacific Ocean waters (CAF, 1998).

The lower lands on the Pacific coast of Ecuador and Peru and part of the Bolivian Amazon received strong precipitations and many rivers raised their water levels, leading to widespread flooding, thereby damaging the countries economic and social infrastructure, as well as such as agriculture and livestock production, industry, trade and the environment (see **Figure 2**).

In areas of steep slopes in Bolivia, Colombia, Ecuador and Peru (with unstable soils and low water-retention capacity), the precipitation caused landslides and mud avalanches, damaging housing in marginal areas, roads and urban infrastructure.

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(1) For the purpose of this document, the Andean Countries are Bolivia, Colombia, Ecuador, Peru and Venezuela (the Andean Community).

In 1997 and 1998, El Niño caused important patrimonial losses due to flooding in the coastal areas of those countries, especially Peru and Ecuador, destroying housing, schools, health centers, road and railway networks, drinking-water systems, sewage systems, hydroelectric plants, power transmission lines and infrastructure of production sectors. The floods caused economic losses in ll sectors of the countries economies.

El Niño reversed the hydrologic cycles in the Bolivian highlands and the Colombian and Venezuelan lowlands. This caused not only a decrease in annual precipitation, but also an extended dry season, and important reductions in the volume of water of rivers flowing into the Atlantic Ocen.. In general, the drought produced deficits in water supplies for people, livestock, power generation, and irrigation in plantations and crops, affecting agriculture, industry and trade.

Figure 2. Environmental effects of El Niño in 1997-1998
on the hydrological regimes of andean countries

Source: CAF 1998a

Modifications of other climate variables, included higher levels of sunshine and temperatures in the same areas in Bolivia, Colombia and Venezuela, and stronger winds blowing in directions different to the normal ones. These factors might have contributed to the spread of fires (both intentional and unintentional) that reached forested and protected areas alike, affecting even navigation visibility in some cases. (Table 7).

Increases in sea level averages and water temperatures, and changes in salinity levels, produced important high tides which, combined with river swellings, blocked natural water drainage and exacerbated flooding in coastal areas, damaging the tourism and road infrastructures located near the coastline. More importantly, changes in the ocean water characteristics originated the migration of typical pelagic species of Ecuador and Peru, reducing catch , fish mill production and exports. Fishermen and the fishing industry were economically affected.

Coastal ecosystems also suffered. Mangroves were affected when water levels in wetlands decreased and salinity levels changed. Coral reefs were affected (lixiviation), but survived.

Estimation of damages on the socio-economic sectors caused by environmental alterations

The total damage amount, as Table 3 shows, was 6,718 million US dollars. This figure does not include expenditures for emergency and/or prevention. The information shows that most of the damage was due to mud avalanches and floods..

Table 3. Amount of damages due to El Niño, in the andean community

Origin of Damage	Damage amount (millions of US)	Total percentage
Floods and Avalanches	5,112	68
Drought	826	11
Changes in the ocean	780	10
Prevention and Emergency	827	11

Fuente: CAF,1998

Anthropogenic Impacts and El Niño

Although El Niño affected the environment, the pre-existing deterioration of the environment aggravated in several ocassions, the effects of the phenomenon.

The environmental deterioration of watersheds, caused by human intervention, facilitated the ocurrence of avalanches and mud slides; while deforestation and erosion increased river flows making them crest and peak. This put into the record the need for land planning and sound water resource and watershed management to reduce the environmental vulnerability to flooding and droughts.

Valorization of some damages caused to the environment by El Niño

The Andean Promotion Corporation estimated in US$55 Million the damage by fire to forests in the five Andean countries.. Calculations were based on the environmental services rendered by forests, which is derived from the benefits of natural ecosystems (benefits such as wood, genetic banks, medicinal plants, carbon sink, soil protection, water production, recreation, etc.).

According to Carranza et al. (1996), the cost of environmental services (carbon fixation, water, biodiversity and ecosystem protection) not rendered during a recovery period can vary between 40 and 50 dollars/Ha/year, depending on the type of forest. ECLAC has used these values in several ocassions to evaluate the environmental impact of natural disasters in the Region.

Assessment of the economic impact of El Niño, (CAF, 1998)

The effect of El Niño 1997-1998 on the social and economic sectors was severe, causing important drawbacks in the development and life condition of the people affected. Flooding particularly affected agriculture and livestock production, causing a reduction of this sector.. Damages to infrastructure led to significant reductions in industry, trade, mining and tourism. Estimates show that damages in the Andean Region ascend to US$7,543 Million. **Table 4** shows economic damage per country.

Table 4. Damage amount in Andean countries due to El Niño (1997-1998)

Country	Amount of damage (millions of US$)	Total Percentage
Total de la región	7,543	100
Bolivia	527	7
Colombia	564	7
Ecuador	2,882	38
Perú	3,498	47
Venezuela	72	1

Fuente: CAF, 1998

Table 5 shows the types of damage.

Table 5. Types of damages and amounts (US$)

Type of damage	Damage amount (millions of US$)	Total percentage
Total	**7,543**	**100**
Damage to patrimony	**2,189**	**29**
Production loss	**2,959**	**39**
Higher costs of operation	**1,590**	**21**
Other damages and expenses	**808**	**11**

Source: CAF, 1998

These figures show that production sectors suffered the highest damage (US$ 2,959 Million or 39% of total damages). "Other Damages and Expenses" includes prevention and emergency costs.

It is also important to see the distribution of the damage by sector.

Table 6. Damage distribution by sector in the Andean Region

Affected sector	Damage amount (Millinos of US$)	Total percentage
Total	7,543	100
Social sectors	736	10
Service sectors	621	8
Infrastructure	1,752	23
Productive sectors	3,593	48
Other sectors	844	11

Source: CAF, 1998

The Region's most affected sectors were the production and infrastructure, mainly transportation. Damages to the environment (due to forest fires) , and costs of prevention and emergency, are included under "Other sectors".

The production sectors most affected were agriculture and livestock (US$2,070 Million or 27% total), tranportation (US$1,758 Million or 23%), industry –incluing fisheries (US$944 Million or 12%), costs of emergency response and prevention ((US%722 Million), electricity (US$509 Million), commerce (US$394 Million) and housing (US$384 Million). However, it is important to put these figures in perspective. The total damage was approximately 3% of the andean region GDP, i.e. the combined GDP of the five countries affected. Losses in the productive sectors (US$2,959 Million) represent a 14% of the Andean region GDP in productive sectors. Patrimonial damage amounts to a 13% of the region's value added of the construction sector. In other words, losses in production loss were equivalent to one-seventh of the production in a normal year, and it will take the construction industry 7 years to replace the lost patrimony, if all other type of construction was to be put aside.

This analisis indicates that , at the level of the five countries affected, the impact of El Nino has been of considerable magnitud, particularly if the difference between the total amount of damages and each country's GDP is taken into account. Considering the relative size of each country's economy and the amount (in US$) of the damage, the countries most affected were, in descending order, Ecuador, Bolivia and Peru.

In **Table 7** a summary of damage by sector after El Nño is presented by sectors in each country of the Andean region.

Table 7. Andean Community: damage by sector after El Niño (1997-1998) - Millions of US$

	Bolivia	Colombia	Ecuador	Peru	Venezuela	Total
TOTAL	**527**	**564**	**2,882**	**3,501**	**71**	**7,545**
Type of damage						
Direc damage	213	56	846	1,612	3	2,729
Indirect damage	314	508	2,036	1,888	69	4,815
By sector						
Social sectors	5	44	205	485	0	739
Housing	5	4	153	223		384
Education			33	228		261

	Bolivia	Colombia	Ecuador	Peru	Venezuela	Total
Health		41	19	34		94
Service sectors	248	315	830	955	30	2,378
Drinking water and health services	9	2	17	71	11	109
Electricity supply	1	308	17	166	17	509
Hydrocarbons			2			2
Transports	238	6	795	718	2	1,758
- rivers		***4***			***2***	***6***
- ground (roads, railway, and urban)	***238***		***794***	***718***		***1,749***
- sea transportantion		***2***				***2***
Telecommunications			*1*			*1*
Productive sectors	262	149	1,516	1,625	39	3,519
Agriculture	119	101	1,187	612	1	2,019
Cattle		7	15		30	51
Fisheries			42	26		68
Mining				44		44
Industry	58	41	166	675	4	944
Trade	85		36	268	5	394
Tourism			70			70
Other types of damage	12	55	331	434	3	835
Forest Firles						55
Government infrastructure				58		58
Emergency and prevention	12	3	331	376		722

Source: CAF 1998

Impact of El Niño in Other Countries of the Region: the case of Chile and Mexico

a) Environmental And Economic Impacts on Chile's Fishing

The El Niño cyclic events are associated with dramatic changes in the flora and fauna diversity and geographic distribution in Colombia, Ecuador, Peru and Chile.

In 1998, the raise in the ocean water temperatures caused by El Nino, affected negatively fish catchs in Chile, and making practically disappeared many species from Chilean waters. According to the Chilean Fisheries Under-secretariat, the first two months of 1998 recorded a 41% catch decrease, falling from 1,554,000 Tons to 923,741 Tons. Catch of anchovy and horse mackerel dropped from 71% to 49%, as a consequence, the Government established a ban for horse mackerel fishing, 10 March and 12 April 1998 (between the Third and Tenth Regions). Because Chile and Peru are the two largest exporters of fishmeal in the world, the drop in fish catch experienced in 1998 caused a sharp increase in fishmeal prices (40%).

b) Impacts of El Niño on Fishing, Marine Crops and Destruction of Forest in Mexico

The impact of El Niño phenomenon on fish catch and marine crops has been both negative for some species and positive for others. For example, shrimp catch had one of its best productive years while catfish and prawns registered significant losses. Marine algae, an important Mexican marine crop dropped from 35,000 to 3,000 Tons/year.

Forest fires in 1998 in Mexico destroyed 582 thousand Hectares, of which 405,694 Has were part of the forest ecosystem and the rest were grass lands. According to some estimations, the Mexican economic lost between US$ 140 and 1,028 Million due to fires in 1998, depending on the value per Hectar, of the environmental services of the different forest (CESPEDES, 1999; Table 8). The same analysis indicates that half of the total area lost to fires corresponded to tropical forests and woodlands, while the other half to temperate forests (2).

Table 8. Estimated costs of forest fires in Mexico during 1998

Affected area (hectares)	**Unit value of environmental services and goods (US$/ha/year)**		**Loss costs of environmental services and goods (US$ millions/year)**		**Unit value of forest assets (US$/ha)**	**Loss costs of forest assets (US$ millions)**
	Adger,et al. 1995*	Constanza, et al. 1997	Adger,et al. 1995*	Constanza, et al., 1997	INEGI, 1995 (EUA$/ha)**	INEGI, 1995 (EUA$/ha)**
Tropical forests 202 847 ha	507	2.007	103	407	2.536	514
Temperate forests 202 847 ha	181	302	37	61	2.536	514
Total 405 694 ha	-	-	**140**	**468**	-	**1.028**

* Media of figures estimated by author

** Wood goods

Source: CESPEDES, 1999

B. Hurricane George and its environmental impact on the Dominican Republic - Caribbean Region

Characterization of the hurricane and its environmental effects

The Dominican Republic, and other Caribbean islands and countries, is located in the middle of a high cyclone activity area. Every year, tropical waves, storms and hurricanes threat the island and some sweep through its territory affecting human settlements and productive activities. With a territory of 48,511 Km2 and 8.25 Million inhabitants, the Dominican Republic is exposed to natural disasters both meteorological and geologic. Through out the years, damages due to cyclonic activity have been high, and it has taken considerable effort to the country to overcome them.

The southeastern part of the country, which respresents a 40% of the flatlands, has an annual rainfall of 1,500 mm and it is clasified as humid forest, was the most affected region.

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[2] The figures used in these calculations come from studies cited in Constanza et al., 1997 and Adger et al., 199X, and from the National Institute of Statistics, Geography and Informatics (INEGI, 1995). In the first two studies, the total unit value of the environmental services of forest is calculated from four types of values: direct use (wood, other forest products and tourism), indirect use (forest services in climate regulation, hydrological regulation, erosion control and others), option value (potential value from obtaining pharmacological products) and the intrinsic value (scientific, cultural and moral aspects). See Annexes 3 and 4 for detailed clculations of these values.

A small area located eastward of the plains, has dry- subtropical forests, with slow-growing shrubs and an annual rainfall of 700 mm. This area was particularly affected given the vegetation slow rate of growth and regeneration.

A second area that was hard hit by the hurricane, was a strip that surrounds the front of the cyclone path.

Both areas cover no more that a 10% of the country;, yet they hold the country's source of water for irrigation and to generate hidrological power. Two national reserves, the Green Ebony Scientific Reserve and the Lomas de Barbacoa National Park, are located in that region; they suffered damages between 35% and 60%. During the 60's, peasants invaded this region, introducing agricultural practices into the mountain ranges.

The magnitude of the damage has been linked to the geomorphology of the country and the power of the hurricane. The Dominican Republic has a rugged topography, with high exposure to landslides, lowlands vulnerable to flooding and coastal areas susceptible to water waves effects. Because of this, the Dominican authorities have understood the need to adopt strategies to mitigate environmental risks, accoring to the recommendations of the United Nations's Decado for Reduction of Natural Disasters.

Although the August-September period coincides with the hurricane season in the Caribbean, the 1998's will be remembered as an extraordinary season. Indeed, during the 35 days that run between 19 August and 23 September 1998, 10 cyclones, formed Atlantic Ocean, hit land in different place in the Caribbean and with different intensities. On September 25th , 4 hurricanes were active at the same time; a rare event that happened for first time in the century. (Georges, Ivan, Jeanne y Karl).

Hurricane Georges was formed on 15 September from a tropical wave over the Atlantic Ocean, and it was elevated to a "tropical storm" the morning of the 16th. On the 17 Septmeber, the US National Hurricane Center located in Miami named it a hurricane, based on satellite images that showed the formation of an "eye". Since the, the hurricane began traveling north and northwest, at a speed of 15-20 miles per hour, generatin winds of up to 150 miles/hour –a category 4 on the Saffir-Simpson scale–, and a minimum pressure of 938 mbars at the centre. Georges was located at approximately 420 miles east of the Island of Guadeloupe in the Lesser Antilles.

According to the weather station in Santo Domingo, the total amount of rainfall exceeded 409.3 mm in 15 hours and 28 minutes, with sustained winds of 170 Km/hour, and gusting winds of up to 220 Km/hour. Such powerful winds caused swelling of the ocean affecting vegetation along the coast and destruction of sugarcane plantations and other crops inland, including vegettation in the mountain ranges.. The hurricane damaged homes, warerhouses and sugar-mills, and also affected some of the most important tourist centers in the country.

The intense rains caused rivers and other water bodies to Santo Domingo and southern area of the country, devastating urban and rural infrastructure, ,crops and husbandry areas along the river banks. Landslides and mudslides in fragile mountain lopes were also recorded. As for the inhabitants, many human lives were lost, and many others were reported as injured or missing. Thousands were left homeless, and their production systems and service activities were paralyzed; a situation that lasted for months.

Population affected

Unlike in other countries, the entire population of the Dominican Republic suffered the consequences of Hurricane Georges: 8.2 million Dominicans suffered physical or psychological damages, loss of property and revenue, and alterations in their daily activities. The low-income part of the population lost 56% of their homes and the lowest income level (approximately 19% of the population) lost everything. Total death count was 235, and more than half of them were in San Juan de la Maguana, Azua, Bahoruco and Barahona.

Environmental and Anthropogenic Impacts of Hurricane Georges

The Dominican Republic has suffered sudden natural disasters before, the most common are tropical storms and hurricanes during the hurricane season, between August and October. During the 1887-1979 period, 48 tropical storms hit the country. . The storms usually enter the islnd through the south; in few ocassions has the northern part of the country been hit by hurricanes originated in the Atlantic's equatorial east (See Annex __ for a diagram chain of impacts Hurricane Georges).

The impact of natural disasters of this kind is magnified by a combination of human activities and a relatively fast demographic growth. Man's different activities impact the environment; for example the utilization of forested land, with no agricultural capacity, for purposes of agriculture production (such as mountain slopes, stream beds and primary terraces of rivers), the construction of roads, and urban infrastructure without taking into account the environmental impact of the activity; or the application of land planning (especially in agriculture and human settlements) to ensure an harmonic relationship between man and the environment tht surrounds him. Unfortunately those fragile spaces are the most sensitive to natural pehnomena.

Although there have been efforts in reforestation and an increase in the awareness of the population of the need of environmental conservation, more needs to be done. After Hurricane David in 1979, the population of the DR was 5,570, 000 Million, with an average densiy of 115 inh/km2. If only the arable land is considered, the population density is 267 inh/km2. If current trends continue, the population in the DR will, in 10 yers, reach 10 million. If these current trends do not change, the higher population density will produce an indiscriminate land occupation, which will undoubtedly increase the country's vulnerability to natural phenomena.

This requires a proactive action to –prevent a worsening of the situation. ion actions in all senses. The fast-growing population rates of the 50's and 60's have decline to reach 2.6% in the 80's. Nevertheless, even if the rate of population growth in the late 90's is at 2.1%, that good performance has to go hand in hand with land planning policies and measures, nature conservation and environmental education activities.

Estimation of the Environmental Damage of Hurricane Georges

To estimate the damage produced by Hurricane Georges, it was used the mean value of the environmental services that forests in protected areas and ecological reserves contribute in the way of carbon fixation, water production and protection, biodiversity, ecosystems and scenic quality. These values were obtained from a research carried out in Costa Rica for primary and secondary forests. (see **Table 9**).

Table 9. Mean values of forest environmental services (US$/ha/year)

Environmental Services	Primari forest*	Secondary forest*	Mean value for Dominican Republic
Total	58.00	41.76	60.00
Carbon fixation	38.00	29.26	30.00
Water protection	5.00	2.50	10.00
Biodiversity protection	10.00	7.50	10.00
Ecosystem protection **	5.00	2.50	10.00

* Based on: Echeverría *et al*., 1996, Carranza *et al*, 1995; values for Costa Rica.

Source: ECLAC 1998a

This evaluation took into account four environmental service categories: i) decrease in greenhouse gas emissions, ii) water protection for urban, rural or hydroelectric use, iii) protection of the biodiversity to preserve it as a genetic resource, and iv) protection of ecosystems, way of life and natural scenic beauty for scientific, touris and environmental education.

Table 10 shows the calculations made for natural wealth damages, per year for 14 years.

Table 10. Dominican Republic: damage estimate to environmental services in protected areas

Type of area and damage percentage	Affected area (km^2)	Equivalent total damage (km^2)*	Direct damage (US$ thousands)					
			CO_2 Capture	Water protection	Biodiversity	Exosystems protection	Total by year	Services that will not be generated during the recovery period**
Total	7,096	2,848	8,544	2 ,848	2,848	2,848	17,087	119,612
National parks and other reserves (40%)	6,780	2,712	8,136	2,712	2,712	2,712	16,272	113,904
Coastal and rain forests (60%)	50	30	90	30	30	30	180	1,260
Urban parks and botanical gardens (37%)	16	6	18	6	6	6	35	248
Forest plantations (40%)	250	100	300	100	100	100	600	4,200

a/ Using real areas and the percentage of fallen trees and palm trees, it was calculated an area equivalent to total destruction.

b/ Estimated recovery time is at least 14 years, with the integration of partial services with time..

c/ The anthropogenic intervention in coastal and gallery forests was calculated to be 20%..

Source: ECLAC, 1998a.

Although the recovery period still remains unknown in many cases, for others there some estimations available. Overall, full recovery could take between 10 and 20 years . Given those conditions, the global cost of damages is approximately US$ 120 Million. These figures do not take into account the annual discount due to differentiated carbon- absorption; yet as a first approximation, these figures are appropriate.

The fluvial and coastal systems (approximately 1,000 Km), protected by law, were severely damaged, and therefore it is worthwhile to assess the damage. . The affected river network has a 20% human intervention. These are high production systems and their worth is not well known because the network runs across agriculture and husbandry fields.

Estimation of the socioeconomic Impacts of Hurricane Georges

The total figure for damages inflicted by Hurricane Georges is approximately US$ 2,193.4 Million, of which US$ 1,377 Million (61%) were direct effects on property and production, and US$ 633.5 million (29%) were indirect costs (see **Table 11**).

Table 11. Dominican Republic: Summary of the damage caused by Hurricane Georges in 1998 (millions of US$)

Sector and subsectors	Damage			Component of importation or loss of exportation
	Total	Direct damage	Indirect damage	
National total	2,193.4	1,337.0	644.5	856.1
Social sectors	322.7	169.8	152.9	143.7
Housing	231.9	106.7	125.2	80.0
Health	22.1	6.4	15.7	16.5
Education	68.8	56.8	12.0	47.1
Infraestructure	453.7	225.1	228.6	193.9
Water supply and sewage system	16.4	7.7	8.7	9.4
Energy and electricity	88.9	27.3	61.6	60.0
Transportation and telecommunications	332.0	173.8	158.2	117.9
Urban infrastructure and public buildings*	16.3	16.3	0.0	6.5
Productive sectors	1,081.3	822.5	258.8	518.6
Farming and fishing	527.4	441.1	86.3	216.9
Industry	323.3	199.0	124.3	120.5
Tourism	174.5	149.0	25.5	174.5
Trade	56.0	33.3	22.7	6.7
Environment	123.9	119.6	4.3	0.0
Other emergency expenditures	211.9	0.0	0.0	0.0

Source: ECLAC, 1998a.

These figures, when aggregated, represent a net loss of property that without doubt will make an impact on the savings capacity and formation of capital in the country for several years. The major effect occurred in the productive sector (49.3%) with a marked emphasis in the damage suffered by agriculture and livestock. This has consequences on the balance of trade both due to a decline in exports of the sector –in some cases like the losses of cacao plantations, for several years- and the increase of imports that must be made to replace production for domestic consumption.

Their impact of the hurricane on the country's infrastructure (20.7% of total damage) is also noticeable, imposing significant indirect costs, particularly in the area of transportation (24.6% of indirect damage is centered in this activity) due to the importance it has as the link between producers and consumers.

As to the social sectors (14.7% of total damage), the main impact was seen on housing, where in addition to property loss there indirect costs of even higher importance, because they have a negative impact on the quality of life of an important part of the population that was already in a state of poor welfare and had the highest degrees of fragility and exposure to weather and health hazards.

Thus, while in the strictest sense of the word, productive sectors and infrastructure were the most affected in qualitative terms, the damage produced in social sectors wasparticularly significant. Women had to become head-of-family, while their spouses went looking for alternative jobs in other areas to rebuild their homes and recover their means of production. Therefore, in the context of reconstruction, greater importance and priority should be given to those groups.

C. Hurricane Mitch and its environmental impact in the countries of Central America

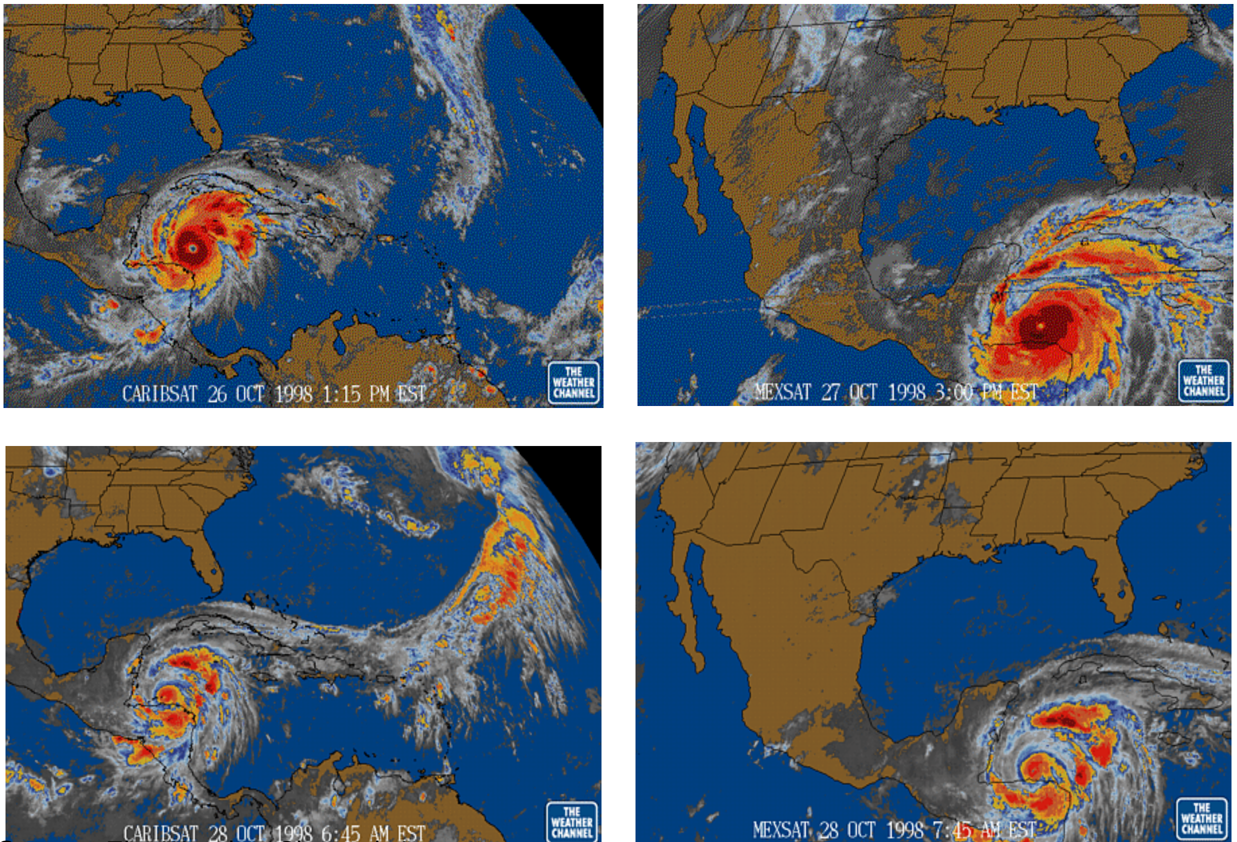
Description and characteristics of the disaster

Hurricane Mitch has been rated as the most serious disaster of hydrometeorological origin that has taking place in Central America in many years. It was unique not only because of the force it reached when touching land, but also for its diameter, the accumulation of moisture andrainfall to whih it gave rise, as well as the erratic path it maintained for several days.

On 24 October 1998, Mitch reached the category of hurricane, becoming one of the most destructive storms that Central America and the Caribbean had ever witnessed. During the following week, the hurricane moved across Honduras, Nicaragua, Guatemala, El Salvador, Belize and Costa Rica, while the eye of the storm stayed about 150 km. from the coast. It remained stationary off the Caribbean coast of Honduras for several days, producing torrential rainfalls, floods, landslides and winds of high intensity.

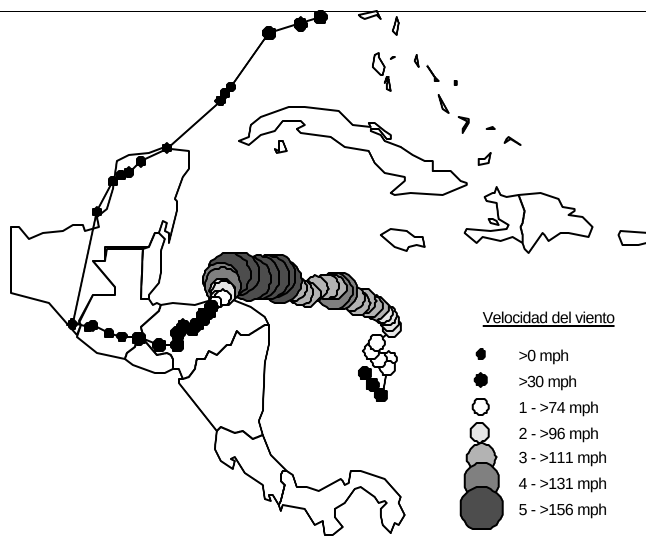
At its peak, during October 26 and 27, the hurricane reached category 5 (the highest on the Saffir-Simpson scale), one of the four that have reached this level during this century in a region where this type of weather occurs quite frequently. During those days it produced winds of almost 300 km per hour, discharging all its force over Central America (see figures 4 and 5).

Figure 4. Satellite images showing Hurrican Mitch over Central America (October 26 to 28, 1998)



Source: The Weather Channel, Internet.

Figura 5. Displacement route of Hurricane Mitch, between October 22 and November 5, 1998)



Source: John Hopkins University Applied Physics Laboratory. Copyright 1998 Ray Sterner and Steve Babin.

Environmental effects of hurricane Mitch in Central America

When passing through the region, the huge volume of rainfall discharged by the hurricane, caused many rivers to overflow at levels never seen before in the last century, with severe floods in the coastal plains, like in San Pedro Sula, Honduras, or the lower valley of the Lempa River, in El Salvador. When the meteor struck the mountains of Honduras, Nicaragua, and Guatemala, it caused landslides and cave-ins on the slopes and strong currents in the rivers, devastating bridges, roads and all sorts of infrastructure. The magnitud of the damage was due both to the intensity and extension of rainfall, and the pre-existing deterioration of the catchment basins due to the action of man. The largest number of victims occurred because of mud slides and floods. In the case of Nicaragua, over 80% of the deaths reported were due to mud slides, increased by the eruption of burning material from the Casita volcano, that razed towns located at its feet, in the northwest of the country.

Rainfall, floods and overflowing rivers made a strong impact on the population of Central America. Between dead and missing people, the regional toll was over 18,000; most of them in Honduras and Nicaragua. There were almost 3.5 million people affected directly, i.e., 11% of the total population of Central America. There are no previous records of one single natural phenomenon that involved five countries at the same time and caused so many casualties like hurricane Mitch. The impact on the population of an event of this size is not fully reflected when an economic assessment of the losses is made. There are no parameters yet to evaluate the effects of the temporary separation of families, the loss of the pillars of household economy, the disappearance of personal reference axes, the traumatic effects of physical harm or the irreversible weakening of the family nucleus.

As it has happened in previous disasters, most of the population involved are low-income groups whose suffering was exacerbated because of the loss of homes, furniture and personal belongings. Unfortunately, the location of these groups in particularly vulnerable areas, is a phenomenon that has become more acute as the population and impoverishment increase.

Moreover, a large portion of the poor population does not have access to social services required by their special condition of health vulnerability. In particular, they are affected by the lack of drinking water and appropriate sewage systems. The hurricane evidenced the fragility of the infrastructure to remedy these needs. Many aqueducts and latrines where destroyed by floods or landslides, which gave rise at the same time, to the pollution of wells or aqueducts. The population of rural areas was the most affected by the destruction of croplands and the infrastructure of local roads and bridges, as well as that for trade in agricultural products trade. The situation was worsened by the loss of income sources which, in some areas like the banana-growing areas, could be felt for over a year.

In any case, it must be recognized that the ecological deterioration of Central America involves greater vulnerability of the habitat in the face of events like hurricane Mitch. Human activities break down the environment and it becomes even weaker when it suffers the blows of hurricanes and similar phenomena. Therefore, the gradual recovery of the ecological wealth goes beyond any quantitative estimation, because it must be taken into consideration that a large part of the region's environmental infrastructure was already in poor condition.

The effects, severe in themselves, of the rainfall were augmented by pre-existing conditions made by human beings, such as deforestation –basically at the foot of high slopes-, the inappropriate use of land, settlements in the hillfoots or on river and lake banks. The characteristics of natural drainage systems prevailing in the Pacific and the degraded vegetative cover also helped to increase the impact of the disaster.

In the case of hurricane Mitch, there was a debate directly related with the vision of sustainable development, the future of the environmental platform, the role of various social players, institutional arrangements to implement it, the culture of prevention and the inclusion of the environmental variable in all reconstruction projects.

Central America is a region of great geological, geographic, climatic and biotic diversity, containing 7% of the biodiversity of the planet. Because of this huge natural wealth, reality shows us that the high vulnerability of Central American society to natural disasters , is closely related to the population's precarious standards of living3. In turn, these standards of living are directly related to models of appropriation, access and use of natural resources that the various social and economic agents make.

Economic impoverishment and poor employment and health conditions are important components of vulnerability. Under these conditions, the possibilities to be concerned about preventing or reducing the risks of a disaster are few. This, sometimes interpreted as a lack of "prevention culture", is combined with fatalism and resignation vis-a-vis "the blows of nature".

Even in the most fortunate sectors of society, and in governments themselves, there are great shortcomings insofar as to standards, techniques and safety levels of construction, in addition to the location of buildings and infrastructure. This has been evidenced with each physical event that has affected the region in the last 25 years. The lack of a proper awareness or calculation of the existing levels of threats and hazards; the lack of appropriate standards or controls on construction, the lack of regulations for land use and property or the lack of enforcement of the above, places wide sectors of the society in a position of high vulnerability.

Thus, the basis of the region's natural resources (forests, land, water and biodiversity), is subjected to different productive processes and social and economic dynamics that far from considering natural wealth as an environmental service and contributing to the development of the region, have become the major causes of environmental, social and economic decline, turning Central America into a highly vulnerable area.

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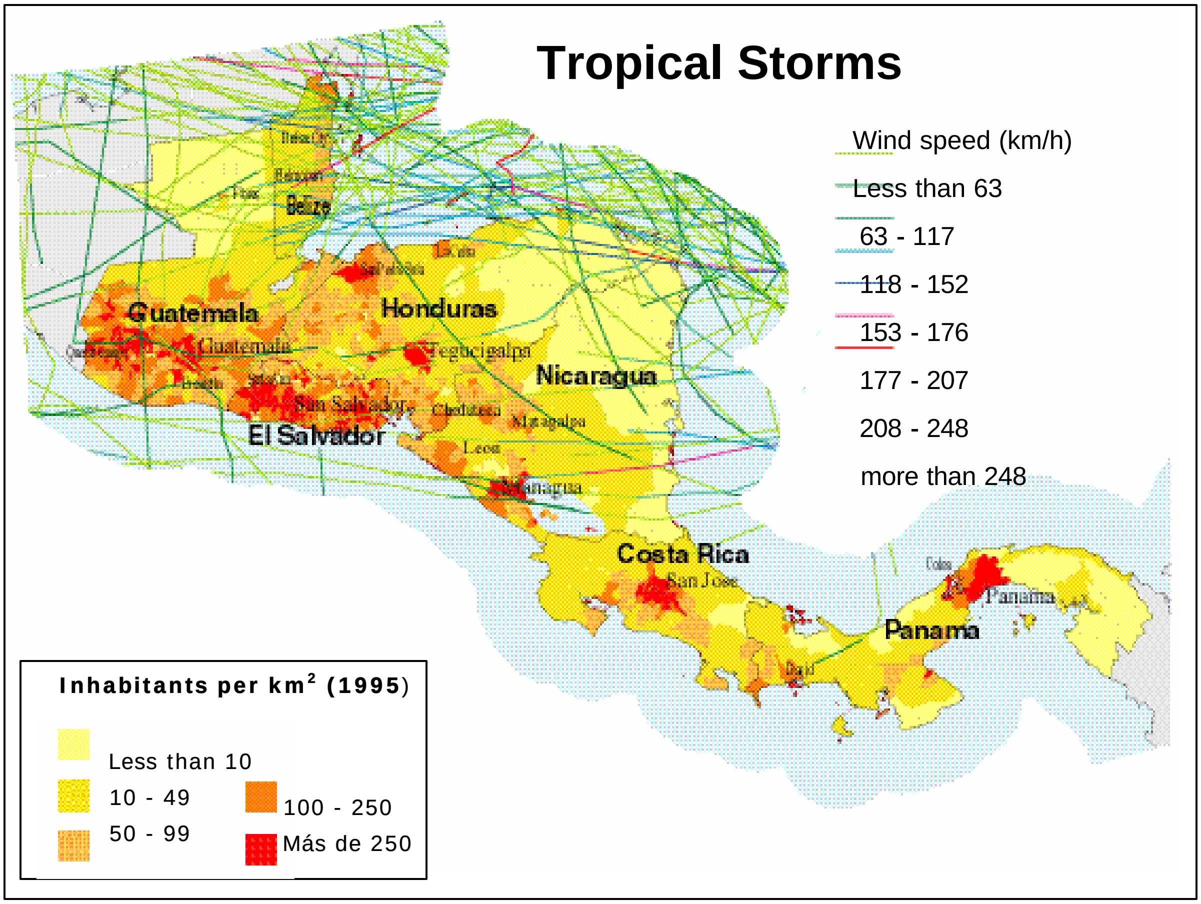
(3) According to data from the Central American Integration System (SICA), the region has an approximate population of 30 Million inhabitants, of which over 68% live in poverty. The poverty rate in the region increased approximately 47% between 1980 and 1990. Many landless peasant families, casual workers and small subsistence farmers are found in rural areas; a wide informal sector, high unemployment rates and even a formal sector with very low-income, are found in urban areas. In some countries, the percentage of access to basic utilities like drinking water and proper removal of sewage and solid wastes, continues to be very low. In El Salvador, only 48% of the population has access to drinking water, while in Nicaragua the ratio is 54%, in Guatemala 62%. In these same countries, environmental health services reach 58%, 27% and 59% of the population respectively.

Figure 5. Expose and vulnerability to tropical storms in Central American countries



Source: Adapted from Colorado State university y NOAA Tropical Prediction

Evaluation of the environmental damage caused by MITCH

As a starting point to assess the damage produced by the hurricane, one could use sme measure of what would not be obtained from the environmental benefits of the ecosystem in full equilibrium. Studies used in assessing environmental damage caused by El Niño, and the assessments made in the Dominican Republic were applied (ECLAC, 1998).

It was estimated that the damage to ecological reserves and protected areas of Central American were over US$ 67.4 million, and that their rehabilitation would require at least US$ 137.7 million, based on the above assessments.

Unquestionably, there is a cumulative effect, particularly in 1998, of the weather changes associated with El Niño (in terms of floods, droughts and fires) that left a weakened ground for the devastating impact of the rainfall produced by Mitch. The higher water level makes it go beyond the natural riverbeds, thus damage is produced to both the riverbanks and the surrounding land. The pollution of these sites by refuse, sand and stone deposits and the erosion of the vegetative cover, makes recovery very expensive, to the point of being unaffordable in some cases. Moreover, sedimentation in riverbeds will have long-standing effects on the course of the water and will require high investments to remove part of those sediments and channel future high water or recover original courses.

The economic assessment of the damage caused by hurricane Mitch, must take into account the loss of the benefits derived from the presence of natural areas. These are the “environmental services”, which are benefits derived from natural ecosystems, such as the genetic pool, medicinal plants and biodiversity as a whole, the uptake of carbon dioxide or the production of oxygen, protection of the soil, production of water, generation of landscape and recreational areas, among others. These areas are widely recognized in international spheres as necessary elements for the sustainable development of present and future generations and it is necessary to pay for these services.

The tables below show estimates of the damage caused by hurricane Mitch, to the environmental services for Honduras , El Salvador, Guatemala and Nicaragua.

Table 12. Honduras: estimate of the damage to the environmental services of protected areas or areas with some protection (US$·per year)

Type of area	Affected area (km²) and damage (%)	Equivalent total damage (km²)	Cost (US$ thousands) c/					
			CO_2 Capture	Water protection	Biodiversity	Ecosystems protections	Total per year	Total d/
Total	12,942.0	418.2	1,463.7	376.4	376.4	125.5	2,341.9	46,838.4
Protected areas (2%)	10,700.0	214.0	749.0	192.6	192.6	64.2	1,198.4	23,968.0
Forests riverbanks b/ (80%)	150.0	120.0	420.0	108.0	108.0	36.0	672.0	13,440.0
Guanaja Island (40%)	58.0	23.2	81.2	20.9	20.9	7.0	129.9	2,598.4
Natural forests with forest management (3%)	2,034.0	61.0	213.5	54.9	54.9	18.3	341.6	6,832.0

a/ . For each area the surface equivalent to total destruction was obtained, based on the actual surface and the estimated percentage of trees fallen or dragged.

b/ Anthropogenic intervention of the riverside forest was estimated at 20% and the lowest sector of the low basin and river estuary are not taken into consideration. The network was estimated at 3,000 km.

c/ The value of the intermediate environmental service between the latifoliate primary and secondary forests was assumed due to the lower productivity of pine forest.

d/ Global cost for a 20-year recovery period is over 46 million dollars.

Source: CEPAL, 1999c

Table 13. El Salvador: estimate of the damage caused by the tropical storm Mitch to the environmental services of protected areas or areas with some protection

Type of area (percentage of average damage)	Affected Area (km²)	Equivalent total damage (km²) a/	Cost (US$ thousands) d/					
			Uptake of CO^2	Water protection	Biodiversity	Ecosys-tems protection	Total per year	Total d/
Total	322	60.1	228.5	30.05	60.1	30.05	348.7	6,974
Protected areas and areas selected for protection (1%) b/	250	2.5	9.5	1.25	2.5	1.25	14.5	290
River bank forests (80%) c/	72	57.6	219	28.8	57.6	28.8	334.2	6,684

Source: ECLAC estimates.

a/ The surface equivalent to total destruction was obtained for each area, based on the actual surface and the percentage of estimated fallen or dragged trees.

b/ Indicated on the Map of the Protected Areas and Coffee-Growing Areas. El Salvador Environmental Program. Environmental Information System; Condition of Natural Resources and the Environment in Central America, 1998. CCAD.

c/ Anthropogenic intervention of the riverside forest was estimated to be 20% and the lowest sector of the low basin and estuary of the main rivers (Lempa and San Miguel) was not taken into consideration, in view of the huge size of the flood and the high degree of vulnerability introduced in those reaches. The network was preliminarily estimated to be 1,800 km.

d/ The overall cost for a 20-year recovery period is roughly 7 million dollars.

Source: CEPAL, 1999d

Table 14. Guatemala: estimate of damage caused by hurricane Mitch to environmental services (1998)

Type of area (percentage of average damage)	Affected area (km^2)	Equivalent total damage (km^2) a/	Cost (US$·thousands)					
			Uptake of CO_2	Water protection	Biodiversity	Ecosystems protection	Total per year	Total b/
Total	63.0	44.1	167.6	22	44	22	255.6	5,112
River bank forests (70%), c/	63.0	44.1	167.6	22	44	22	255.6	5,112

a/ The surface equivalent to total destruction was obtained for each area, based on the actual surface and the estimated percentage of fallen or dragged trees.

b/ The overall cost for a 20-year recovery period is roughly 5.1 million dollars.

c/ Anthropogenic intervention of the riverbank forest was estimated to be 30% and the lowest sector of the low basin and estuary of main rivers is not taken into consideration. The network was preliminarily estimated to be 2,100 km, corresponding to the most affected basins. 30 m of riverbank forest are considered along the entire length.

Source: ECLAC, 1998a

Table 15. Nicaragua: damage caused by hurricane Mitch to the environmental services of forest areas (1998)

Type of area (percentage of average damage)	Affected area (km^2)	Total equivalent damage (km^2) a/	Cost (US$ thousands)					
			Uptake of CO_2	Water protection	Biodiversity	Ecosystems protection	Total per year	Total d/
Total	**1,968**	**74.0**	**281.1**	**36.9**	**73.8**	**36.9**	**428.7**	**8,584**
Protected areas and areas selected for protection (2%) b/	1,917	38.3	145.5	19.1	38.3	19.1	222.1	4,443
River bank forests (70%), c/	51	35.7	135.6	17.9	35.7	17.9	207.1	4,141

a/ The surface equivalent to total destruction was obtained for each area, based on the actual surface and estimated percentage or fallen or dragged trees.

b/ Indicated on the Nicaraguan National Protected Areas System Map (SINAP). Protected areas located in the Central and Pacific Regions of Nicaragua, whose boundaries are the rainfall Isohyet on the west, accumulated between October 21 and 31, 1998, corresponding to 400 mm.

c/ Anthropogenic intervention of the riverbank forest was estimated to be 30% and the lowest sector of the low basin and the estuary of the main rivers is not taken into consideration, in view of the huge size of the flood and the high degree of vulnerability introduced in those reaches. The network was preliminarily estimated to be 1,700 km. 30 m of riverbank are considered throughout its length.

d/ The overall cost for a 20-year recovery period is roughly 8.5 million dollars (93.5 million cordobas)

Source: ECLAC,1999e

Estimate of the damage caused by hurricane MITCH in social and economic sectors

An evaluation of the damage caused in social, infrastructure and production sectors is presented below.

For the region as a whole, damage was over US$ 6 billion , amount which divided almost equally between direct and indirect damages. It has been estimated that the replacement of the lost or damaged infrastructure will cost over US$ 4.4 billion . The farming sector had the greatest losses, both in lands and crops, as well asthe reduction of production.

Social sectors:

Damage in the social sectors mounted to almost US$ 800 Million. There were losses in hospitals, health centers and medical equipment. Thousands of homes were flooded and many families lost their precarious houses and furniture. Many schools and educational institutions were also affected by flooding.

In housing, approximately 176,500 dwellings were affected, with a loss of more than US$ 590 Million, including home appliances. The fragility of the buildings and the vulnerability of many of the locations they were built on, contributed to the devastating effects of the torrential rainfalls and floods.

The health sector suffered losses for approximately US$ 133 million.

In the educational sector, losses mounted to US$ 75 Million, including physical infrastructure, educational materials, textbooks and furniture. In view of the characteristics of school infrastructure, it is estimated that the replacement cost will be about US$ 112 Million.

Infrastructure:

Losses in communications, transportation, energy, water sewage and irrigation infrastructure were over US$ 1.245 Billion. According to ECLAC calculations, the losses of this sector at the regional level are 59 million dollars.

Damage to the water and sanitation sector, mounted to US$ 91 Million. The damage inflicted by the hurricane to irrigation and sewage systems (US$ 26 Million s) gave rise to severe consequences in water management and considerable effects are expected in irrigated agriculture

Productive sectors:

Damage in the production sectors is estimated to be over US$ 3.9 Billion, i.e., this represents almost two-thirds of the total amount estimated for damages. A little over US$ 1.8 Billion were direct losses (capital and production assets) and the rest were indirect effects, basically the loss that production will experience in the future and the additional costs of recovering production sectors to their pre-hurricane normal levels. The farming sector was the most affected, because it suffered over three-fourths of the damage to production sectors and almost half of the total damage.

In the farming sector, the large amount ofrain and humidity carried by Mitch hit the Atlantic coasts with great intensity, leading to flooding, overflowing of rivers, as well as mud and different materials being carried away, affected large farming areas, particularly in the lowlands and next to the streams. The losses in plantations, crops (ready to be harvested or stored) and infrastructure are roughly US$ 1.7 Billion , while disturbances in production flows and their costs would add US$ 1.245 Million more. In other words, total damage in the Central American farming sector was almost US$ 3 Billion dollars.

Insofar as secondary sectors, it is estimated that small and micro businesses suffered the greatest direct impact. Damage to assets (valued at US$ 33 Million), which are presumably significantly devalued, is far lower that indirect damage caused by changes in trade flows and the regular operations of all companies (roughly US$ 575 Million).

The trade and service sector suffered direct damage for losses of assets and inventories for US$ 89 Million.

Table 13 shows total damage caused in each sector by Hurricane Mitch in Central America:

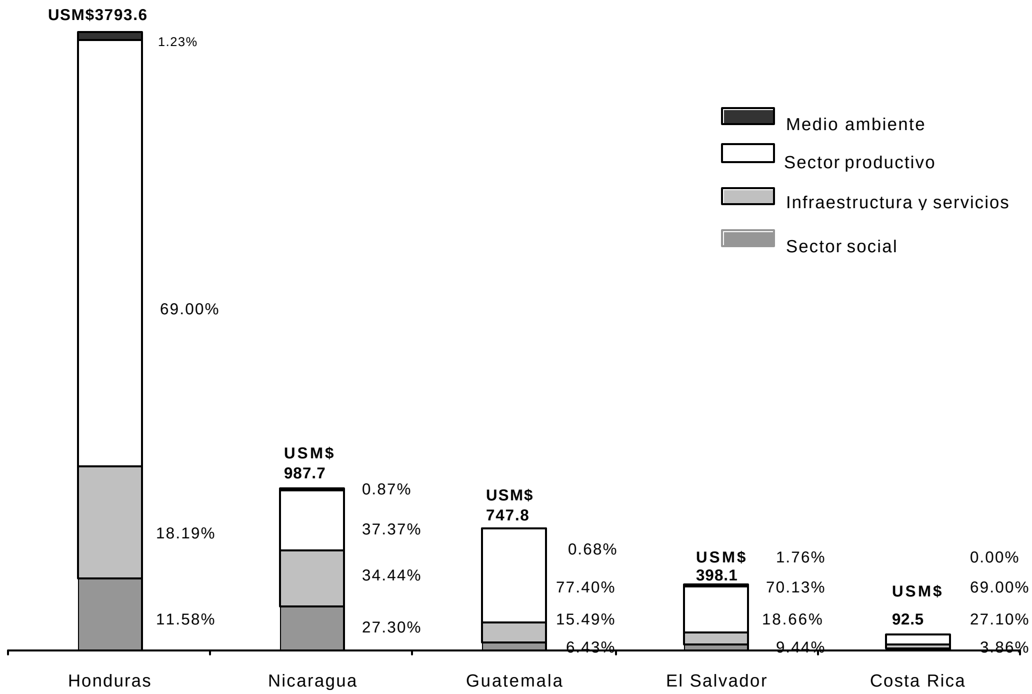
Table 13. Central America: Summary of the damage caused by hurricane Mitch (US$ thousands)

	Total	Direct damage	Indirect damage	Replacement costs
Total sectors	6 018.3	3 100.3	2 918.0	4 477.3
Social sectors	798.5	551.8	246.6	975.1
Housing	590.9	436.3	154.6	746.3
Health	132.7	53.8	78.9	117.0
Education	74.9	61.8	13.1	111.8
Infrastructure	1 245.5	656.9	588.6	1 756.5
Roads, bridges and railroads	1 069.5	528.1	541.5	1 427.9
Energy	58.7	28.6	30.1	60.6
Water and sanitation	91.4	74.6	16.8	224.4
Irrigation and sewage	25.8	25.6	0.2	43.6
Productive sectors	3 906.9	1 824.1	2 082.8	1 635.2
Agriculture, cattle, fishing and forestry	2 946.5	1 701.9	1 244.6	1 302.0
Manufacturing industry	608.0	32.8	575.2	69.9
Businesses, restaurants and hotels	352.4	89.4	263.0	263.3
Environment	67.4	67.4	0.0	110.5

Source: ECLAC, 1999f

Total damage per country in Central America, in the various sectors, is shown in **Figure 6.**

Figure 6. Damage caused by hurricane Mitch



Source: ECLAC, 1999. Notas de CEPAL N 3. Marzo 1999

Considered as the most severe disaster experienced by the sub-region in this century, Mitch caused9,214 dead and 12,845 injured, in areas that were just beginning to recover from the armed conflicts of previous years.

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V. Lessons learned

1. The relation between the type and magnitude of the natural event and the resulting environmental impacts, depends to a large extent, on environmental vulnerability

The lesson learned by examining the environmental impacts of the most recent natural disasters, suggests that the magnitude of the disaster (human, physical, material and environmental damage) is not always directly related to the magnitude of the natural event. In most cases, the majority of the population affected, is the one living in areas of natural risk, such as riverbeds, high slopes, fragile or marginal soils, where either there are no regulations for the use of the land according to its capacity or fragility, or they are not enforced.

The above, combined with inappropriate practices of use and management of natural resources, which exceed the load capacity of ecosystems in general, leads to the deterioration and degradation of physical and biological environments, and make these areas or geophysical units and those that reside in them, more vulnerable to the effects of hydrometeorological events, particularly hurricanes, tropical cyclones and their side effects, such as landslides, floods, and mud avalanches. The affected populations are usually the low-income sectors; thus leading to a vicious circle of poverty and environmental degradation that one can not escape unless comprehensive measures are taken by all players concerned.

In this sense, another experience acquired is that ex-ante prevention measures are much more efficient and effective and less costly than rehabilitation, restoration, etc (the ex-post). The costs of repairing damage are much higher than anticipatory technical, structural and institutional measures of coordination and training. Therefore, the design of regulations in different sectors is essential, in addition to strengthening education and prevention of disasters among the population, before the cyclic recurrence of this type of events

2. Urbanization and increase of environmental vulnerability

In recent decades, the number and density of population in earthquake prone areas or areas affected by tropical storms, have increased. There are population pressures forcing fields into marginal crops, making these areas vulnerable to avalanches or landslides.

Experts agree that rapid, uncontroled urbanization increases the risk of natural disasters. The demand for land for the growth cities means that unsuitable land exposed to natural hazards is used; rapid growth involves an increase of buildings, many times poorly constructed or with inappropriate maintenance. The clogging of natural drainage channels; the location of hazardous industries and materials in urban areas, expose the population to future dangers. These elements, inter alia, become additional threats in the case of disasters. If these phenomena are not reversed, starting by political, local and national commitments, and policies for safer cities, catastrophes will lead to an even greater number of casualties and material damage.

3. The importance of ecosystem assessments

In order to really know the magnitude of the damage in ecosystems and compare it with the cost of prevention, mitigation and recovery measures, in cases of natural disasters, it is important to have more accurate methods of assessing them. The importance of evaluation not only lies exclusively in assigning a price to environmental services, but also in highlighting the role they play both in the economic development of countries, and in the protection from impacts of natural events. Economic assessment also makes it possible to have an objective recognition of the relationship between the complex dynamics of physical and biological processes and their influence on human well-being. Underestimating environmental services leads to unsustainable medium and long-term development strategies.

4. The importance of defining the concept of the environment in relation to natural disasters

For the purposes of environmental impact evaluation and assessment of damage in the case of disasters, it is important to have standardized criteria about the concept of the environment, including the including urbanized environment (for example, infrastructure, housing, industries), agriculture, forestry and fishing, and human health. This broader definition contributes to recognizing the responsibilities in protecting the environment both of the community and government agencies in different territorial and sectoral spheres.

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VI. Recommendations for reducing environmental vulnerability in the event of natural disasters

In view of the serious evidence of social, economic and environmental impacts of natural disasters, it is essential that via the powers of their States, all countries assume a significant and effective role in managing disasters, promoting their mitigation, prevention and reduction in an analytical, technical and proactive way, following as a strategic condition, planning for development and a more appropriate, stringent and applicable land use planning. This must be backed up by the proper legislation and budgets.

Therefore, the following activities are proposed:

a) Assessment of environmental vulnerability at the regional and local levels. For this, it will be necessary on the one hand, to design appropriate methodologies for each case (according to the type of event and the geographical features of the territories involved), and on the other, use geographical information systems (GIS) to prepare comprehensive maps on environmental vulnerability and hazards. A specific proposal is to prepare a number of maps showing the current environmental vulnerability of Latin America and the Caribbean and clearly indicate the areas that need immediate attention.

b) The strengthening of strategies to develop land use plans and their implementation. These plans must include the vulnerability and hazard maps suggested in item a) so that they can be the main input for prevention, reconstruction and environmental emergency plans. A new concept that is being implemented in the region –along the lines of land use planning– is bio-regional planning, making activities for the protection and reconstitution of biophysical systems possible (catchment basins, coasts, mountain areas, for example), which are shared by more than one country, via coordinated actions for comprehensive management of the environment and natural resources.

c) Development and strengthening of methodologies for environmental impact assessments (EIA) of extreme physical events, in order to estimate the magnitude of the damage and losses of natural property (qualitatively and quantitatively) and propose mitigation measures, for future disasters. This will also allow to sensitize decision-makers to the importance of environmental protection and the proper management of natural resources as a preventive measure to mitigate impacts. EIAs are an element of support that help to prioritise reconstruction projects in a way that those that take into account the recovery and rehabilitation of degraded or damaged ecosystems,be considered.

d) Develop, strengthen, disseminate and harmonize monitoring and early warning models that exist in the region. This should be based on existing sub-regional systems and institutions, such as CEPREDENAC in Central America and other stations in the Caribbean, reinforcing skills developed and the experience of recent disasters.

Table 2. Mitigation measures in case of floods

At the global level, floods are the most destructive natural catastrophes; they cause a higher number of casualties.

Among the measures that can be adopted in the face of this hazard there are:

a) Risk assessment (preparation of hazard maps based on hydrological data).

b) Control of land use (intended only for ecological reserves, contention basins or recreational services in those areas prone to frequent floods).

c) Control of high river water (building of dams, contention basins, diversion channels). These works can reduce the impact of high water but, in addition to being costly, they can disturb the environment.

d) Protection against flooding. Measures against floods (construction of buildings on piles. or walls or floodgates around properties).

e) Emergency response plans (involving all players and victims, with public information).

f) Anticipation of water rises

g) In countries affected by El Niño, monitoring networks, for sea temperature, cooperation among countries for early warning systems.

In order to mitigate the damage caused by floods, it is advisable to develop both structural and non-structural protection measures. For example, some structural measures may include the following:

a) Permanent hydraulic (water regulation) works.

b) Works that make water transportation fast and easy.

c) Works to improve watershed management (reforestation, terracing, etc.).

d) Levees.

Amongst the institutional measures, it could be mentioned:

a) Logistic measures, such as the issue of warning bulletins, evacuation.

b) Permanent measures, such as the regulation and control of land use.

c) Restrict settlements in riverbeds or in down stream plains that can be affected by flooding

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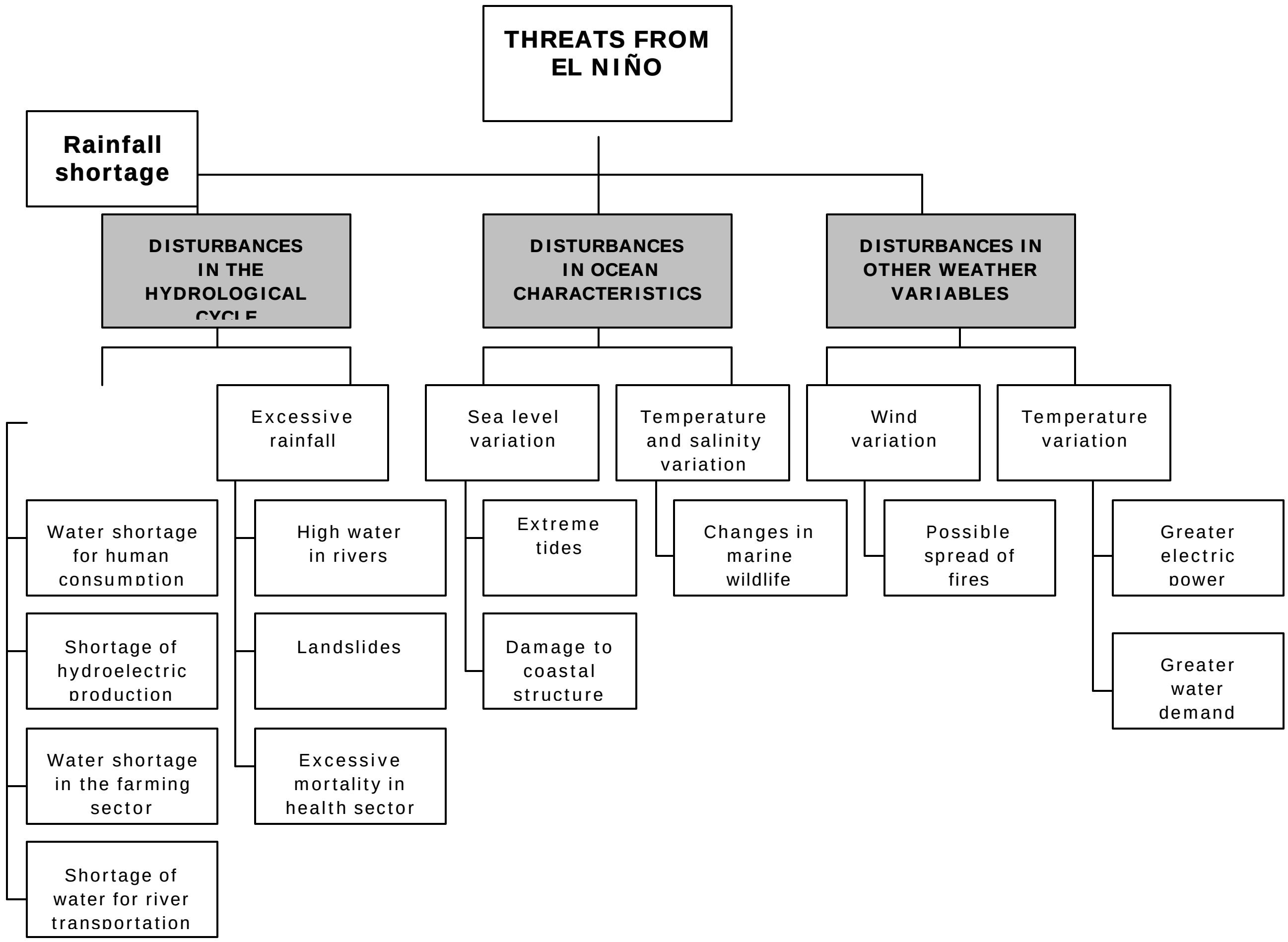
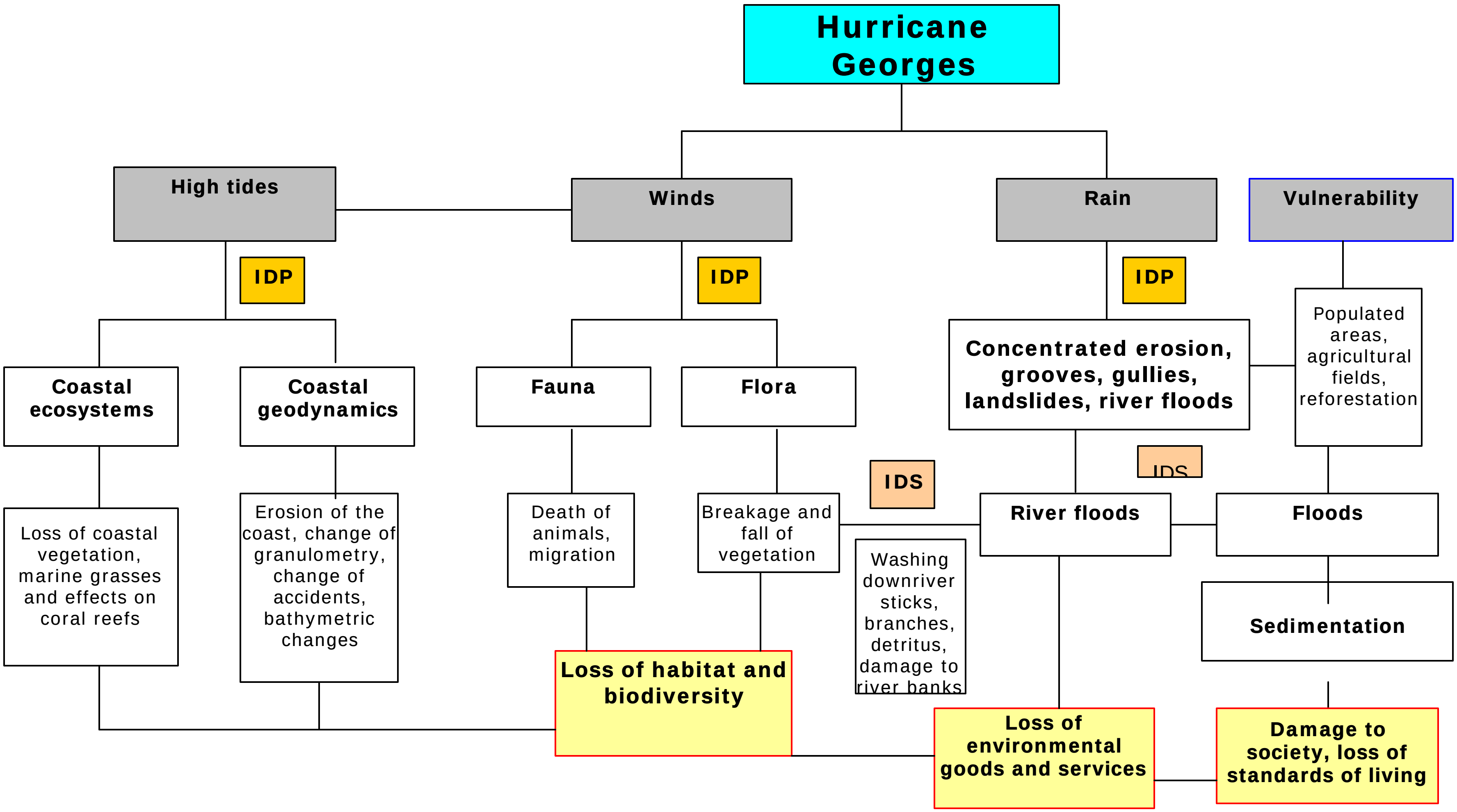
Annex I

Model to identify threats from El Niño phenomenon



Source: ECLAC, 1998.

Annex II
Association of direct impact of hurricane Georges on the natural property of the Dominican Republic



Source: ECLAC, 1998

Annex III
Forest environmental services

(US$/ha/year)

Source: CESPEDES, 1999

	Direct use value			Indirect use value								**Option value**	**Intrinsic value**	**Total unit value**
Author	Timber-yielding	Non-timber-yielding	Tourism ecotourism / landscape	Weather regulation (greenhouse gas)	Natural disturbances control (floods, droughts)	Hydrological regulation	Erosion control	Formation of soils	Nutrient recycling	Removal of excessive organic matter	Biological control	Drug potential	(Scientific, cultural, moral, conservation)	US$/ha/año
Constanza et. al., 1997														
Tropical forests		347[1]	112	223	5	14	245	10	922	87	-	41	2	2007
Temperate forests		75[1]	36	88	-	0	-	10	-	87	4	-	2	302
CCAD and CCAB-CCAP 1998														
Tropical forests		300	10	----[2]	-	10	-	5	-	-	-	10	-	335
Adger, et al., 1995														
Tropical forests		330[3]	20[4]	100[5]	-	0.04[6]	-	-	-	-	-	1-90	10[7]	461-552
Temperate forests		-	20[4]	103[5]	-	0.04[6]	-	-	-	-	-	1-90	10[7]	136-226

Constanza, et al, 1997, op.cit, CCAD y CCAB-CCAP,1998, op.cit, Adger, et al., 1995,op.cit.

1. Non-timber-yielding only includes food production

2. Reported figures are ommitted since they are annualized in flows/ha

3. 1989 US$, only mosophyll and humid forests of the regions of San Luis Potosí, Yucatán and Quintana Roo;

4. Author's figures: 32.1 million US$ per year in a total of 1.6 million ha.

5. At current value, US$3,633.00/ha is estimated for tropical forests, and US$3,436/ha for temperate forests.

6. Only water qualiaty control.

7. Only conservation within protected natural areas.

the value is for non-timber-yielding

Annex IV
Environmental services of forests in Mexico

(US$ x 10^9 /year)

	Direct use value			Indirect use value								**Option value**	**Intrinsic value**	**Total unit value**
Author	Timber-yielding	Non-timber-yielding	Tourism ecotourism / landscape	Weather regulation (greenhouse gas)	Natural disturbances control (floods, droughts)	Hydrological regulation	Erosion control	Formation of soils	Nutrient recycling	Removal of excessive organic matter	Biological control	Drug potential	(Scientific, cultural, moral, conservation)	US$/ha/año
Total value US$ x 10^9 /year[1]														US$ x 10^9 /año
Tropical	28	9.7	3.1	6.2	0.1	0.4	6.9	0.3	25.8	2.4		1.1	0.06	56.1
Temperate	28	2.1	1.0	2.5				0.3		2.4	0.1		0.06	8.5
Total	56	11.8	4.1	8.7	0.1	0.4	6.9	0.6	25.8	4.8	0.1	1.1	0.12	64.6
Total value US$ x 10^9 /año[2]														US$ x 10^9 /año
Tropical	28	8.4	0.3		0.3		0.1					0.3		9.4
Total value US$ x 10^9 /año[3]														US$ x 10^9 /año
Tropical	28	9.2	0.56	2.8		0.001						2.5	0.3	14.8
Temperate	28		0.56	2.8		0.001						2.5	0.3	5.6
Total	56	9.2	1.20	5.6		0.002						5.0	0.6	21.5
Total value US$ x 10^9 /año[4]														US$ x 10^9 /año
Total forests	56	0.90												0.90

1. Constanza, et al., 1997, op cit.
2. CCAD and CCAB-CCAP, 1998, op. cit., not including carbon emissions.

3. Adger, et al., 1995, op. cit.; the value was estimated with the highest figure.

Source: CESPEDES, 1999

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