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Regional assessment on ecosystem-based disaster risk reduction and biodiversity in Mesoamerica and the Caribbean

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Abbreviations

AEC / ACS	Association of Caribbean States
CANARI	Caribbean Natural Resources Institute
CARICOM	Caribbean Community
CCAD	Central American Commission on Environment and Development
CCCCC	Caribbean Community Climate Change Centre
CDB-CBD	Convention on Biological Diversity
CEPREDENAC	Central American Coordination Center for Natural Disaster Prevention
CDEMA	Caribbean Disaster Emergency Management Agency
CDERA	Caribbean Disaster Emergency Response Agency
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CRED	Centre for Research on the Epidemiology of Disasters
CRRH	Regional Committee on Hydraulic Resources
Eco-DRR	Ecosystem-based Disaster Risk Reduction
ENOS / ENSO	El Niño–Southern Oscillation
FLACSO	Latin American Social Sciences Institute
GEF	Global Environment Facility
GIRH / IWRM	Integrated Water Resources Management
GIZ	German Corporation for International Cooperation
GWP	Global Water Partnership
IFA / EVI	Environmental Vulnerability Index
NOAA	National Oceanic and Atmospheric Administration
INBio	National Biodiversity Institute, Costa Rica
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resource Management
MINAE	Ministry of Environment and Energy
ODPEM	Office of Disaster Preparedness and Emergency Management
OMM / WMO	World Meteorological Organization
ORMACC / NACC	North American, Central American and Caribbean Regional Office
PERFOR	Regional Strategic Program for Forest Ecosystem Management
PNUD / UNDP	United Nations Development Programme
PREP	National Ecosystem Restoration Program
RiVAMP	Risk and Vulnerability Assessment Methodology Development Project
SICA	Central American Integration System
SINAC	National System of Conservation Areas of Costa Rica
SINAP	National System of Protected Areas of Honduras
TEEB	Economics of Ecosystems and Biodiversity
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	United Nations Office for Disaster Risk Reduction
USAID	United States Agency for International Development
WANI	Water and Nature Initiative

Executive summary

Mexico, Central America and the Caribbean possess a wide range of biological diversity due to their geographic location and young geological territories. The Central American countries represent less than 1% of the surface of the planet, yet they are home of approximately 7% of world´s know species; more than 20 life zones and approximately 33 ecoregions form the territory.

The region has a population of nearly 200 million people[1], who depend on natural resources and ecosystem services for basic needs such as food, water and fresh air. But the region is also vulnerable to natural hazards such as hurricanes, tropical storms, floods, droughts, frosts, landslides, earthquakes and volcanic eruptions. These are frequent occurrences throughout the year. On many occasions, physical, economic and social vulnerability exacerbates the impact of these natural events, causing losses worth millions in crops, infrastructure and economic activities and making them disastrous for people. As an extreme example, Hurricane Mitch caused losses equivalent to 30% of GDP in Central America in 1998.

In addition to the terrible loss in human life, this affects the economy of the countries, making it more difficult to find the necessary financial resources to cope with emergency care, reconstruction of infrastructure and resuming public services. Cumulative impacts of these adverse effects over time have had a significant negative impact on the most vulnerable people in society, who continue to experience a constant decline in their living standards.

In this sense, the region faces major challenges, including:

a. High vulnerability to climate change effects and to cyclic events of climate variability such as the El Niño (Southern Oscillation) and La Niña phenomena. These lead to economic and social elements that have an impact on the different degrees of vulnerability of the countries;

b. Generating more effective policies and regulations in matters of natural resources, risk management and climate change, so that emerging challenges can be addressed;

c. Strengthening governance and governability, locally as well as regionally, so that governments and state organisations can work together with the communities; and

d. Reducing poverty levels, since poverty is a condition that favours physical vulnerability and is an important factor in the risk equation; people living in poverty and extreme poverty suffer the most from the direct and indirect effects of extreme natural processes and their cumulative environmental, economic, and social effects.

The region also has great opportunities: to grow socially, economically, and environmentally in a holistic manner. The region has policies and strategies based on the reality and current situation of each of the countries. While the level of implementation and application of these instruments sometimes fall short, the policies and strategies of the region are in continuous adaptation, providing opportunities to include new methodologies and concepts, such as Eco-DRR. The great diversity of the region is reflected in communities that organise themselves into effective groups to address key issues of concern. Groups of artisanal fisher, groups of women, groups of politicians, groups of conservationists, local emergency care committees, citizen safety committees, groups

1 This is the approximate sum of the population of Mexico, Central American and Caribbean countries.

of agriculturists, and many others are found throughout the region. The better organised committees have demonstrated a greater capacity, increasing resilience and adaptability to change.

This document contains a regional overview of the focal countries, the most significant natural hazards and impacts, the biodiversity of ecosystems and species, an explanation of the regional and national policies about risk management, and the experiences in the region on Eco-DRR.

The focal countries are:

Table 1. Focal countries, UN Human Development Index and GDP

Country	UN-Human Development Index[1]	GDP (US$ billions)[2]
Mexico	0.756	1.295 (trillion)
Belize	0.715	1.6
Guatemala	0.627	58.83
Honduras	0.606	19.39
El Salvador	0.666	25.16
Nicaragua	0.631	11.81
Costa Rica	0.776	49.55
Panama	0.780	46.21
Cuba	0.769	77.15
Jamaica	0.719	13.89
Dominican Republic	0.715	64.14
Trinidad and Tobago	0.772	28.88

Finally, the document describes six case studies involving the relationship between society and ecosystems in reducing disaster risk, listed in Table 2:

Table 2. Case study by country

Country	Case study
Mexico-Guatemala	Basins associated with the Tacaná Volcano in Guatemala and Mexico. Transboundary governance of water and implementation of the IWRM through local community involvement
Dominican Republic	Regional Strategic Program for Forest Ecosystem Management. Central America and Dominican Republic
El Salvador	Shade-grown coffee and alterations to reduce pressure of the change in land use in the southern region of Ahuachapán, El Salvador. Integrated basin project associated with the hydrographical complex in Barra de Santiago-El Imposible (BASIM)
Guatemala	Lachuá Lagoon Project. Experience systematisation. Guatemala.
Trinidad and Tobago	Pilot Project: Community action to build climate change resilience in Trinidad and Tobago.
Dominican Republic	Protected areas and climate change: Legal perspectives and action management in Dominican Republic.

2 Programa de las Naciones Unidas para el Desarrollo. 2015. Panorama general. Informe sobre Desarrollo Humano 2015. Naciones Unidas. NY. Estados Unidos

3 Data, World Bank. Available at http://datos.bancomundial.org/ Accessed on 27 May 2016.

1. Introduction

Mexico, Central America and the Caribbean possess a great variety of terrestrial and marine ecosystems due to their geographic location, ranging from tropical rainforests, swamps, and wetlands to cloud forests, paramos, coral reefs, gulfs, and estuaries, among others. The Pacific Ocean and Caribbean Sea are part of the main coastlines of the region. The second largest barrier reef in the world is located in the Caribbean Sea (the Barrier Reef of Belize) and Central America is home to 7% of the known biodiversity on the planet,[4] including 20 life zones,[5] 33 ecoregions and approximately 206 types of ecosystem.[6]

The region covers an area of approximately 6,046,233 km^2 with an approximate population of 199,029,644 people. This is predominately comprised of people of mixed race, indigenous people and those of African descent.[7] (See Figure 1)

From a socio-economic point of view, the region has sharp contrasts in Human Development Index (Table 1), so the countries vary dramatically in their physical and socio-economic vulnerabilities. This results in a high level of differences in their resilience, which is also evident in the implementation and policies for conservation of biodiversity.

Figure 1. Location of Mexico, Central America and Caribbean countries in relation to the American continent.[8]

4 Economic Commission for Latin America. 2011. Economy of climate change in Central America. Technical report 2011. British Ministry for International Development, Economic Commission for Latin America, Cooperation for Development of Denmark. Mexico D.F., Mexico.

5 Holdridge life zones refers to a group of vegetative associations according to climate, edaphic conditions and a series of levels.

6 GIZ. 2011. Biodiversity, forests and development in countries members of the Central American Integration System. Regional document. GIZ. SICA. CCAD.

7 Data, World Bank. Available at http://datos.bancomundial.org/indicador/AG.LND.TOTL.K2. Accessed on 11 January 2016.

8 ESRI digital map database.

Healthy ecosystems have an important role to play in disaster risk reduction. For example, forests reduce the possibility of landslides, and mangrove forests and coral reefs diminish the force of the waves during a hurricane or tropical storm.

Healthy habitats not only benefit the people by providing ecosystem services, but in some cases can also lower risk and physical vulnerability in the face of events like hurricanes, turbulent wave activity, storm surges, and tsunamis of low to medium intensity. Healthy and well-managed ecosystems also provide multiple benefits such as water retention, transform carbon dioxide into oxygen, reproduce species for commercial value and increase crop yields.

This role is reflected in Ramsar Resolution XII.13 (2015), about wetlands and risk reduction: "the Parties affirm (…) *the need to develop and implement management plans for wetlands or adapt them in instruments designed for the management of existing natural resources, especially Ramsar Sites, that integrate the principles of ecosystem-based management and adaptation against natural hazards such as dust and sand storms, floods, droughts, fires, landslides, coastal erosion, tsunamis, hurricanes, storms, and storm surges, and also against accelerated sea level rise, and STRONGLY ENCOURAGES the mainstreaming of disaster risk reduction measures in these management plans and into all relevant policies, action plans and programmes* (…)."[9]

The introduction of new approaches helps to improve existing policies on the issue of risk reduction and ecosystem conservation, in this case, Eco-DRR.

1.1 Important concepts

What is understood by **risk**? A physical geography dictionary defines it as a "perceived incident that threatens the life or wellbeing of an organism, especially man."[10] However, others (such as White 1978 and 1993) explain the relationship of natural risks with demographic growth, as well as economic, social and environmental processes, where underdeveloped countries emerge as candidates that suffer the social and economic impact of natural processes; with greater economic development, the loss of lives and economic impact due to natural risks will be lower.[11]

Risk is currently conceived as a **social construction**, which means risk does not depend on the natural event, but rather on political and economic decisions of a country or region; it has to do with generating conditions of social vulnerability and inequality, where the occurrence of disasters represents unresolved development issues.[12] This is why "natural disasters" do not exist, only "social disasters."

A linked concept is **vulnerability**, which is connected to the socioeconomic status of a group of people or population. It includes important elements such as ethnic group, gender, age, access to information, cultural knowledge and social networks; therefore, some groups are more vulnerable than others where poverty becomes a condition[13] but not the cause.

In this summary, a concept of great importance is missing: **resilience**, which has to do with the ability of an individual or a population to deal with and overcome the negative impact of natural processes, where civic networks gain relevance in communities that lack economic resources, building resilience does not necessarily depend on economic power but on community organisation.

The El Niño Southern Oscillation (ENSO) is a natural climatic process that occurs cyclically. El Niño consists of the warming of surface waters (eastern and central) of the equatorial Pacific every two to seven years and has a duration ranging from 9-18 months; meanwhile La Niña is the cooling of the surface waters with periods of frequency similar to El Niño.[14]

9 Ramsar. 2015. Resolution XII.13. Wetlands and disaster risk reduction. 12th Meeting of the Conference of the Parties to the Convention on Wetlands (RAMSAR). Uruguay

10 Whittow, J. 1988. Diccionario de geografía física (Physical geography dictionary). Madrid: Alianza Editorial.

11 White, G. 1975. "La investigación de los riesgos naturales" en Chorley, R. Nuevas tendencias en geografía. Madrid: IEAL

12 Lavell, A. 1999. "Un encuentro con la verdad: Los desastres en América Latina durante 1998" en Anuario político y social de la América Latina. Nº 2. San José: FLACSO.

13 Saurí, D. 2003. "Tendencias recientes en el análisis geográfico de los riesgos ambientales" en Revista AREAS. Los procesos del riesgo con origen natural: una constante en la relación entre hombre y medio, Revista de Ciencias Sociales, Nº 23. Murcia: Universidad de Murcia.

14 Guevara, J. M. 2008. El ABC de los índices usados en la identificación y definición cuantitativa de El Niño-Oscilación del Sur (ENSO). Revista Terra. Vol. XXIV, No. 35, pp 85-140

El Niño causes periods of severe drought in Mexico, western Mesoamerica, Venezuela, Brazil and the Amazon Basin, and flooding in the Mesoamerican Caribbean, Ecuador, Peru, Chile, Argentina, Uruguay, Paraguay and the South of Brazil.[15] Meanwhile, La Niña generates abundant rains in Mexico, Central America, Colombia, Ecuador and rainfall deficit in Argentina, Chile, Paraguay, Brazil and Uruguay.[16]

Both El Niño and La Niña may intensify the effects of global warming by increasing the intensity of droughts and the number of tropical storms and hurricanes.

Gender. It is mostly poverty-stricken women that are most vulnerable (physically, socially and economically) and have a lesser degree of resilience. For example, the impact of climate change will exacerbate the exclusion of women farmers due to the lack of fertile soils, since land management and property rights often put women of limited resources at a disadvantage.[17]

Ecosystem-based Disaster Risk Reduction (Eco-DRR) refers to "the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development,"[18]also "decision-making activities that take into consideration current and future human livelihood needs and bio-physical requirements of ecosystems, and recognize the role of ecosystems in supporting communities to prepare for, cope with and recover from disaster situations. Sustainable ecosystem management for disaster risk reduction is based on equitable stakeholder involvement in land management decisions, land-use trade-offs and long-term goal setting."

So, ecosystem-based disaster risk reduction (Eco-DRR) cannot focus only on environmental health since it is not the only variable that intervenes in the equation, but also depends on the organisation of the communities, the existence and implementation of environmental, social and economic policies, the reduction of vulnerability and recognition of the importance of ecosystem services for human beings and other species.

Ecosystems can reduce physical exposure and vulnerability to natural hazards such as tropical storms, hurricanes, landslides, flooding, by serving as natural protective barriers,[19] for example, the mangrove forest is a protective barrier against storm surges, and healthy primary forest can reduce the risk of landslides in mountains and valleys.

For this reason, the objective of this document is to review information and experiences on Eco-DRR and its link with the conservation and restoration of the biodiversity of ecosystems and species in the geographic context for the Regional Office of the IUCN for Mexico, Central America and the Caribbean.

15 Repercusiones climáticas del fenómeno El Niño en América Latina y el Caribe. GRID Arendal. Available at http://www.grida.no/publications/vg/lacsp/page/2792.aspx Accessed on 4 July 2016.

16 La Niña y sus consecuencias sobre el sector agropecuario en América Latina. Organización de las Naciones Unidas para la Alimentación y la Agricultura. http://www.fao.org/agronoticias/agro-editorial/detalle/en/c/121917/ Accessed on 4 July 2016.

17 Aguilar, L. 2009. Manual de capacitación en género y cambio climático. IUCN, PNUD y GGCA. San José, Costa Rica.

18 Idem [2]

19 Renaud,F., Sudmeier-Rieux, K, Estrella, M. 2013. The role of ecosystems for disaster risk reduction. Tokyo: UNU-Press

2. Methodology

This assessment was carried out through desk research. A synthesis report on Ecosystem-based approaches to climate change adaptation and disaster risk reduction developed by the Secretariat of the Convention on Biological Diversity (Lo, 2016) was used as a basis throughout the assessment (with regards to the methodology used and sources of information).

A review of existing literature including project reports, scientific articles and policy documents obtained from various sources was conducted and data from different online databases were also extracted and analysed to document the following topics for the assessment:

- Regional overview on types of hazards, impacts of disasters, vulnerability to disasters, the biodiversity of species and ecosystems
- Policy context to Eco-DRR and biodiversity in the region
- Biodiversity case for Eco-DRR: practical examples of how species diversity, ecosystems diversity (different habitat types) and means of conservation (different management approaches) contribute or can contribute to Eco-DRR outcomes in the region
- Economic case for Eco-DRR: example of economic benefits of Eco-DRR in the region and financing opportunities with the integration of biodiversity conservation and risk reduction.

For the case studies, research was carried out on the different documents,[20] as much as on international organisations dedicated to the study of natural resources, as well as government entities; for example, Ministries of Natural Resources of the region, as well as organisations on a regional level such as the Central American Integration System and the Caribbean Community Secretariat.

For economic and social matters, official documents were accessed on a national level as well as a regional level through the databases of the Central American Integration System, the Caribbean Community Secretariat, the International Bank for Reconstruction and Development and the Economic Commission for Latin America.

The investigation about natural risks and risk management was completed with information from the Central American Coordination Center for Natural Disaster Prevention, National Oceanic and Atmospheric Administration, Office of Disaster Preparedness and Emergency Management, World Meteorological Organization, Center for Research on the Epidemiology of Disasters, Caribbean Disaster Emergency Management Agency, among others, as well as specific literature on the subject created by investigators and scientists.

The focus countries for this document are: Mexico, Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Cuba, Jamaica, Dominican Republic and Trinidad and Tobago. The main criterion used for selection was the Global Climate Risk Index 2015 position.[21]

20 See Literature and references section.

21 The Global Climate Risk Index, an indicator developed by German watch analyses to what extent countries have been affected by the impacts of water related loss events. The index indicated the level of exposure and vulnerability to extreme events that countries understand as warning to be prepared for frequent severe events in the future, based on data from Munich Re NatCatSERVICE, which examines both absolute and relative impacts to create a ranking of countries in four indicating categories. Munich Re records the number of total losses caused by weather events, number of deaths, insured damages and economic damages (number of deaths, number of deaths per 100 000 inhabitants, sum of losses in US$ in purchasing parity and losses per unit of Gross Domestic Product). For more information see www.germanwatch.org

3. Regional overview

Mexico, Central America and the islands of the Caribbean Basin are located on the Tropic of Cancer (west of the Greenwich meridian and north of the equator in the northern hemisphere).[22] The geographic position makes the area vulnerable to mainly hydro meteorological processes. Likewise, the area forms part of the Pacific Ring of Fire, which indicates the presence of active volcanoes and highly seismic areas. However, this document does not cover this last matter.[23]

3.1 Natural hazards in the region

The most frequent natural hazards in the region (hydro meteorological) are hurricanes, tropical storms, low-pressure systems, floods, landslides, rock slides and droughts, as well as hailstorms and frosts to a lesser degree. It is important to mention that in most cases the floods, landslides and rock slides are linked to hurricanes and low-pressure systems. Also, the occurrence of these events may increase due to the influence of the El Niño/La Niña phenomena. (See Table 3)

Table 3. Effects of some hurricanes in the region in the last 30 years.

Event	Affected region	Year	Economic losses US$ millions
Hurricane Joan	Caribbean & Central America	1988	840 [24]
Hurricane Cesar	Costa Rica	1996	151 [25]
Hurricane Mitch	Honduras	1998	3,500 [26]
Hurricane Keith	Belize	2000	258 [27]
Hurricane Iris	Mexico	2001	209 [28]
Hurricane Stan	El Salvador and Guatemala	2005	1,168 [29]
Hurricane Felix	Nicaragua and Honduras	2007	716 [30]

Source: IUCN ORMACC.

22 Countries in the region: Mexico in North America; Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama in Central America. Finally, Bahamas, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Saint Kitts and Nevis, Antigua and Barbuda, Guadeloupe, Dominica, Martinique, Saint Lucia, Barbados, Saint Vincent and the Grenadines, Grenada and Trinidad and Tobago in the Caribbean.

23 Ecosystems are not thought to reduce risk during volcanic eruptions or earthquakes, since they are endogenous and have different dynamics than exogenous processes. On the contrary, during this type of events important effects in the different ecosystems have been documented as a result of landslides, gas emissions, ash and lava, and even elevations or depressions of the continental platform, as well as fractures in tectonic plates.

24 Comisión Económica para la América Latina. 1988. Daños ocasionados por el huracán Joan en Nicaragua. Sus efectos sobre el desarrollo económico y las condiciones de vida y requerimientos para la rehabilitación y reconstrucción.

25 Comisión Económica para la América Latina. 1996. Efectos de los daños ocasionados por el huracán César sobre el desarrollo de Costa Rica en 1996. CEPAL.

26 EIRD. 2008. Sistematización de mejores prácticas educativas para le gestión del riesgo en Centroamérica. EIRD.UNICEF. SICA.

27 Consejo Regional de Cooperación Agrícola. 2001. Desastres en Centroamérica: Perspectiva sectorial agropecuaria. IICA. CORECA. CAC

28 CENAPRED. 2001. Impacto socioeconómico de los principales desastres ocurridos en la República Mexicana en el año 2001. CENAPRED. México.

29 Comisión Económica para la América Latina. 2005. Los efectos del huracán Stan en El Salvador y Guatemala.

30 Comisión Económica para la América Latina. 2008. Impacto del huracán Félix en la Región Autónoma del Atlántico Norte y de las lluvias torrenciales en el noroeste de Nicaragua.

From a geological point of view, Mexico, Central America and the Caribbean are young territories in comparison with North and South America. This is land that emerged thanks to volcanic and seismic processes, over the past 12-15 million years with geodynamics forming extensive valleys, hydrographic basins and mountains with elevated gradients, located between two oceanic systems which have defined different climate zones and as a result, a great variety of ecosystems.

Although the geodynamic processes (endogenous and exogenous) have generated life on Earth and have created the mountains and coasts that we know to this day, with the presence of human beings and their vulnerability and exposure to natural events, they have had a negative impact on people on many occasions.

According to the Global Climate Risk Index, Central America is the second most vulnerable region in the world to climate risks; the first region is Asia. This index reports that between 1993 and 2012, Honduras, which is ranked at first place, was affected by a total of 65 events, with 329 victims and more than 667 million dollars in losses. In the third place is Haiti with 60 events, 307 victims and 212 million dollars. Nicaragua, Dominican Republic and Guatemala are ranked at fourth, eighth and tenth places respectively.[31]

The Center for Research on the Epidemiology of Disasters (CRED) of the University of Leuven (Belgium) mentions that in Central America alone between 1970 and 2011, 69% of the disasters that occurred originated from hydro meteorological processes, 21% from volcanism and tectonism, while 9% came from biological threats.[32] It should be noted that all of the islands in the Caribbean, as well as the Caribbean coasts in Central America and Mexico, make up the Atlantic Hurricane Belt; that is to say that depressions and tropical storms are formed there, some of them eventually turning into hurricanes. The Mexican Pacific is also a "hot spot" for the formation of these types of processes. (See Figure 2)

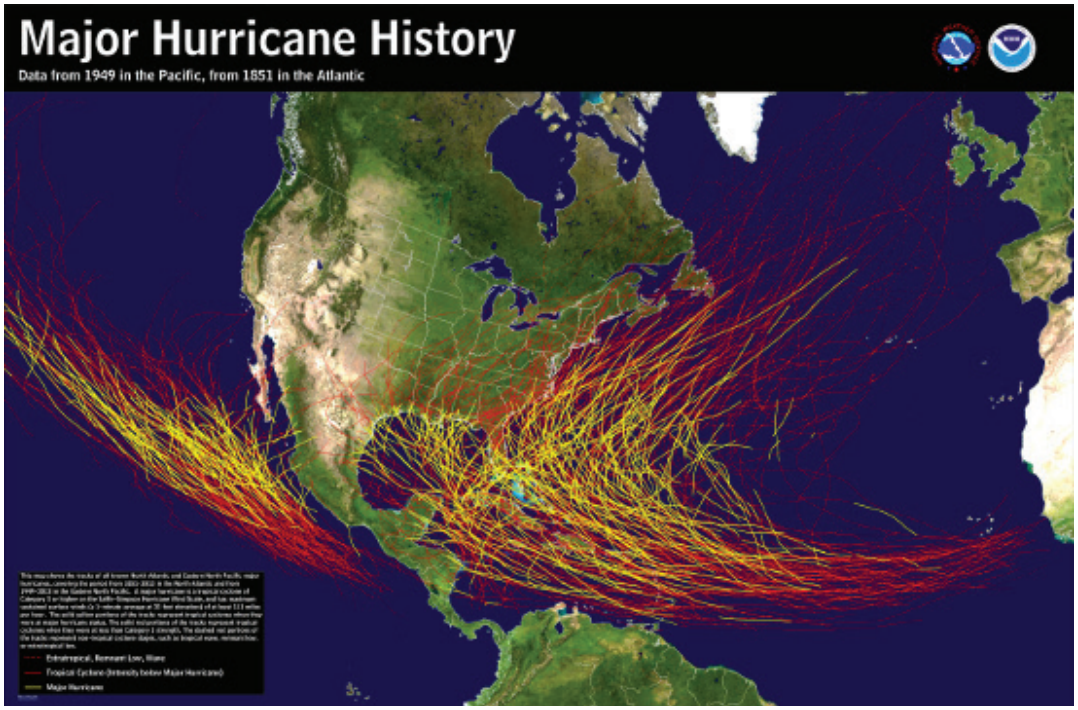


Figure 2. Hurricanes larger than category 3 on the Saffir-Simpson scale that occurred in the Caribbean, north Atlantic and northeast Pacific between 1949 and 2013 (Pacific) and 1851 and 2013 (Atlantic and Caribbean).[33]

31 INISDR-CEPREDENAC. 2014. Regional report on the state of vulnerability and disaster risk in Central America. United Nations Office for Disaster Risk Reduction.

32 Cited in INISDR-CEPREDENAC. 2014. Regional report on the state of vulnerability and disaster risks in Central America. United Nations Office for Disaster Risk Reduction.

33 Tropical cyclone climatology. Available at http://www.nhc.noaa.gov/climo/ Accessed on 12 January 2016.

Even though all of the countries of the region have natural emergency care plans some have given greater importance to such events that may affect them more frequently. For example, Jamaica has preparation and emergency plans specifically for hurricanes due to the great amount of events that hit the island. Between 2001 and 2012, Jamaica was hit by eight hurricanes with categories that range from 3 to 5 on the Saffir-Simpson scale.[34] The Office for Disaster Preparedness and Emergency Management has a great amount of information on the subject available to the community, ranging from preparation guides to emergency plans.

Another example of national preparedness for hurricanes and tropical storms is Cuba, since, like Jamaica, the island is located in the same area where these types of hydro meteorological events are frequent each year.

Climate processes like storms, depressions and hurricanes produce extraordinary precipitation (that is to say, outside the monthly or daily average). This high intensity rainfall saturates the ground water levels and increases river water levels that can cause floods and landslides. It is because of this that the region is equally susceptible to these events each time there is low atmospheric pressure.

On the other hand, Mexico, Central America and the Caribbean are also vulnerable to droughts and aridity and semi-aridity processes, or water stress. The first ones are mainly associated with the El Niño and La Niña phenomena. Mexico and Central America are currently experiencing the most severe droughts since 1997, as a consequence of El Niño. As a result, the Dry Corridor of Central America and the Pacific coast of the isthmus had eight dry months during 2015, when normally it has been between four and five. According to the National Office of Meteorology in the Dominican Republic, during May and November 2015 a 38.4% deficit of rainfall was registered, affecting virtually all of the country.

The periods of drought in the region have a negative impact mainly on sectors such as energy, agriculture, access to drinking water and sanitation.[35] The drought as a process isn't anything new in the region; during 2001 drought affected 23.5 million people. In 2009 Nicaragua lost 30% in basic grains, while in Costa Rica the losses were estimated at US$6.25 million.[36]

In agriculture, drought affects several types of crops, among them corn and beans, which are staple foods of the population. Among the 13 countries that consume the most beans in the world, six are in the area (Nicaragua, Belize, Costa Rica, Guatemala, Honduras and Mexico). Beans and corn tortillas are the main food source for the poverty-stricken population in the region.[37]

It may be concluded that the major risks the region faces are based on annual hydro meteorological processes; their effects are cumulative over time due to the low resilience and high physical, social and economic vulnerability of some countries, especially the ones with low income. To the events of hydro meteorological origin, cyclic processes such as El Niño and La Niña, and more recently the negative effects of climate change, must also be added.

3.2 Most vulnerable countries

In this section, the Global Climate Risk Index[38] (by Germanwatch) will be taken into consideration, based on available data about the effects of extreme meteorological processes and socio-economic conditions in different countries. The Global Climate Risk Index is based on data from the past 20 years and its objective is to put into context the different vulnerabilities that a country may have. To begin this section, the countries with a higher climate risk index will be enumerated in order to demonstrate the high vulnerability of the region. Five countries in the region are part of the top ten of the Global Climate Risk Index: Honduras, Haiti, Nicaragua, Do-

34 Office for Disaster Preparedness and Emergency Management. 2014. Country Document on Disaster Risk Reduction. ODPEM. Jamaica.

35 Global Water Partnership. 2015. Information sheet. The drought in Central America. Available at http://www.droughtmanagement.info/wp-content/uploads/2015/07/IDMP-CA_HojaInformativa-Sequiavs.pdf. Accesed on 22 January 2016.

36 FAO. 2012. Characterization study of the dry corridor of Central America. Countries CA-4. Volume 1. Action against hunger. European Union, Food and Agriculture Organization. Cited in Bonilla, A. 2014. Patrones de sequía en Centroamérica. Su impacto en la producción de maíz y frijol y uso del índice normalizado de precipitación para los sistemas de alerta temprana. GWP y Cooperación Suiza. Tegucigalpa, Honduras.

37 Bonilla, A. 2014. Patrones de sequía en Centroamérica. Su impacto en la producción de maíz y frijol y uso del índice normalizado de precipitación para los sistemas de alerta temprana. GWP y Cooperación Suiza. Tegucigalpa, Honduras.

38 See above description of this indicator

minican Republic and Guatemala. They are part of the focal countries, jointly with Belize, El Salvador, Costa Rica, Panama, Cuba, Jamaica and Trinidad & Tobago.[39] (See Figure 3)[40]

CRI 1994–2013 (1993–2012)	Country	CRI score	Death toll	Deaths per 100,000 inhabitants	Total losses in million US$ PPP	Losses per unit GDP in %	Number of Events (total 1994–2013)
1 (1)	Honduras	10.33	309.70	4.60	813.56	3.30	69
2 (2)	Myanmar	14.00	7137.40	14.80	1256.20	0.87	41
3 (3)	Haiti	16.17	307.80	3.41	261.41	1.86	61
4 (4)	Nicaragua	16.67	160.15	2.98	301.75	1.71	49
5 (7)	Philippines	19.50	933.85	1.13	2786.28	0.74	328
6 (5)	Bangladesh	20.83	749.10	0.54	3128.80	1.20	228
7 (6)	Vietnam	23.50	391.70	0.48	2918.12	1.01	216
8 (8)	Dominican Republic	31.00	210.45	2.38	274.06	0.37	54
9 (10)	Guatemala	31.17	83.20	0.68	477.79	0.62	80
10 (12)	Pakistan	31.50	456.95	0.31	3988.92	0.77	141

Figure 3. Global Climate Risk Index, 2015. Outlined in red are the most vulnerable countries of the region.[41]

Even though a disaster occurs only when there is negative impact on people, the extent of the impact is also linked to the intensity of the physical event and the society's degree of resilience. In this manner, vulnerability is linked to the imbalance between the social structure and the physical environment.[42]

A country's economic ability is also an important factor when measuring vulnerability. The region has different categories of economic income, according to World Bank data.[43] (See Table 4)

39 The criteria used for this selection were Global Climate Risk Index 2015 position, socio-economic situation (these countries are middle and low income), biodiversity and natural ecosystems variety (the region has more than 7% of the worlds biodiversity) and high vulnerability to natural disasters (the region is vulnerable to hurricanes, tropical storms, floods, landslides, droughts, etc.)

40 Haiti is a special case that will not be studied in this document. This is because after the earthquake of 2010, the country has had a large investment of international cooperation on different issues, including risk management and ecosystem restoration.

41 Kreft, S., Eckstein, D., Junghans, L., Kerestan, C. and Hagen, U. 2015. Global Climate Risk Index. Who suffers most from extreme events? Weather-related loss events in 2013 and 1994 to 2013. Germanwatch.
Note: The Global Climate Risk Index for 2016 will be ready in January of 2017

42 Calvo, F. 2001. Sociedades y territorios en riesgo. Barcelona. Ediciones del Serbal. Cited in Berrocal, M. 2011. Evaluación de la vulnerabilidad física del Volcán Arenal, Costa Rica. ISBN 978-3-8443-4795-1. Editorial Académica Española. Alemania.

43 Country and lending groups. The World Bank. Available at http://data.worldbank.org/about/country-and-lending-groups#Lower_middle_income Accessed on 25 January 2016.

Table 4. Country and lending groups.

Country	Income
Haiti	Low income
El Salvador	Medium to low income
Guatemala	Medium to low income
Honduras	Medium to low income
Nicaragua	Medium to low income
Belize	Medium income
Costa Rica	Medium income
Cuba	Medium income
Dominican Republic	Medium income
Jamaica	Medium income
Mexico	Medium income
Panama	Medium income
Barbados	High income
Trinidad and Tobago	High income

Source: World Bank

The preparation of the government as well as of the population in general is another fundamental element when talking about vulnerability, given that even if a country has a low or medium income, if their degree of organisation is high and they take into consideration the natural risks in their planning policies, the vulnerability will be largely reduced.

As was mentioned previously, Honduras is the country with the highest climate risk index in the world, followed by Nicaragua, Dominican Republic and Guatemala.[44] Three of these four countries have low income and high poverty and extreme poverty rates, so together with Haiti they are the most vulnerable of the region. However, Haiti represents a special case; after the 2010 earthquake it became the country in the region with the most organisations present working on restoration, so it is receiving greater foreign economic assistance.

3.3 Most significant impact on the region

Before discussing with the explanation of the most significant economic impacts in the region, it is important to mention that ecosystems cannot respond quickly to natural events such as hurricanes on a scale of 4 and 5, tsunamis with tides greater than 10 metres, large-scale landslides, increases in sea level, etc. On the contrary, they will require time to recover from such major shocks; as a result, the Eco-DRR is not immediately effective in all cases.

Mexico, Central America and the Caribbean have been affected by major processes of hydro meteorological origin several times due to their geographic location. Figure 3 and Table 4 show the total loss in millions of dollars and its equivalent in the Gross Domestic Product as a result of the impact of natural processes between 1994 and 2013 in the countries with the highest Global Climate Risk Index. Due to poor prevention and mitigation when faced with natural events, the economic losses were high and created serious issues in the countries' reconstruction and respective economies. (See Table 5)

One of these events, Hurricane Mitch, was a turning point in the study of risk management and development of national and regional policies pertaining to this matter.

44 INISDR-CEPREDENAC. 2014. Regional report of the state of vulnerability and disaster risks in Central America. United Nations Office for Disaster Risk Reduction.

Table 5. Most significant hydro meteorological events in the region due to economic effects.[45][46][47][48][49][50]

Event	Country/Region	Year	Estimated loss in US$ million
El Niño[10]	Central America	1997 – 1998	475
Hurricane Mitch[11]	Central America	1998	6.018
Drought[12]	Central America	2001	14
Hurricane Stan[13]	Guatemala	2005	983
Tropical storm Agatha [14]	El Salvador	2010	112
Drought El Niño phenomenon[15]	El Salvador	2015	28

Hurricane Mitch was formed in October 1998, just after the El Niño made itself present in the region and the countries were already suffering from the aftermath of continuous flooding during 1997 and 1998. This situation, together with the weak prevention and mitigation policies by the governments, the lack of adequate territorial and urban planning for tropical environments, the population inhabiting high risk zones, urban infrastructure in poor conditions and a lack of preparation for natural emergencies, made Central America the perfect place for a disaster to occur.

It is reported that 3,464,662 people were directly affected, approximately 9,214 victims were found dead and 9,171 were reported missing. More than 466,000 people lived in shelters for months. The damage was calculated at US$ 6,018 million, a seventh of the regional GDP (13.2%), a high amount if it's compared to the earthquake in Mexico that took place in 1985, which cost 1.4% of GDP and Hurricane Andrew in the US which cost 0.4% of that nation's GDP.[51]

Another important event was storm Stan, which was formed in October 2005, affecting mainly Guatemala. At that time there were 670 victims found dead and 495,927 injured due to flooding, floods and landslides, with losses estimated at US$ 983 million.[52]

Along the same lines, Guatemala and El Salvador were affected by storm Agatha (2010), which exceeded the average of accumulated rain over 24 hours in the last 40 years, with 483 mm of rainfall in 24 hours. The economic impact in El Salvador alone was US$ 112 million, product of the effects accumulated from storm Ida, which appeared weeks before Agatha.[53]

Also, during 2014 and 2015 in Mexico as well as in Central America and the Caribbean, there were significant periods of drought which had not been present since 1997, a product of El Niño, intensified by climate change. In the Dominican Republic, reservoirs are below the minimum amount permitted, affecting the water supply to the population.[54] In Nicaragua, the drought has caused death to more than 5,000 livestock as well as loss of corn and rice crops.[55]

45 Bonilla, A. 2014. Patrones de sequía en Centroamérica. Su impacto en la producción de maíz y frijol y uso del Índice Normalizado de Precipitación para los Sistemas de Alerta Temprana. Global Water Partnership. Oficina de Cooperación Suiza en Honduras. Tegucigalpa, Honduras.

46 Sistema de integración Centroamericana. Sf. Reconstrucción y transformación de Centroamérica después del huracán Mitch: Una visión regional. Secretaría general SICA. S.l, s.d

47 Idem [28]

48 Organización Panamericana de la Salud. 2006. III Crónica de un desastre: Tormenta tropical Stan en Guatemala. Informe de actividades desarrolladas en la atención y control de los daños por el huracán Stan en Guatemala con fondos de donantes para el Flash Appeal. Guatemala

49 Tormenta Agatha la más extrema de 2010. Ministerio de Medio Ambiente y Recursos Naturales. El Salvador. Available at: http://www.marn.gob.sv/index.php?option=com_content&view=article&catid=162:especiales&id=703:agatha-supero-a-micht Accessed on 25 January 2016.

50 El Niño provoca cuantiosas pérdidas en las cosechas de América Central. Available at: http://www.fao.org/news/story/es/item/328686/icode/ Accessed on 9 February 2016.

51 Idem [28]

52 Idem [30]

53 Tormenta Agatha la más extrema de 2010. Ministerio de Medio Ambiente y Recursos Naturales. El Salvador. Available at: http://www.marn.gob.sv/index.php?option=com_content&view=article&catid=162:especiales&id=703:agatha-supero-a-micht Accessed on 25 January 2016.

54 República Dominicana sufre su peor sequía en 20 años. Agencia EFE. Available at: http://www.efe.com/efe/america/sociedad/republica-dominicana-sufre-su-peor-sequia-en-20-anos/20000013-2610719. Accessed on 25 January 2016.

55 Nicaragua alerta por sequía en 2015. El Nuevo Diario. Available at: http://www.elnuevodiario.com.ni/nacionales/339069-nicaragua-alerta-sequia-2015 Accessed on 25 January 2016. / Consulted on: 01-25-2016

3.4 Types of ecosystems and biodiversity

Before mentioning the biodiversity of species and ecosystems in the area, it is necessary to understand the origin of Central American territory and the islands of the Caribbean. The union between what we know today as North America (including Mexico) and South America, occurred during the Late Cretaceous, Paleocene and the Early Eocene periods.[56]

A series of islands emerged thanks to volcanic activity and tectonics. In the following millions of years it became an isthmus, separating the waters of the Pacific Ocean and the Atlantic Ocean. The volcanic chain at the same time formed the islands of the Caribbean Sea, which separates the Central American Isthmus from the Atlantic Ocean. (See Figure 4)

Climate factors, fertile soils of volcanic and sedimentary origin and different altitudinal zones favour the appearance of flora and fauna species, as well as migration and later adaptation.

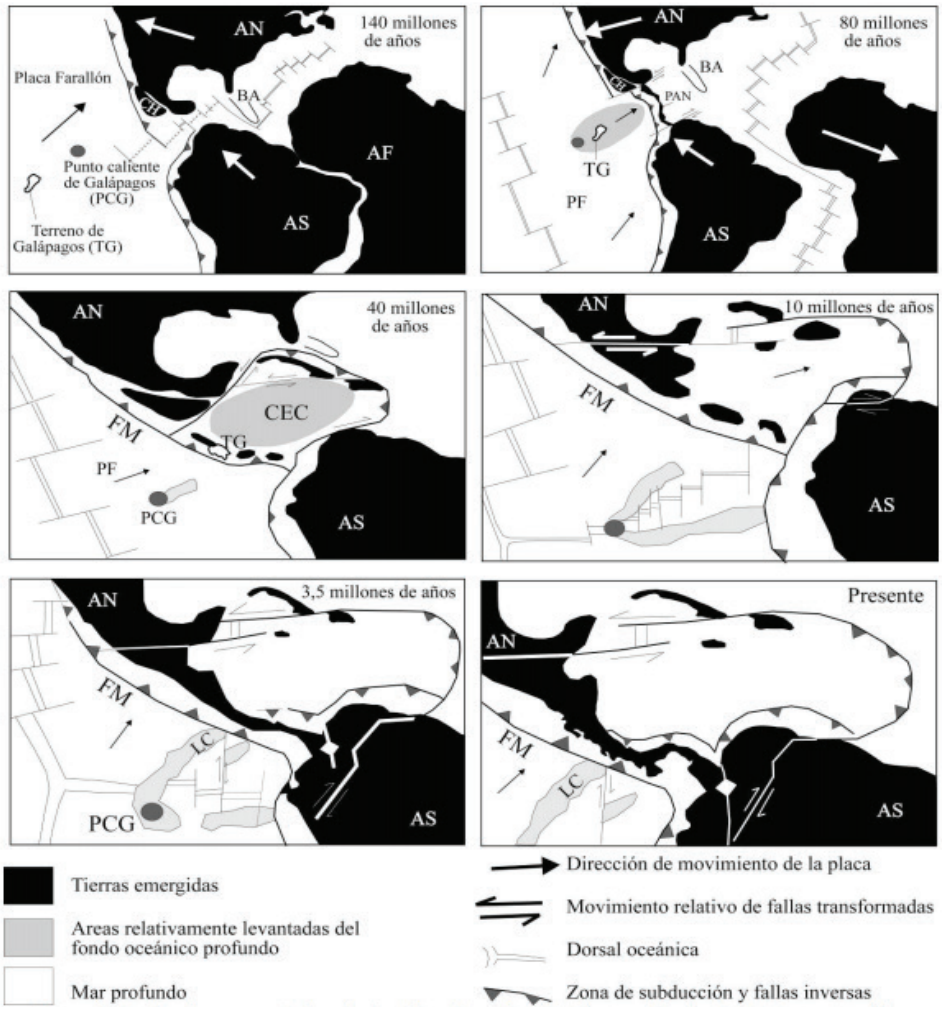


Figure 4. Geotectonic elevation of Central America. CH: Chortis Block, PAN: Proto Antilles, CEC: Caribbean Oceanic Crust, FM: Middle America Trench, LC. Cocos Ridge, AN: North America, AS: South America PF: Farallon Plate, PCG: Galapagos Hotspot, TG: Galapagos Land, BA: Bahamas Platform.[57]

56 Denyer, P. 2008. Geología y geotectónica de América Central y el Caribe. Escuela Centroamericana de Geología. Universidad de Costa Rica. Ponencia presentada en el Congreso Latinoamericano de Geología. Lima, Perú.

57 Idem. Modified by Denyer et al. 2003 and based mainly on: Di Marco (1994), Duncan & Hargraves (1984) and Pindell & Barret (1990).

Ecosystems are defined by the organisation of different types of soils, water, biochemical cycles, living organisms and control mechanisms for the environment's functioning.[58] These factors permitted diverse ecosystems to be formed. In broad terms, there are aquatic, lotic, lentic,[59] forest and coastal ecosystems, each with different characteristics.

The classification that has been used the most in the region is Holdridge life zones. The map created by the Central American Commission on Environment and Development (CCAD-SICA) in 2004 shows that the Central American region possesses moist forests, wet forests, paramos, rainforests and dry forests in different altitudinal zones (tropical, premontane, low montane, montane and subalpine), wetlands, mangrove forests, with altitudes that vary between 0 MASL to 4200 MASL. Mexico has mountain ranges that exceed 5000 MASL. (See Figure 5)

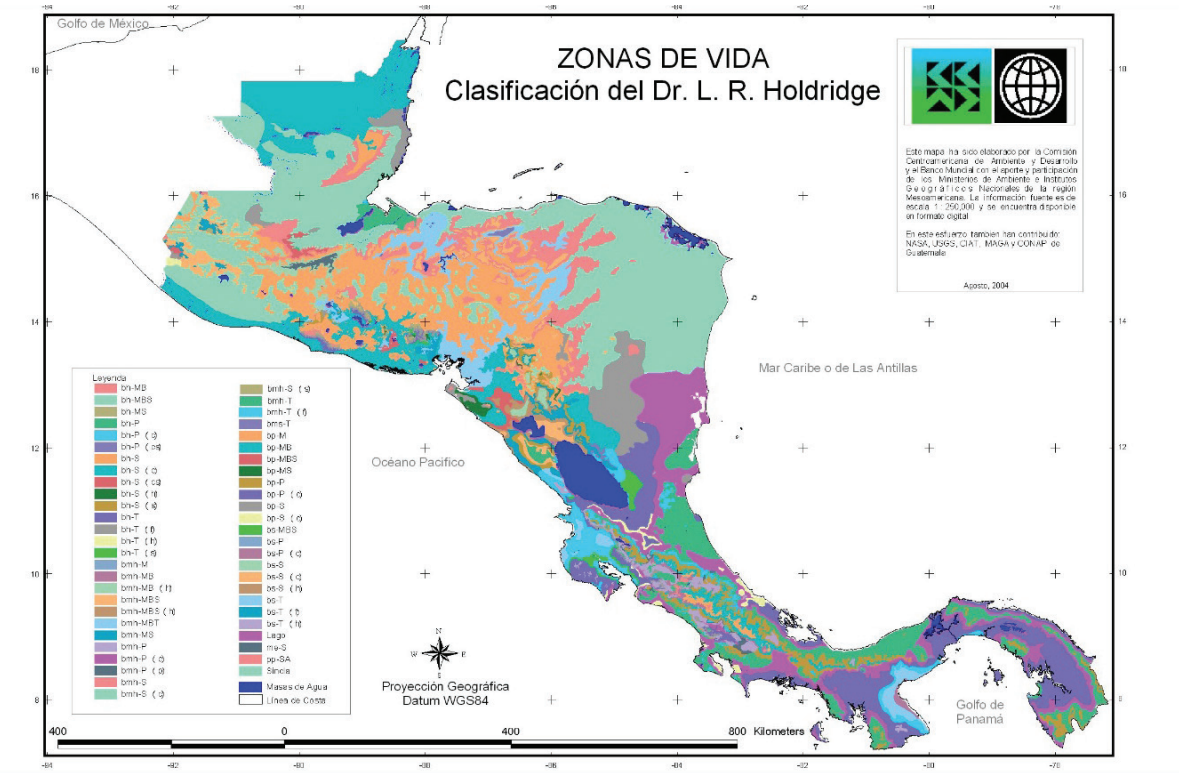


Figure 5. Holdridge life zones for Central America. CCAD (Central American Commission on Environment and Development), 2004

The Dominican Republic has nine life zones: subtropical thorn woodland, subtropical dry forest, subtropical moist forest, subtropical rainforest, subtropical lower montane moist forest, subtropical lower montane wet forest, subtropical lower montane rainforest, and subtropical montane wet forest.[60]

As for Trinidad and Tobago, even though their forests have been classified differently, they have been documented as dry littoral forests, seasonal deciduous forests, semi-deciduous forests, evergreen forests, rainforests, wetland forests and young secondary forests.[61]

58 Odum, H. 1993. Systems Ecology. An Introduction. John Wiley and Sons, Inc. ISBN 0-471-65277-6. Cited in Ministerio del Ambiente y Recursos Naturales. 1999. Biodiversidad en Nicaragua. Un estudio de país. Environmental Program Nicaragua-Finland. Nicaragua.

59 Lotic and lentic ecosystems are associated to freshwater biomes, whether they be in movement or stagnant. These may include thermal, sulphur waters with other geochemical components. They may be associated to volcanic activity or to local faults. Flora and fauna in these ecosystems have very special characteristics.

60 Ministerio de Medio Ambiente y Recursos Naturales. 2010. Cuarto Informe Nacional de biodiversidad. República Dominicana. GEF, PNUD, Volvamos al verde. República Dominicana.

61 Helmer E., Ruzychi T., Benner J., Voggesser S., Scobie B., Park C., Fanninf D. and Ramnarine S. 2012. Detailed maps of tropical forest types are within reach: Forest tree communities for Trinidad and Tobago mapped with multiseason Landsat and multiseason fine-resolution imagery. Forest Ecology and Management. Elsevier Magazine.

Several countries in the region have richness in species diversity that places them at the top on a global level. For example, Guatemala is the third richest country on the planet based on diversity of angiosperm and vertebrates per unit area, and possesses at least 800 endemic vegetative species[62].

Costa Rica is one of the 20 countries with the highest biodiversity in the world; at least 500,000 species are known in the territory, in other words, 5% of the known species worldwide,[63] including 125 species of virus, 213 bacteria and microalgae, 2,311 fungi, 564 algae, 10,000 plants, 670 protozoa, 71,030 vertebrates, 66,265 insects, 88 nematodes and parasites and 1,550 molluscs, among others.[64]

Honduras has documented 6,166 species of vascular plants, the seaweed on the Caribbean coast being the most studied: 47 types and 81 species have been identified, as well as the plants located in the Yojoa Lake (31 species of angiosperm, 11 families of emerging macrophytes and 7 families of submerged macrophytes.) More than 537 species of invertebrates have been registered on the Caribbean coast, as well as 2,500 insects, 33 molluscs, 229 species of mammals, 715 birds, 212 reptiles and 121 amphibians.[65]

In Nicaragua, approximately 100,000 species of fungi and lichen, 6,500 vascular plants, 251 mammals, 676 birds, 172 reptiles, 62 amphibians, 643 fishes, 58 coral reefs, and 3,716 molluscs have been documented. The country also has the most extensive lacustrine ecosystem in the region.[66]

Belize is a special case in the region as the second most important and largest barrier reef in the world, declared by UNESCO in 1996 as a World Heritage Site, resides on its coasts. It has atolls, sand and mangrove cays, 500 species of fish, 65 species of stony coral, 350 molluscs as well as sea sponges and crustaceans.[67]

At present, it is technically impossible to know the exact amount of species of flora and fauna that exist within this group of countries since the scientific community makes new discoveries on a day-to-day basis, and because the entirety of species that live on the planet is unknown. However, the previous information provides an idea of the biological richness and diversity that makes the region a challenging area when it comes to conservation and restoration of ecosystems.

The existence of protected areas, conservation policies and international agreements[68] has improved environmental health among the countries of the region. However, important challenges remain especially regarding over-exploitation of ecosystems, poaching, illegal extraction of goods and materials, use of damaging fishing practices, contamination of water sources, erosion of soils due to agricultural over-exploitation, and lack of policies and/or effective application of territorial planning, among others.

In Central America as well as in the Dominican Republic, 595 species of fauna are threatened, including 78 mammals, 235 birds, 14 amphibians, 34 reptiles, 9 fishes, and 225 invertebrates. As for flora, the threatened species total 2,971, among those that stand out are 152 Cactaceae, 92 Cyatheaceae, 2,670 Orchidaceae and 37 Zamiacea.[69]

The fifth national report of the Convention on Biological Diversity, Costa Rica, in 2004, indicates that even though the country had gained forest cover (it increased from 21% in 1984 to 52.4% in 2010), there is still forest deterioration, loss of ecosystem coverage such as mangroves and paramos, forest fires in protected areas, illegal logging, reduction in fish and commercial crustacean popu-

62 Consejo Nacional de Áreas Protegidas. 2008. Guatemala y su biodiversidad. Un enfoque histórico, cultural, biológico y económico. Guatemala.

63 Biodiversidad en Costa Rica. Instituto Nacional de Biodiversidad. Available at: http://www.inbio.ac.cr/es/biod/bio_biodiver.htm Accessed on 26 January 2016.

64 Instituto Nacional de Biodiversidad. 2001. Biodiversity and tourism in Costa Rica. INBio, SINAC, MINAE. Costa Rica.

65 Portillo, H. 2007. Recopilación de la información sobre biodiversidad de Honduras. Instituto Nacional de Biodiversidad. Costa Rica. Secretaria de Recursos Naturales y Ambiente.

66 Ministerio del Ambiente y Recursos Naturales. 1999. Biodiversidad en Nicaragua. Un estudio de país. Programa Ambiente Nicaragua-Finlandia. Nicaragua

67 Belize barrier reef reserve system. UNESCO. Available at http://whc.unesco.org/en/list/764 Accessed on 26 January 2016.

68 The majority of the countries in the region have ratified important multilateral agreements in matters of the environment (AMUMAS) such as CDB, CITES Protocol, Basilea Agreement, MARPOL, among others. See following sections.

69 Convention on International Trade in Endangered Species of Wild, Flora and Fauna 2010. Current lists of flora and fauna species included in the appendixes of CITIES, distributed in Central America and Dominican Republic. CITIES. CCAD. USAID.

lations, high use of pesticides, decrease in sanitary quality of beaches, estuaries and rivers, environmental conflict, water deficit, and effects of climate change (the average temperature of surface seawater has increased).[70]

The previous summary makes clear the importance of the region in terms of biological diversity as well as issues associated with economic development that are not integrated into the sustainability of natural resources and the value of ecosystem services. The natural resources and ecosystem services exceed monetary value, providing them into a livelihood for human beings and supporting the rest of the species of flora and fauna that the territory is shared with.

70 MINAE-SINAC. 2014. V informe nacional al Convenio sobre Diversidad Biológica. Costa Rica. MINAE. Costa Rica.

4. Policies

Before addressing the main policies, programmes and national and regional plans on biodiversity, climate change and risk management, it is necessary to clarify that none of them expressly contemplates the concept of Eco-DRR as yet. However, in the last 30 years, the region has made substantial progress in developing a legal framework involving conservation and the restoration of biodiversity, especially in tropical forests and marine ecosystems, such as coral reefs, as well as the establishment of protected areas, with the sole purpose of the recovery and preservation of the diversity of species and ecosystems, in addition to promoting sustainable development. It has also promoted risk management in vulnerable communities and the installation of early warning systems. While the role of ecosystem services is recognised, it has not been incorporated into the general legal framework of the region, only into the environmental conservation projects.

4.1 Regional and national institutions

The countries in the Central American region make up the Central American Integration System (SICA), which was created in 1991. By the year 2013 the Dominican Republic joined, and currently Haiti is in the process of being incorporated. SICA is backed by the General Assembly of the United Nations. Its purposes include consolidating democracy, concretising a new model of regional safety, achieving socio-economic well-being and justice, establishing concrete actions directed towards preserving the environment and harmony with nature and ensuring equilibrium and rational exploitation of natural resources.[71]

SICA's framework includes several secretaries and specialised institutions, among them being the Central American Coordination Center for Natural Disaster Prevention (CEPREDENAC), the Regional Committee on Hydraulic Resources (CRRH) and the Central American Commission on Environment and Development (CCAD). These three organisations make up the Environmental Sub-System of the region for SICA, and have formulated a series of exercises, strategies, plans and programmes that address climate change, vulnerability reduction and risk management, which will be covered later on.

The Caribbean countries are grouped together in a similar organisation called the Caribbean Community (CARICOM), which has a Caribbean Community Secretariat, where one of the associated institutions is the Caribbean Disaster Emergency Management Agency (CDEMA), established in 1991, whose main responsibility is coordinating emergency responses.[72] This includes providing training to the personnel in charge of disaster management, developing the disaster legislation model, developing emergency policies, contingency plans, improving early alert and telecommunication systems for emergencies, developing information and communication systems for emergencies, education and public awareness. The CDEMA is made up of all of the countries that are members of CARICOM. Another organisation created by CARICOM is the Caribbean Community Climate Change Centre (CCCCC), with headquarters in Belize.

A third regional organisation is the Association of Caribbean States (ACS). The Constitutive Agreement of the ACS was signed on 24 July 1994 in Cartagena de Indias, Colombia, with the purpose of promoting consultation, cooperation and concerted action among all of the countries in the Caribbean. It is made up of 25 Member States and 7 Associate Members. One of their main objec-

71 Central American Integration System. SICA. Available at: http://www.sica.int/ Accessed on 1 February 2016.

72 Caribbean Community Secretariat. Available at: http://www.caricom.org/ Accessed on 1 February 2016.

tives is strengthening regional cooperation and the integration process, with the purpose of creating a broader economic space in the region; preserving the environmental integrity of the Caribbean Sea, which is considered the common patrimony of the people of the region; and promoting sustainable development of the Greater Caribbean. Their current focal areas are trade, transportation, sustainable tourism and natural disasters.

The countries that are members are: Antigua and Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Dominican Republic, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Venezuela. The associate countries are Aruba, Curacao, Guadeloupe, Martinique, Saint Maarten, France, in the name of (French Guyana, Saint Barthélemy and Saint Martín) and the Netherlands, in the name of (Bonaire, Saba and Sint Eustatius).

It has five Special Committees: Trade Development and External Economic Relations; Sustainable Tourism; Transport; Disaster Risk Reduction; and Budget and Administration. It also has a Council of National Representatives of the Special Fund that is responsible for supervising efforts for resource mobilisation and project development.

Besides SICA, CARICOM and ACS, each country has its own national organisation in charge of emergency assistance and prevention, as well as centres for surveillance and monitoring climatological, meteorological and oceanographic conditions, some of which are appointed to state universities, which provide information permanently to the different government's instances and at the same time form part of technical consultant committees. However, none of these official organisations has included the Eco-DRR methodology in their regional policies and / or activities.

4.2 Regional and national policies

The Central American countries have ratified a series of regional agreements pertaining to the environment:

- Agreement for the Conservation of the Biodiversity and Protection of Priority Wilderness Areas in Central America. Managua, 5 June 1992.
- Regional Agreement on Climate Change. Guatemala, 29 October 1993.
- Agreement for the Management and Conservation of Natural and Forest Ecosystems and the Development of Forest Plantations. Guatemala, 29 October 1993.
- Regional Agreement on the Transboundary Movement of Hazardous Waste. Panama, 11 December 1992.[73]

The Central American countries are signatories to, and have ratified, the main international agreements on environmental matters, among them are:[74]

73 International Union for Conservation of Nature. 2005. Manual de derecho ambiental en Centroamérica. UICN. Oficina Regional para Mesoamérica. Ed. Grethel Aguilar; Alejandro Iza. San José, Costa Rica.

74 BEL = Belize, GUA = Guatemala, ELS = El Salvador, HON = Honduras, NIC = Nicaragua, CRC = Costa Rica, PAN = Panama.

Table 6. International environmental agreements signed and ratified by Central American countries.

Agreement	BEL	GUA	ELS	HON	NIC	CRC	PAN
Convention on Biological Diversity (CDB) signed in Río de Janeiro, 1992	X	X	X	X	X	X	X
Cartagena Protocol on Biosafety, Montreal, 2000	X	X	X	X	X	X	X
RAMSAR Convention. Agreement with regards to wetlands of international importance, especially as a habitat for aquatic birds (signed by the countries between 1990 and 1998)	X	X	X	X	X	X	X
Convention on International Trade in Endangered Species of Wild Fauna and Flora (signed by the countries between 1975 and 1987)	X	X	X	X	X	X	X
Vienna Convention for the Protection of the Ozone Layer (signed by the countries between 1989 and 1997)	X	X	X	X	X	X	X
United Nations Convention on the Law of the Sea (signed by the countries between 1983 and 2000)	X	X	X	X	X	X	X
United Nations Framework Convention on Climate Change (signed by the countries between 1994 and 1995)	X	X	X	X	X	X	X
Stockholm Convention on Persisting Organic Pollutants (signed by the countries between 2001 and 2002)	X	X	X	X	X	X	X
United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification (signed by the countries between 1996 and 1998)	X	X	X	X	X	X	X
Kyoto Protocol to the United Nations Framework Convention on Climate Change (signed by the countries between 1993 and 2000)	X	X	X	X	X	X	X

In turn, each country possesses its own environmental legislation, under different names, for example: Environmental Protection Act, Wildlife Protection Act, Forest Act, Organic Law of the Environment, Environment Law, Protection and Improvement of Environment Law, General Environment Law, General Environment and Natural Resource Law, Wildlife Law, Water Law. The governing entities in charge of executing these laws are the environment ministries of each country, as well as their branches.

Some countries in the region, such as Mexico and Honduras, even have explicit territorial planning legislations, but they are not completely linked to environmental regulations. Even though Costa Rica is in the process of creating a territorial planning policy, since the year 2006 the environmental vulnerability index figure (EVI) was included in municipal planning studies, which take into account the environmental and risk variables to natural processes for each municipality.

On the level of Central America and the Dominican Republic, through the Central American Integration System, with support from the Central American Council for Housing and Human Settlements and the German Corporation for International Cooperation, a study called "Territorial planning and gender equality in the region of Central America and Dominican Republic" was produced in 2013 within the framework of the Spatial Planning and Sustainable Development project in Central America, where the importance of gender focus in spatial planning was addressed, as well as the "state of the art" in the region.

Even though the agreements, policies and laws previously explained do not mention the issue of gender explicitly,[75] most countries have inclusion and equality policies, as well as official entities that address the matter holistically.

4.3 Regional policies in risk reduction

The regions of Central America and the Dominican Republic within the SICA, CCAD framework have developed and implemented several important strategies, among them the Regional Strategy for Climate Change (2010); it explains what this global process entails for the region, the established repercussions, possible impact to the economy, population growth tendencies, environmental degradation dynamics, the current energy demand, the increase in vulnerability and the most important hydro meteorological events that have had an impact on the area, food insecurity, deforestation and loss of ecosystems, availability of drinking water,

75 The Río +20 declaration does include gender equality and women empowerment in its new vision.

possible impact on human health, loss of marine resources, the effects on living standards of the population and economic assessment of the impact of climate change.

Among the principles that this strategy is based on are mainstreaming, intersectoral collaboration, interculturality, and gender equality and equity, coherence of governability and solidarity policies, and social justice.

On the strategic line 1.1 that refers to extreme climate events and risk management, "undertake vulnerability studies risks to climate disasters in urban and rural enclaves, by sectors, taking into consideration gender, indigenous people, communities of African descent, and implementing measures to prevent risks on an adequate scale," is prescribed; also "integrate gender perspective in disaster policies on risk management, plans, and decision-making processes including those related to risk evaluation, early alert, education, training and information management."

The above reference is a small example of how the gender perspective is considered in this strategy, but it should be noted that the matter is a central concept in the entire document.

The strategy also proposes an action framework to face climate change that involves adaptation and mitigation, risk management, strengthening of institutions, agriculture and food security, ecosystems and species diversity, water resources, public health, coastal and marine resources, tourism, towns, ethnic groups and communities of African descent, public infrastructure, education, raising awareness, communication and participation, technological transfer, international negotiations and management.[76]

The members of CARICOM also possess a strategy and action plan named "Disaster risk management and climate change adaptation in the CARICOM and wider Caribbean region. Strategy and action plan" (2015),[77] which contains 20 objectives, related to fishing and aquaculture from an ecosystem standpoint. Among its objectives are sustainable regional development through integral disaster management, integrating environmental and coastal and marine management with fishing policies in order to protect fish and their ecosystems, and natural disaster impact mitigation.

Strategies include: the integration of adaptation to climate change in sustainable development; fostering adaptation measures to address vulnerabilities in the region; fostering actions to reduce greenhouse effect gases by reducing use of fossil fuels; promoting use of clean energy; establishing actions to reduce vulnerability of natural and human systems facing the impact of climate change; and fostering actions that result in social, economic and environmental benefits from rational management of forests.[78]

The document also indicates as part of its objective to achieve sustainable regional development through integral disaster management, a holistic approach that involves a gender and community perspective on the study methods of natural and anthropogenic hazards, as well as recovery and reconstruction procedures in communities.

In specific regards to disaster management, Central America and Dominican Republic have the "Central American Policy of Integral Disaster Risk Management" (2011); its general objective is to provide the region with a guiding framework in integral disaster risk management, facilitating the link between political decisions and tools for implementation, intertwining social, economic and environmental management[79].

Its principles include gender equity, the gradual and effective implementation of tools that guarantee achievement of political objectives, transparency and citizen participation, as well as attribution of competencies, regionality, territoriality, integral territorial safety, and so on.

76 Comisión Centroamericana de Ambiente y Desarrollo. 2010. Estrategia regional de cambio climático. Sistema de Integración Centroamericana. El Salvador.

77 McConney, P., Charlery, J., Pena, M., Phillips, T., Van Anrooy, R., Poulain, F. and Bahri, T. 2015. Disaster risk management and climate change adaptation in the CARICOM and wider Caribbean region – Strategy and action plan. Rome. 29 pp

78 Idem

79 Centro de Prevención de Desastres Naturales para Centroamérica. 2011. Política Centroamericana de Gestión Integral de Riesgo de Desastres. CEPREDENAC-SICA. El Salvador.

Its general objective is to "provide the Central American region with a guiding framework in matters of integral disaster management, that facilitates the link between political decisions with their corresponding mechanisms and tools for implementation, intertwining risk management with economic management, management of social cohesion and environmental management from an integral point of view (multi-sector and territorial), with respect to guaranteeing human rights, and taking into consideration multiculturality and gender equity."

The countries of the Caribbean on behalf of CDEMA created the "Regional Comprehensive Disaster Management Strategy and Programming Framework 2014-2024." Its scope is: (i) that national, regional and local institutions have a minimum capacity standard in order to apply this programme, (ii) knowledge management to apply during decision making, (iii) recovery capacity when faced with disasters in key sectors for the economy, (iv) operational availability on a regional, national, sector and local level, (v) develop communal resilience with a gender perspective present in all phases and levels, (vi) resource allocation that sustains the strategy's development capacity. The central concepts of it are: gender, climate change, information and communications technology and environmental viability.

Even if these policies and strategies are not explicit about the issue of risk reduction based on ecosystems, they do indicate the need for management and environmental viability. It is important to mention that the key to risk reduction is the integration of several factors, such as social, economic, environmental, infrastructure, community networks and communication.

The lessons learned in the region have caused many of these elements to be considered in new policies, strategies and laws, although the successful implementation of them is a long process that involves political will, economic resources, organisation and communication among public and private institutions, consultation with communities, raising consciousness not only among decision-makers, but among civil society as well.

Finally, one of the most important tools for disaster risk management on a global level is the **Hyogo Framework for Action**[80] (2005-2015), which takes into account 5 priorities: (i) guarantee that disaster risk reduction is a national and local priority with a solid institutional foundation for its implementation, (ii) identify, evaluate and closely observe disaster risks and improve early alerts, (iii) use knowledge, innovation and education to create a culture of safety and resilience on all levels, (iv) reduce fundamental risk factors and (v) strengthen disaster preparation for an efficient response on every level.

From 2015, the Hyogo Framework for Action was replaced by the Sendai Framework for Disaster Risk Reduction (2015-2030), which has seven global targets; (i) substantially reduce global disaster mortality by 2030, (ii) substantially reduce the number of affected people globally by 2030, (iii) reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030, (iv) substantially reduce disaster damage to critical infrastructure and disruption of basic services, including developing their resilience by 2030, (v) substantially increase the number of countries with the national and local disaster risk reduction strategies by 2020, (vi) substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the Framework by 2030 and (vii) substantially increase the availability of and access to multi-hazards early warning systems and disaster risk information and assessments to the people by 2030.[81]

In this sense, the States are responsible for the development of national coordination mechanisms, they carry out evaluations on disaster risk reduction situations, publish and bring national programmes up to date, check national progress, apply the relevant international legal instruments and integrate risk reduction to climate change strategies.

The Caribbean Disaster Emergency Response Agency (CDERA) as well as the Central American Coordination Center for Natural Disaster Prevention (CEPREDENAC) are active associates of the International Strategy for Disaster Reduction of the United Nations, the governing body of the Hyogo Framework for Action, which means that the States of the region are implementing it.[82]

80 Now Sendai Framework for Disaster Risk Reduction (2015-2030).

81 Sendai Framework for Disaster Risk Reduction. Available at: www.unisdr.org/we/coordinate/sendai-framework/ Accessed on 19 May 2016.

82 United Nations. International Strategy for Disaster Reduction. 2003. Hyogo Framework for Action 2005-2015: Increasing the resilience of the nations and communities in the face of disasters. United Nations.

One of the advances in the region under the Hyogo Framework for Action (2005-2015) is the Regional Plan for the Reduction of Disasters 2006-2015, prepared by CEPREDENAC for Central American countries. Its strategic objectives are to (i) promote the incorporation of risk reduction of disasters in legislation, policies, plans and investment projects for sustainable development and security in the Central American region, (ii) increase the resilience of the Central American population to natural hazards and (iii) promote the incorporation of the disaster risk analysis in the design and implementation of prevention, mitigation, response, recovery and reconstruction in the countries of the region.[83]

Another advance in the region was the development and adoption of the "Central American Policy for Integral Disaster Risk Management" (2011), thus including prevention and mitigation of natural disasters and the effects of climate change on the permanent agenda of the Central America Integration System (SICA), whose purpose is explained above.

This policy has also enabled the strengthening of the National System for Risk Management and Civil Protection in each country, by means of staff training and the use of digital platforms such as the Regional System for Visualization and Monitoring in Mesoamerica, which contains information in real time on weather, forest fires, climate change, oceanography, and an early warning system for floods, etc.[84]

On 22 July 2011, the Summit of Central American Presidents pledged its support for the "Central American Policy of Comprehensive Disaster Risk Management" and the Regional Climate Change Strategy. Agreement no. 10 of the summit states: "Instructs the CEPREDENAC and its Executive Secretary to coordinate and develop the following strategic products and processes under the PCGIR, whose results and progress will be presented at the next summit in December: Strengthening the National Systems for Risk Management, regional mechanism for mutual disaster relief, Central American Fund for the Promotion of Integral Disaster Risk Management, establishment of the PCGIR regional consultative forum risk management in public investment at the regional level and regional information and communication platform." Furthermore, the summit reaffirmed the commitment made by the States under the Hyogo Framework for Action.

Meanwhile, the Caribbean countries through the CDERA implementation of the Regional Comprehensive Disaster Management (CDM) Strategy and Programming Framework 2014-2024, whose principle objective is "safer, more resilient and sustainable CDEMA participating States through Comprehensive Disaster Management."

Their priorities are: (i) national, regional and sectoral institutions with adequate/minimum standards of capacity to deliver the CDM programme, (ii) knowledge management which is applied for fact-based decision making, (iii) disaster resilience which is enhanced within key sectors of the economy, (iv) operational readiness at regional, national, sectoral and local levels, (v) a clearly established and understood nexus between CCA and DRR with harmonised programming and governance, (vi) community resilience which has been enhanced for the most vulnerable with gender concerns addressed at all stages and levels, and (vii) resource allocation which underpins the ability to deliver the strategy.

Since its inception, the CDM incorporates the principles and guidelines of the Hyogo Framework for Action and it is committed to monitoring agreements and the Sendai Post Hyogo Framework for Action.

4.4 Climate change policies on a national level

Since all of the countries of the region are signatories of the Rio Convention, the Kyoto Protocol, as well as the United Nations Framework Convention on Climate Change, the governments have fulfilled their duties and produced "National Communications on Climate Change" as well as the respective inventories of greenhouse effect gases. (See Table 7)

83 Centro de Coordinación para la Prevención de los Desastres Naturales en América Central. 2006. Plan Regional de Reducción de Desastres 2006-2015. Secretaria Ejecutiva, Guatemala, República de Guatemala.

84 www.servir.net

Table 7. National Communications on Climate Change by country[85]

Country	Document
Mexico	National Climate Change Strategy, created by the Intersectoral Commission for Climate Change
Guatemala	National Climate Change Policy
El Salvador	National Climate Change Strategy
Honduras	National Climate Change Strategy
Nicaragua	National Environment and Climate Change Strategy
Costa Rica	National Climate Change Strategy
Panama	National Climate Change Policy
Dominican Republic	National Strategy for Adaptation to Climate Change
Cuba	National Climate Change Strategy and Action Plan
Trinidad and Tobago	National Climate Change Policy
Jamaica	Climate Change Green Paper
Belize	Adaptation Strategy and Action Plan

4.5 Biodiversity and its connection with risk reduction policies and adaptation to climate change

The Regional Climate Change Strategy for Central America mentions that even the ecosystems of greatest importance like the Mesoamerican Biological Corridor, are not articulated in national development policies. Natural resources in general are subjects to great pressure, responding to an extractive and predatory development dynamic, where spatial planning is absent. The document mentions how deforestation and loss of ecosystems together with climate change will favour the development of disease and harmful invasive species for forests and agriculture.

For this reason, the document explains, in strategic area 1.3, forest ecosystems and biodiversity, the strategic objective that society must acknowledge the importance of forest ecosystems and biodiversity for adaptation to climate change. Therefore, it is proposed to reduce the vulnerability of these ecosystems through policies, incentives and the generation of scientific knowledge.[86]

In Costa Rica's case, the National Climate Change Strategy proposes creating a plan to adjust and execute the actions contained in the Conservation Strategy, Use and Management of Biodiversity in order to restore and maintain forest cover, ecosystems and ecological processes of national importance and carbon captures, environmental goods and services.

In Cuba, the National Climate Change Strategy identifies important lines of action, one of them being natural resource management (water resources, forests and biodiversity).

In the Dominican Republic, the strategic areas mentioned for adaptation and mitigation of climate change are biodiversity, forests and coastal and marine resources. Among the measures that they propose are sustainable forest management programmes, reforestation and afforestation. It also indicates that biological diversity and climate change must be considered with a holistic vision in order to combat desertification and soil degradation, and promote activities for conservation and sustainable use of biological diversity.[87]

Lastly, the countries are signatories to the Convention on Biological Diversity (CBD), which means each country accepts responsibility for devising their respective national reports, and implementing the actions called for by the Conference of Parties.

85 All of these legislations are designed, regulated and applied by the ministries for natural resources of each country.

86 Idem [45]

87 Secretaria de Estado de Medio Ambiente y Recursos Naturales. 2008. Lineamientos para una estrategia nacional de cambio climático. Santo Domingo, República Dominicana.

The following table summarises the progress according to the Fifth National Report by country:

Table 8. CBD. Fifth National Report. Achievements and progress[88]

Country	CBD. Fifth National Report. Achievements and progress
Mexico	General Wildlife Law General Law of Sustainable Rural Development Sustainable Forest Development law Biosafety of Genetically Modified Organisms Law Sustainable Fisheries and Aquaculture Law Strategy for the Conservation and Management of Shorebirds and Their Habitat National Strategy on Invasive Species in Mexico, Prevention, Control and Eradication Climate Change Strategy for Protected Areas National Strategy for Conservation and Sustainable Development of the Mexican Insular Territory Mexican Strategy for Conservation National Care Strategy for Mangrove Ecosystems Climate Change Law Seas and Coasts of Mexico National Policy Environmental Responsibility Federal Law National Climate Change Strategy.
Belize	The report explains the importance of forests to reduce vulnerability to landslides, especially in the tropical storm season, about flood control it states: "(…) Belize has large areas of low-lying wetlands, and with 35% of the population concentrated in coastal areas, these wetlands are extremely important in their role of flood control - storing flood waters after tropical storm events, and then releasing them slowly back into the rivers. Crooked Tree Wildlife Sanctuary and Burdon Canal Nature Reserve, whilst originally designated for their importance for birds, are both critical in the regulation of flood waters during tropical storm events, mitigating downstream impacts that would otherwise affect Belize City, with an estimated 18% of Belize's population (SIB, 2014) – much of the city lies in a basin, at or just below sea level, and is increasingly vulnerable to flooding (Padeco, 2011). Despite the knowledge of this important function, poorly planned construction of causeways has an impact on water flow, reducing the functionality of the Crooked Tree wetland (…)." Advances in the strategy and action plan are; National Integrated Water Resources Management Policy (Endorsed 2009) National Policy on Responsible Tourism (2010) National Sustainable Tourism Master Plan of 2030 (Endorsed 2012) Revision of the outdated Fisheries Act as the Fisheries Resource Bill (Draft - awaiting endorsement) Integrated Coastal Zone Management Plan (Draft - awaiting endorsement) National Environmental Policy and Strategy (2014 - 2024) (Draft - awaiting endorsement).
Guatemala	Guatemala is a mega diverse country officially recognised by the CBD. During 2009 - 2013, approximately 103 new species records have been reported. However, the value of ecosystem services has been poorly recognised by all sectors. This can be reflected in the lack of an integrated management of biodiversity as a public good which contributes to reduce risk from vulnerability to climate change and support human welfare. Another weakness identified for national biological and cultural diversity is the lack of information, systematically generated and based on indicators that could allow a consistent assessment of their status and trends. The National Biodiversity Strategy is comprised of five operational strategies, fourteen targets, eleven goals and an action plan with 35 strategies to be assumed and implemented by all stakeholders and sectors involved directly or indirectly in the management of biodiversity, in order to contribute to sustainable development. Through the strategy, Guatemala has defined 14 national targets that must be achieved during the "decade of life and development," between 2012 and 2022.
El Salvador	One of the greatest achievements and progress of this country is the National Environmental Policy 2012, also, the national wetland improvement plan, national strategy for protected areas, policy management and use of coastal marine resources. El Salvador has an Action Plan and a new National Biodiversity Strategy for 2013; the goals are; (i) strategic integration of biodiversity in the economy, (ii) restoration and conservation of critical ecosystems and (iii) biodiversity for people. Advances in the strategy are: activation of the Strategic Environmental Assessment, policies, plans and programmes incorporating good practices that guarantee the conservation and sustainable use of biodiversity, preparation of the draft General Law and the proposed National Fisheries and Aquaculture Policy, recovery and promotion of traditional practices of conservation of genetic resources, local economic options based on biodiversity, especially for communities, and launch of the National Ecosystem Restoration and Landscapes Program.
Honduras	According to the report, Honduras does not have a national biodiversity strategy and action plan, nor does it have defined targets according to the Aichi Biodiversity Targets.
Nicaragua	Law for the Promotion of Organic Production and Agroecology Law on Use and Conservation of Biodiversity Strengthening the capacity of local people in the protection and conservation of biodiversity

88 CBD. Fifth National Report. Available at: https://www.cbd.int Accessed on 28 May 2016.

Costa Rica	The report mentions the potential negative effects of climate change on ecosystems, the country requires more plans on adaptation and mitigation of climate change, it is necessary to formulate a strategy for adaptation to climate change focused on biodiversity, although the country has an important legal framework for biodiversity and conservation. National Climate Change Strategy National Strategy for Illegal Logging National Forest Development Plan National Program for Biological Corridors National fire control programme Water resource conservation canon National programme of payment for environmental services
Panama	The protected areas coverage has not reduced Increased the coverage of drinking water and sanitation Legislation on conservation and restoration REDD+ initiative implemented The National Biodiversity Strategy and Action Plan are in process
Cuba	Manual for the use of Cuban forests (low impact) Regulation of the National Forest Development Fund Procedures Manual for the National Forest Development Fund National Program to Combat Environmental Pollution National Coordinator for the National System for Protected Areas Strategy of the National System for Protected Areas 2009-2013 Protected Areas Management Plan
Jamaica	Climate Change Policy Framework and Action Plan for Jamaica Forest Policy for Jamaica Policy for National System of Protected Areas Policy on Strategic Environmental Assessment Towards an Ocean and Coastal Zone Management Policy National Biosafety Policy
Dominican Republic	Development of the first list of endangered species National Invasive Species Strategy Project Mitigating the Threats of Invasive Alien Species in the Insular Caribbean Analysis of Invasive Species in the Dominican Republic Action Plan for the Conservation of Terrestrial Mammals Endemic to La Hispaniola
Trinidad and Tobago	Has no Fifth National Report.

With the exception of Belize, none of the other countries in the region mentioned in their CBD Fifth National Reports and/or Action Plans the issue of risk reduction, although they do mention the possible negative impacts of climate change on biodiversity.

5. Eco-DRR experiences in the region (case studies)

5.1 Implementation of Eco-DRR in the region

Because Eco-DRR is a relatively new concept, relatively few projects in the region are being implemented to achieve specified Eco-DRR outcomes. However, even if not labelled as Eco-DRR, several projects pertaining to the conservation of natural resources and risk management have been developed that are contributing to achieve Eco-DRR outcomes. The Eco-DRR approach requires the protection of ecosystems, and the maintenance of good environmental health as a tool for risk reduction in the event of extreme natural events that lead to disasters. It is, therefore, an integrative approach that includes working with different sectors: communities, conservation and restoration of ecosystems and risk management.

Case study 1. Basins associated with the Tacaná Volcano in Guatemala and Mexico. Transboundary governance of water and implementation of the IWRM through local community involvement.[89]

This is a project based on water management and improving environmental health, as well as raising awareness about this resource. It was integrated into local communities through Micro basin Councils for greater cohesion and strengthening ties. The project outlines the activity plan in case of disasters as part of the basin management plan. This project was implemented by the International Union for Conservation of Nature (IUCN).

Pilot projects were combined based on livelihoods and integrated governance. They facilitated a greater influence on regional and national management of water resources, as well as strengthened the ability for resilience on a local level.

Among the prominent aspects are:

- Development of community projects in the processes of water resources related to degradation and basin management.
- Collection and organisation of information and knowledge available at a local level.
- Organisation and development of Micro basin Councils.
- Support for reconstruction and disaster risk reduction after tropical storm Stan.
- Development of alliances to facilitate the incorporation of local actions for the development of an integrated focus on water resource management.

As a result, by 2011, 107 projects were implemented throughout micro basins in matters of conservation and environmental restoration, food security, income generation, and basic social services.

89 International Union for Conservation of Nature. 2012. Cuencas asociadas al volcán Tacaná, Guatemala y México. Gobernanza transfronteriza del agua e implementación de la GIRH a través de la acción comunitaria local. Estudio de caso de la iniciativa Agua y Naturaleza (WANI).

Case study 2. Regional Strategic Program for Forest Ecosystem Management. Central America and Dominican Republic.[90]

This programme developed a strategic planning tool to strengthen regional forest strategy. It is sustained in the Mesoamerican Biological Corridor, Puembo I and II, community forestation and possession rights of the indigenous people. This project was implemented by the International Union for Conservation of Nature (IUCN).

Its objectives are to strengthen capacities for forest management, plantations and forest ecosystems, prioritising mitigation and adaptation to climate change. It also aims to improve the administration and management of forest actors, especially in indigenous communities and villages. The project also seeks to position itself with an integral vision of national and regional strategies, as well as with international commitments that have to do with the multifunctionality of the territories and forest ecosystems.

It is indisputable that good environmental health of forests reduces the negative impact of climate change head-on and intensified hydro meteorological processes through this global process. Furthermore, forests provide important ecosystem services such as access to water, carbon capture, species diversity, air quality, among others, all indispensable for the continuity of life.

Case study 3. Shade-grown coffee and alterations to reduce pressures of change in land use in the southern region of Ahuachapán, El Salvador. Integrated basin project associated with the hydrographic complex in Barra de Santiago-El Imposible (BASIM).[91]

This project was born out of concern due to a decrease in shaded coffee plantations, a product of the coffee crisis in the decade of the 1990s. The project was implemented by the International Union for Conservation of Nature (IUCN).

Shaded coffee has proven to be an important element in water conservation and biodiversity due to its agricultural ecosystem characteristics. For example, it helps mitigate the force with which raindrops hit the ground, decreasing laminar erosion; the abundance of trees generates better conditions for an increased in the number of animal and vegetative species, and they also capture carbon. In this type of agricultural ecosystem, a great number of insects, many of them bio indicators and pollinators, have been found.

Shaded coffee plantations also provide ecosystem services; they reduce the risk of erosion, landslides, and depletion of water sources and springs, and they serve as small biological corridors that different animal and vegetative species can move through avoiding being confined to a small area where their vulnerability increases.[92]

The project not only succeeded in raising awareness among coffee producers about the importance of this type of agricultural ecosystem, but also about the hazards for the environment that would be a result of a massive change in land use. On the other hand, the coffee producers were assisted in seeking alternatives and diversifying their production by including fruit trees, and experimenting with ecotourism and non-traditional markets.

Case study 4. Lachuá Lagoon Project. Experience systematisation. Guatemala.[93]

The Lachuá ecoregion is made up of the Lachuá Lagoon National Park as well as neighboring communities that include 52 towns. It is located in the Municipality of Cobán, Guatemala. The park is part of the biological corridor between Montes Azules (Mexico) the Maya Biosphere Reserve, the Sierra Cháma and Sierra de Los Cuchumatanes in Guatemala. This project was implemented by the International Union for Conservation of Nature (IUCN).

90 Comisión Centroamericana de Ambiente y Desarrollo. 2014. Programa estratégico regional para el manejo de los ecosistemas forestales (PERFOR). Región Centroamericana y República Dominicana. Sistema de Integración Centroamericano. SICA. El Salvador.

91 International Union for Conservation of Nature. 2004. Café con sombra y alternativas para reducir la presión del cambio del uso del suelo en la zona sur de Ahuachapán. El Salvador. Proyecto "Manejo integrado de cuencas asociadas al complejo hidrográfico Barra de Santiago-El Imposible (BASIM).

92 Idem [73]

93 Acuña, K. 2010. Proyecto Laguna Lachuá. Sistematización de la experiencia. Unión Internacional para la Conservación de la Naturaleza. Costa Rica.

In the 1970s, demographic pressure grew in the region with an increase in colonisation programmes; in addition, the Guatemalan State declared the Northern Transversal Strip as an agricultural development zone. At the time that the project began, there were extensive cattle breeding, corn, beans and rice crops in the area, among others. All of this generated degradation within the different ecosystems, which is why in 1975 the natural reserve was created and in 1996 the National Park, with 10,000 hectares dedicated to conservation.

The project worked with 25 indigenous families located within the "collective agricultural heritage" on the park's boundaries, as well as with the mixed-race population dedicated to cattle grazing, which put the protected areas at risk. The main social and economic issues that had negative impacts on ecosystems were identified, which helped define the main objectives of the project, "achieve conservation of natural resources contained in the park and the sustainable use of natural resources in its influence zone, in order to improve the living conditions of the local inhabitants."

Other project objectives were focused on guiding the restoration and conservation of biodiversity, sustainable products, diversification and improvements in product marketing, as well as contributing to establishing legal tenure of the land.

The subsequent phases of the project focused on supporting local management processes for the conservation and protection of the natural resources aimed at spatial planning. The project brought together the Ministry of Agriculture and Livestock, the National Council of Protected Areas and the National Forest Institute in order to implement the park's Master Plan, including a forest development strategy, in addition to strengthening local organisation.

After 12 years of the project, work was implemented in environmental management, an environmental education strategy in communities was created, ecosystems were restored by reforestation, technical assistance was provided in promoting good practices for the use of soil, contributing to lower conflicts of use, access to and management of natural resources, promotion of the use of non-timber products.

Keeping ecosystems healthy is important to lower the secondary effects of hydro meteorological processes such as storms and droughts. The ecosystems also help to maintain water supplies and edible resources that have commercial value, as well as ecotourism. Increasing the level of resilience so that communities are able to face disasters is key in the adaptation and mitigation of climate change.

Case study 5. Pilot Project: Community action to build climate change resilience in Trinidad and Tobago.[94]

This is a pilot project developed by the Caribbean Natural Resources Institute (CANARI), within the framework of the United Nations program for climate change and disaster risk reduction. It was developed in the community of Valle Caura, Trinidad and Tobago.

The main objective of the project was to "improve resilience in livelihoods and ecosystems to disasters related to climate change, building capacities among inhabitants, especially those that are most vulnerable, manage ecosystems efficiently in order to respond adequately to climate change by means of investigation, learning in action and development of abilities, as well as diffusion and communication of lessons learned."

CANARI facilitated community dialogue on the degree of vulnerability to climate change and its link to the impact on natural resources between the Council of the Valle de Caura and the Association of Agriculturalists of the Valle de Caura. Through a three-day workshop, 25 people in the community were mobilised where they discussed the impact of climate change in their town and the development of relevant plans.

Also, some locals were trained in the use of video cameras (cell phones) in order to document interviews with their neighbors; how they perceived the vulnerability in their communities, their experiences during the flood season, the lack of drinking water and river

94 Caribbean Natural Resources Institute. 2013. Case study on a pilot project on community action to build climate change resilience in Caura Valley. Trinidad. CANARI, GEF, SGP, UNDP. Trinidad and Tobago.

contamination, the growing of crops in riverbeds to fight the effects of the drought, road congestion and dumping solid waste, as well as an increase in dengue as a consequence of contamination and the presence of mosquitoes.

The community created a montage of photographs they took themselves (photojournalism) where they demonstrated the environmental issues the community is faced with. By use of social networks, such as Facebook and You Tube, the neighbors shared not only the videos but also the photographs.[95]

Case study 6. Protected areas and climate change: Legal perspectives and action management in the Dominican Republic.[96]

The report of the project is made up of 6 chapters: (i) referential framework on the mitigation and adaptation measures as a response to climate change and its link to protected areas; (ii) constitution and main characteristics of the SINAP (National System of Protected Areas) in the Dominican Republic; (iii) regulations of the Dominican legal framework on protected areas; (iv) analysis of the legal framework and institutional framework of protected areas in the face of challenges due to climate change; (v) recommendations for an effective implementation of Law 202-04 in the face of climate change; and (vi) actions for climate change adaptation and mitigation by the SINAP. This project was implemented by the International Union for Conservation of Nature (IUCN).

Climate change represents an important threat to protected areas and their ecosystems, according to scenarios and forecasts. The effects could translate into loss of species diversity, invasion of new disease species, an increase in forest fires and floods, migration of species and an increase in human pressures.

The study demonstrates the legal gaps and threats surrounding protected areas and their vulnerability in the face of climate change, at the same time that it proposes concrete actions to avoid constant degradation of these areas and increase their resilience and the livelihoods of the population in the face of climate change.

Among the recommendations that are provided are: promote efforts for adaptation and mitigation of climate change in protected areas, guarantee the existence of the National System of Protected Areas, promote the creation of new protected areas, incentivise conservation, foster the design and management of protected areas, increase awareness among decision makers, and guarantee consensual governance structures.

The document also recommends modification of the Dominican Republic's legal framework, specifically Law 202-04 (Sectorial Law of Protected Areas) in the face of climate change.

5.2 Eco-DRR for biodiversity

The Eco-DRR approach involves important aspects like ecosystem management, promotes incentives for conservation, protects the biodiversity of species and preserves ecosystem services, as a way to improve the quality of life of people and communities. Healthy ecosystems are more resilient to the negative impacts of natural disaster and become natural barriers protecting human activities for the benefit of communities, especially the most vulnerable in economic terms. However, it requires the joint efforts of government officials, conservationists and residents within communities to obtain the best results.

A very good example of such synergies between government officials of the Ministry of the Environment and researchers, is the project "Thinking outside the protected area boundaries for flood risk management: the Monterrico Multiple Use Natural Reserve in Guatemala" by the University of San Carlos, Guatemala and IUCN Global Protected Programme.

Researchers, government and the community work together to update the Reserve´s Master Plan to include flood management, through a Conceptual Ecological Model, and to establish a permanent stakeholder engagement process. In the new scale of

95 https://www.facebook.com/media/set/?set=a.563605503664855.150728.159735514051858&type=3
https://www.youtube.com/watch?v=MSEyW_uKrLc

96 International Union for Conservation of Nature. 2012. Áreas protegidas y cambio climático: Perspectivas legales y acciones de gestión en República Dominicana. IUCN. Ministerio de Medio Ambiente y Recursos Naturales. República Dominicana.

actions, they include three (i) watershed level with actions to be taken in any of the three watersheds influencing the reserve, (ii) Chiquimula channel that includes the area comprised by this channel and (iii) Reserve level actions, taking place inside the legal limits of the protected area.[97]

They agreed a new set of government arrangements, incorporated additional stakeholders such as sugarcane industry actors, municipalities inside the watersheds and other governmental institutions related to watersheds. This opens up the possibility of creating a council in which decisions are taken amongst all stakeholders. Finally, the new approach proposed is based on (i) better coordination and synergy amongst different research centres with the University and (ii) processes rather than isolated management actions.

Another good example is the National Program for Ecosystem and Landscape Restoration (PREP) (El Salvador, 2012), presented as part of the Adaptation to Climate Change Policy, whose objective is to promote and facilitate the restoration of ecosystems, basins and rural landscapes as a mechanism to ensure ecosystem services, and the conservation of biodiversity as a way of adapting to the impact of climate change, especially to variability in weather.

The components of the programme are:

- Promoting change towards sustainable agriculture at a landscape and territory level based on existing human and social capital
- Restoration and conservation of critical ecosystems (mangroves, forests and wetlands)
- Massive use of natural infrastructure together with grey infrastructure
- A new way of acting through the joint implementation between ministries and local actors.

The Program, in component 2 (restoration and conservation of critical ecosystems), states that the actions begun in 2012 are:

- Unclogging natural mangrove canals in the Bahía de Jiquilisco
- Natural regeneration of mangroves in degraded areas of Bahía de Jiquilisco and Jaltepeque
- Pilot plan design of the Rio Lempa and Rio Jiboa restoration of riverbank forests
- Update of the Management of Protected Areas strategy
- Design and implementation of the mangrove and coral reef conservation project in Los Cobanos
- Study of the condition of land tenancy and critical ecosystems.

Another component of the Program is the use of green infrastructure, which consists of increasing the vegetation in rural and urban areas to improve water regulation capacity, reducing erosion and transportation of sediment. For that it is necessary to restore riverbank forests, eliminate solid waste from riverbeds, stabilise soils and create a hydrographic basin management plan, especially in the Usulutan zone.

To this end, El Salvador established a new Environment Law in 2012, as well as the Territorial Planning Law and the Water Law, but it is also dependent on international loans and international cooperation.[98]

Probably the best model of disaster risk reduction in this region is Cuba. The success of their model lies in the organisation of their people and in their trust in government institutions. The greater part of the Cuban population belongs to the Defense of Revolution Committees, the Federation of Cuban Women, the National Association of Small-scale Agriculturists, and the Association of Soldiers of the Cuban Revolution. The joint work between government officials and the community is key to increasing resilience and reducing vulnerability.

97 Murti, R. and Buyck C. (ed) 2014. Safe Havens: Protected Areas for Disaster Risk Reduction and Climate Change Adaptation. Gland, Switzerland: IUCN. Xii + 168 pp

98 Barry, D. 2012. Programa Nacional de Restauración de Ecosistemas y Paisajes. Esfuerzo principal de adaptación al cambio climático en El Salvador. Ministerio de Medio Ambiente y Recursos Naturales. MARN. Programa de las Naciones Unidas para el Desarrollo. PNUD. El Salvador.

Even though these organisations do not have the main goal of natural risk reduction, they take on local prevention actions, even sanitary and hygiene campaigns, especially to fight vector-borne diseases such as dengue. Likewise, they jointly assume responsibility with the government for evacuations in case of a natural danger and for recovery tasks. They also indicate that each community defines their disaster risk and creates their own disaster risk reduction plans. In addition, the Cuban State prohibits the construction of residential areas in high-risk areas. However, the document does not address the subject of ecosystems and natural resources.

The National Program for Facing Climate Change for Cuba (2007) states that among the expected impacts is that: 84% of sandy beaches will suffer erosion, with an estimated coastline regression of 1.2 meters, in addition to a 19% reduction in mangrove health and 70% of reef crests will suffer deterioration.

Therefore, among the measures that are being implemented is the development plan for medium- and long-term restoration of mangrove areas, as well as measures to stop the deterioration of reefs most affected by human activities. Another action that has been taken was the reforestation of 1,467 hectares of coastal forests, including mangrove forests.[99]

This country as well as others of the region is taking action on ecosystem restoration, especially to face the negative effects of climate change within the framework of their national strategies.

As will be explained in later sections, Jamaica provides another example of a government that has implemented several disaster risk reduction programmes. Part of their action plan is the implementation of projects to construct community resilience, and a risk and vulnerability pilot plan is in place, led by organisations of the United Nations called "Risk and Vulnerability Assessment Methodology Development Project" (RiVAMP). This includes the role that ecosystems play in risk reduction and the vulnerability associated with natural dangers with an emphasis on climate change.[100]

The methodology covers: (i) ecosystems and ecosystem services, (ii) environmental changes caused by human activity and climate change, (iii) vulnerability and local livelihoods, and (iv) environmental governance.

The inclusion of public institutions was fundamental for putting the pilot project into practice, including the Planning Institute of Jamaica, National Environment and Planning Agency, National Spatial Data Management Division and Office for Disaster Preparedness and Emergency Management participated.

The project combined the use of Information Systems to process information about population density, infrastructure, satellite images and other types of information that is essential for the analysis. The pilot project concentrated on the northeastern part of the island and took into consideration technical-scientific studies created in the area by investigation centres and universities.

Among the results from the applied methodology are the following:

- Satellite information analysis was used to determine the distribution of marine ecosystems, especially of coral reef and seagrass, as well as estimating the erosion of Negril beach in the last 40 years.
- The effects on coral reefs were studied using a hydrodynamic model to measure wave frequency and sea level.
- Statistical analysis established the correlation between beach erosion, coral reefs and seaweed.
- An estimation of future erosion risk scenarios on Negril beach.
- A theoretical model on the origin of storms and the association with floods in Negril based on return periods of 10 and 50 years.
- Elaboration of maps on environmental degradation in the last 40 years, created by the community.

99 Rivero, O. 2013. La experiencia de Cuba frente al cambio climático. Dirección de Medio Ambiente. CITMA. Cuba.

100 Office for Disaster Preparedness and Emergency Management. 2014. Country document on disaster risk reduction. Jamaica, 2014. Jamaica.

Lastly, the United Nations Development Programme established "hands-on learning," a process that helped develop the country's ability to apply the methodology in other parts of Jamaica.[101] The pilot project contributed to the conservation of biodiversity (coral reefs and seaweed), and has raised awareness in communities about their importance by creating mapping (made by the local population) about their perception of the degradation of natural resources in their places of residence.

5.3 Biodiversity case for Eco-DRR

Ecosystems are the best strategy against natural hazards due to their natural ability to survive through adaptation to change that has stood the test of time. The integration between the use of biodiversity and disaster risk reduction can be seen as a tool to prevent large-scale catastrophes while helping preserve the natural ecosystems.[102] Central America and the Caribbean, as mentioned before, are prone to droughts, floods, storms and landslides. Nature-based solutions to fight against disasters are a crucial strategy that has successfully been applied to reduce vulnerability.[103] In the last few years with climate change, and El Niño and La Niña becoming a significant factor towards the shifting hydro meteorological processes in Latin America, the need to prevent and prepare for disasters is a concern that must be addressed.[104]

As discussed earlier, healthy and well-managed ecosystems have an important role to play in reducing disaster risks from such hazards. Biodiversity in Eco-DRR is not only about ecosystems, but how different species and management tools are actively used as a mechanism to fight against natural disasters and hazards.

While the importance of ecosystems in disaster risk reduction is largely documented worldwide, the role of biodiversity is less understood and not yet recognised. While several definitions of biodiversity include ecosystem diversity, here we refer to biodiversity as the variety of different species. It is recognised that the variety of ecosystems is indeed an integral part of biodiversity but for the purpose of this assessment, the distinction is needed to particularly showcase the role that species diversity plays in disaster risk reduction.

5.3.1 The role of biodiversity in risk reduction

The health of ecosystems and their ability to provide ecosystem services such as the protection against natural hazards is linked to their biodiversity. Diversity of species and functional groups of species contributes to the complexity of ecosystems and is critical for resilience and consequently the provision of ecosystem services.[105] Recent studies further illustrate the importance of biodiversity in contributing to the resistance of ecosystem productivity to climate extremes[106] and long-term resilience of ecosystems' functions and services.[107] Biodiversity can not only contribute to risk reduction by maintaining healthy ecosystems but diversity of species is also equivalent to variation in characteristics, traits, structures and genetic diversity that can provide different tools and strategies for DRR.

Biodiversity and restoration of coral reefs

Coral reefs are natural sea barriers that provide protection from storm surges that are commonly produced through hurricanes or tropical depressions. Coral reef structure is indispensable due to its characteristics in helping protect coastal regions by dampening the energy from tides and waves reaching the coast. In the last few decades, meteorological and anthropogenic hazards have

101 United Nations Environment Programme. 2010. Risk and Vulnerability Assessment Methodology Development Project. Linking ecosystems to risk and vulnerability reduction. The case of Jamaica. Results of the pilot assessment. UNEP. Jamaica.

102 Dudley, N., MacKinnon, L. and S. Stolton, S. 2013. Reducing vulnerability: The role of protected areas in mitigating natural disasters. In F.G. Renaud, K. Sudmeier-Rieux and M. Estrella (eds.) The Role of Ecosystems in Disaster Risk Reduction. United Nations University Press, Tokyo, New York and Paris.

103 International Union for Conservation of Nature. 2012. Why do ecosystems matter for disaster risk reduction? Available at https://www.iucn.org/about/work/programmes/ecosystem_management/disaster/ecosystems/. Accessed on 3 September 2016.

104 World Meteorological Organization. 2014. El Niño/Southern oscillation. OMM. Geneva, Switzerland.

105 Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L. and Holling, C.S. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution, and Systematics*, pp.557-581.

106 Isbell, F., Craven, D., Connolly, J., Loreau, M., Schmid, B., Beierkuhnlein, C., Bezemer, T.M., Bonin, C., Bruelheide, H., De Luca, E. and Ebeling, A., 2015. Biodiversity increases the resistance of ecosystem productivity to climate extremes. *Nature*, 526(7574), pp.574-577.

107 Oliver, T.H., Heard, M.S., Isaac, N.J., Roy, D.B., Procter, D., Eigenbrod, F., Freckleton, R., Hector, A., Orme, C.D.L., Petchey, O.L. and Proença, V., 2015. Biodiversity and resilience of ecosystem functions. *Trends in Ecology & Evolution*, 30(11), pp.673-684.

increasingly affected the health of coral reef biodiversity. According to the IUCN Red List of Threatened SpeciesTM107 coral reefs have the highest extinction rate among all taxa, resulting in less effective coral reef barriers to protect coastal communities affected by storm surges.

The biodiversity of coral reefs for disaster reduction needs to be healthy in order to maintain the reef structure, so investing in the restoration of coral reef health contributes directly towards the reduction of risk and disasters from coastal areas. In their report from 2011, the Caribbean Catastrophe Risk Insurance Facility indicated that the most cost efficient plan to mitigate climate change from sea level rise and storm surges was through the investment in coral reef restoration.[108]

Besides contributing to the health of reef ecosystems, specific coral species possess desirable characteristics for reef restoration efforts. The choice of species used is one key factor that can determine the success of such restoration works. For example, reef rehabilitation through translocation of coral fragments is more successful with specific coral species that reproduce by fragmentation or are able to withstand breakage, as noted in the Philippines.[109]

In Belize, the community-based organisation Fragments of Hope is implementing coral restoration projects at two locations, the Placentia Peninsula and the Laughing Bird Caye national parks where they have established in-situ coral nurseries. Restoration efforts in these areas are not only attempting to restore this important habitat but also aim to maintain a high level of genetic diversity of the coral species.[110] For example, experiments have been conducted to determine thermally tolerant Acropora species that can be propagated in the nurseries and used in restoration.[111] The use of resistant genotypes can both speed up the recovery of corals and contribute to climate change adaption.

The reason that coral reefs have the ability to maintain a natural sea wall is due to their natural biological processes that secrete calcium carbonate on top of older coral structures, thus maintaining their ability to repair and maintain their sea wall structure through several repeated disasters. The reduction of living coral will cause the degradation of the natural sea wall through constant erosion that would allow storm surges and rises in tides to reach coastal communities.

The case study in Belize and the Philippines demonstrates how biodiversity can be restored by maintaining healthy coral reefs that have been damaged or died, as it is vital to maintain the biodiversity in a healthy reef system to prevent further coral reef loss. To maintain a healthy reef is crucial as demonstrated in a study to measure the effectiveness of coral reefs as natural barriers; and as a result, it was concluded that wave energy was reduced on the Pacific island of Guam by as much as 97%, and from the reef crest by as much as 86%.[112] Investing in restoring the species in coral reefs, like those in Belize and the Philippines, will help future generations in the reduction of disasters through reducing wave energy reaching the coast.

Coral reefs play a tremendous role for both biodiversity and the reduction of risks from natural disasters. The less biodiversity in coral reefs, the more prone they are to losing the reef structure, increasing the likelihood of rough seas hitting coastal communities.

Mangroves and biodiversity

Mangrove forests are essential for the protection of coastal regions due to their importance for the reduction of disasters from the rising of the sea, but also by buffering floods and winds by creating a barrier between the sea and coastal communities. As mentioned earlier, mangroves are recognised as being important in protecting shorelines, for example against storms and winds [113]

108 Caribbean Catastrophe Risk Insurance Facility. 2011. A Snapshot of the Economics of Climate Adaptation Study in the Caribbean. Grand Cayman, Cayman Islands.

109 dela Cruz, D.W., Villanueva, R.D. and Baria, M.V.B., 2014. Community-based, low-tech method of restoring a lost thicket of Acropora corals. *ICES Journal of Marine Science: Journal du Conseil*, 71(7), pp.1866-1875.

110 Fragments of Hope. 2016. Fragments of Hope. [ONLINE] Available at: http://fragmentsofhope.org/. Accessed 23 May 2016.

111 Bowden-Kerby, A. and Carne, L. 2012. Proceedings of the 12th International Coral Reef Symposium, Cairns, Australia, 9-13 July 2012, 20A Restoration of coral reefs.

112 Farrario, F., Beck, M.W., Storlazzi, C.D., Micheli, F., Shepard, C.C. and Airoldi, L. 2014. The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Nature Communications 5:3794 doi: 10.1038/ncomms4794

113 Das, S. and Crépin, A.S., 2013. Mangroves can provide protection against wind damage during storms. E*stuarine, Coastal and Shelf Science*, 134, pp.98-107.

In Belize, the shoreline protection services provided by mangrove ecosystems are estimated at US$ 11-167 million annually.[114] In Mexico, mangroves are also estimated to reduce storm surges by 50%.[115]

These natural barriers are able to dampen storm surges through their dense foliage, as they are able to control and distribute the influx of water preventing further surges beyond the mangrove forests. They are natural distributers of water as they are naturally flooded and are susceptible to large influxes of water levels.

The case for biodiversity within mangrove forests to protect coastal communities can be seen by maintaining and translocating the species that are essential to maintain healthy mangrove forests. It is crucial to be able to maintain the health of the forests to be able to reduce future disasters. For example, a study conducted in Sri Lanka and Thailand indicates that the identity of species and their structural characteristics can contribute to increasing the protective function of these ecosystems.[116] The authors noted for example that some mangrove species such as Rhizophora apiculata types that have complex aerial root structures provided more protection from tsunami damage.

It is possible to identify the specific species and their structural characteristics directly connected towards the health and maintenance of the mangrove forests. Thus, investing in the biodiversity and characteristics of composition of a mangrove forests contributes directly towards risk reduction though nature. Being able to identify what species are vital for the health of mangrove ecosystems is a key step towards restoring and maintaining the health of the ecosystem to better protect coastal communities.

The importance of biodiversity in mangrove ecosystems is also a key factor to consider when restoring theses habitats. The international NGO, Mangrove Action Project (MAP), has been promoting the innovative Community-based Ecological Mangrove Restoration (CBEMR) method as an alternative to monoculture plantations when restoring mangroves. This method aims to restore functional biologically diverse mangrove ecosystems, a technique that is more successful compared to others. It particularly "focuses on re-establishing the hydrology that will facilitate this natural regeneration process. One of the advantages is the restoration of a more biologically diverse, natural species composition, as compared to the rather 'artificial' composition achieved through single species, hand planting."[117] While MAP does not have specific projects in the region, they have conducted a capacity-building workshop on the CBEMR technique in El Salvador in 2011 and elements of the approach are being integrated into the national programme of mangrove restoration.[118]

A restoration programme the conserves the biodiversity of a mangrove ecosystem needs planning and investigation to identify the correct methodology or technique to develop an action plan for its conservation. Taking into account the diversity of mangrove ecosystems is crucial for protection against storms and winds, thus is an excellent example of a nature-based solutions for the reduction of risk and disasters.

Shade-grown coffee plantations

The power of biodiversity towards reducing the risk of disasters is a result of how ecosystems are environmental bioengineers by adapting to changes in the landscape. The natural cycles of each ecosystem must be repaired due to the fact that they have been skewed through anthropogenic alterations. The loss of ecosystems has pushed towards an increase in floods and landslides in Central America that have cost several lives over the last few decades due to climate related disasters[119].

114 Cooper, E., Burke, L. and Bood, N. 2008. Coastal Capital: Economic Contribution of Coral Reefs and Mangroves to Belize. Washington DC: World Resources Institute.

115 Blankespoor, B., Dasgupta, S. and Lange, G.M., 2016. Mangroves as protection from storm surges in a changing climate. World Bank Policy Research Working Paper, (7596).

116 Tanaka, N., Sasaki, Y., Mowjood, M.I.M., Jinadasa, K.B.S.N. and Homchuen, S. 2007. Coastal vegetation structures and their functions in tsunami protection: Experience of the recent Indian Ocean tsunami. Landscape and Ecological Engineering, 3(1), pp.33-45.

117 Global Nature Fund. 2015. Mangrove Restoration guide: Best practices and lessons learned from a community-based conservation project. GNF.

118 Mangrove Action Project. 2016. Country by country. [ONLINE] Available at: http://mangroveactionproject.org/country-by-country/ [Accessed 24 May 2016].

119 INISDR-CEPREDENAC. 2014. Informe regional del estado de la vulnerabilidad y riesgos de desastre en Centroamérica. Oficina de las Naciones Unidas para la Reducción del Riesgo de Desastres.

As mentioned above, growing coffee shrubs under shade trees plays a role in maintaining species diversity. This agricultural method can also provide an adaptive strategy for climatic risks that threaten coffee production and livelihoods in the region. Climatic models for Mexico indicate that climate change may reduce coffee production by 34% and consequently make it economically unviable by 2050.[120] Another literature review highlights the need for site-specific adaptation strategies for coffee plantations considering that land suitability for coffee plantation will change with climate change.[121] The authors of that review also state. "The first step in adaptation is to reduce the vulnerability of coffee farmers to climate change. In this regard, use of technical 'no regret' measures that strengthen the resilience of the system (e.g. sound agronomy, sustainable management of natural resources) will be beneficial to growers and their livelihoods and may also minimize the effects of climate change."

Shade-coffee plantations present one such adaptive strategy and, as indicated by experiments, they are also more resilient to climate fluctuations.[122] Implementation of such resilient crop systems can thus protect the livelihoods of already vulnerable local people that depend on coffee farms for income either as small-scale farmers or as labourers. In addition to contributing to local livelihood resilience, shade- grown coffee plantations are also reported to provide several ecosystem services that directly contribute to risk reduction. For example, trees planted in the coffee plantations help reduce soil erosion, maintain natural biological control, and filter rainwater to avoid floods and landslides.[123] While the contribution of shaded-coffee to risk reduction is explained above, there remains the question of the role of biodiversity in shaded-coffee plantations, and how the latter contributes to Eco-DRR outcomes. Tree diversity is actually important for shade management in coffee plantations and the selection of tree species is important. For example some tree species may compete with the coffee plants for resources and decrease coffee yield while others do not have such impacts.[124,125]

Without the forests, the degradation of soils or soil runoff, frequent flash floods, reduction of groundwater, landslides and mudslides, and droughts would become more frequent .[126] Beer et al. (1998) summarised some of the beneficial attributes of shade trees including "small foliage, provision of timber, fruit or other useful products, sub-soil feeder so that nutrients are recycled by fallen leaves."[127] In their review, Beer et al. (1998) also highlight how the choice of tree species used, such as nitrogen-fixing species, can influence soil fertility, incidence of pest contamination and occurrence of weeds in the plantations.

The improvement of forest management policies to protect the watershed and reduce any further deterioration of the land use will contribute to reducing disasters. Despite not being officially recognised as an Eco-DRR methodology, it is used as an ecosystem barrier towards reducing disasters. In the case of the Guatemala-Mexico watershed, it is clear that reforestation and the improvement of local policies will contribute towards the reduction of risk while improving the biodiversity of the landscape. Investment in the reforestation of trees contributes to the mitigation of climate change by restoring the natural cycles of each ecosystem. In addition, it also bolsters the watershed between the border nations that has been altered due to deforestation and improper land use.

120 Gay, C., Estrada, F., Conde, C., Eakin, H. and Villers, L. 2006. Potential impacts of climate change on agriculture: A case of study of coffee production in Veracruz, Mexico. *Climatic Change*, 79(3-4), pp.259-288.

121 Laderach, P., Lundy, M., Jarvis, A., Ramirez, J., Portilla, E.P., Schepp, K. and Eitzinger, A. 2011. Predicted impact of climate change on coffee supply chains (pp. 703-723). Springer, Berlin and Heidelberg.

122 Lin, B.B. 2007. Agroforestry management as an adaptive strategy against potential microclimate extremes in coffee agriculture. *Agricultural and Forest Meteorology*, 144(1), pp.85-94.

123 International Union for Conservation of Nature. 2005. BASIM Project. Café con sombra y alternativas para reducir la presión del cambio del uso del suelo en la zona Sur de Ahuachapán El Salvador. UICN. Oficina Regional para Mesoamérica. San José, Costa Rica.

124 Dossa, E.L., Fernandes, E.C.M., Reid, W.S. and Ezui, K. 2008. Above and belowground biomass, nutrient and carbon stocks contrasting an open-grown and a shaded coffee plantation. *Agroforestry Systems*, 72(2), pp.103-115

125 Schaller, M., Schroth, G., Beer, J. and Jiménez, F. 2003. Species and site characteristics that permit the association of fast-growing trees with crops: The case of Eucalyptus deglupta as coffee shade in Costa Rica. *Forest Ecology and Management*, 175(1), pp.205-215.

126 Science for Environment Policy. 2015. Soil and Water: A larger-scale perspective. Thematic Issue 52. Issue produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol. Available at: http://ec.europa.eu/science-environment-policy

127 Beer, J., Muschler, R., Kass, D. and Somarriba, E., 1998. Shade management in coffee and cacao plantations. In *Directions in Tropical Agroforestry Research* (pp. 139-164). Springer Netherlands.

Genetic diversity and crop resilience

In the next few decades, one of the biggest threats that is expected to worsen though the effects from El Niño and La Niña and that is intensified through climate change are regional droughts, caused by changes in rain patterns and natural meteorological cycles provoked through changes in sea temperatures. In 2015, Central America suffered from one of the worst droughts affecting the livelihoods of over 2.5 million people according to the European Commission Humanitarian Aid and Civil Protection Office.[128] Thus, it is important to be able to secure future food supplies and prepare for droughts caused by the onset of climate change.

Droughts pose a serious threat to food security and undermine the livelihoods of many people that depend on agriculture for subsistence and a source of income. In Central America, El Niño has contributed to a rise in hunger. Addressing drought and hunger can be a complex endeavuor and biodiversity may not be able to provide all the solutions. However, with climate change and the increased incidence of such hazards in the future, it is important to start integrating genetic diversity into long-term adaptive strategies.

In efforts to establish resilient crop systems, crop wild relatives (CWR) are important genetic resources.[129]CWR are defined as "a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop."[130] Basically, CWR are wild species that are related to crops and can contribute traits for crop improvement including drought resistance.[131] CWR also include native plant species of conservation value and thus provide opportunities to synergise biodiversity conservation, disaster risk reduction and climate adaptation.[132,133] More and more inventories of CWR and priority species or taxa for ex-situ and/or in-situ conservation are being identified and documented.[134,135] In Guatemala, the Atlas of Guatemalan Crop Wild Relatives was published in 2011 following a 10-year collaboration between the United States Department of Agriculture's Agricultural Research Service, Biodiversity International's Regional Office for the Americas, the International Center for Tropical Agriculture (CIAT), and the Agronomy Faculty and the University of San Carlos in Guatemala. The Atlas includes a supporting database and has detailed information on 105 wild Guatemalan plants that are related to crops. Such inventories are the first steps towards the use of CWR to strengthen resilience of crop systems as they provide key information to plant breeders,[136] but the application to improve crops is still underdeveloped.

Droughts are more common in the Pacific basin of Central America where most of the population and agriculture are localised. To protect the food supply, it is vital to invest in strategies that allow for a greater crop genetic diversity to enable crops to become less prone to disease and more resilient to change. The example in Guatemala of the crop atlas is an excellent solution in order to protect future crops' genetic diversity to the climate and disease.

Genetic diversity allows a population to remain healthy by allowing rare alleles, or certain rare genes, in the gene pool that could be beneficial for protection against disease or resistance to El Niño or La Niña. If genetic diversity becomes limited in a single homozygous crop, the probability of disease and resilience of the entire crop could potentially be affected, rather than only a few individu-

128 Watson, K. 2015, October 19th. Guatemala families struggle for food in Central American drought. BBC. Retrieved from http://www.bbc.com/news/world-latin-america-34416771. Accessed 31 May 2016.

129 Dempewolf, H., Eastwood, R.J., Guarino, L., Khoury, C.K., Müller, J.V. and Toll, J. 2014. Adapting agriculture to climate change: A global initiative to collect, conserve, and use crop wild relatives. *Agroecology and Sustainable Food Systems*, 38(4), pp.369-377.

130 Maxted, N., Ford-Lloyd, B.V., Jury, S., Kell, S. and Scholten, M. 2006. Towards a definition of a crop wild relative. *Biodiversity & Conservation*, 15(8), pp.2673-2685.

131 Vincent, H., Wiersema, J., Kell, S., Fielder, H., Dobbie, S., Castañeda-Álvarez, N.P., Guarino, L., Eastwood, R., León, B. and Maxted, N. 2013. A prioritized crop wild relative inventory to help underpin global food security. *Biological Conservation*, 167, pp.265-275.

132 Kell, S.P., Maxted, N. and Bilz, M. 2012. European crop wild relative threat assessment: Knowledge gained and lessons learnt. In: Maxted, N., Dulloo, M.E., Ford-Lloyd, B.V., Frese, L.L., Iriondo, J.M. and Pinheiro de Carvalho, M.A.A. (Eds.), *Agrobiodiversity Conservation: Securing the Diversity of Crop Wild Relatives and Landraces*. CAB International, Wallingford, pp. 218–242.

133 Vincent, H., Wiersema, J., Kell, S., Fielder, H., Dobbie, S., Castañeda-Álvarez, N.P., Guarino, L., Eastwood, R., León, B. and Maxted, N. 2013. A prioritized crop wild relative inventory to help underpin global food security. *Biological Conservation*, 167, pp.265-275.

134 Ibid

135 Castañeda-Álvarez, N.P., de Haan, S., Juárez, H., Khoury, C.K., Achicanoy, H.A., Sosa, C.C., Bernau, V., Salas, A., Heider, B., Simon, R. and Maxted, N. 2015. Ex situ conservation priorities for the wild relatives of potato (Solanum L. section Petota). *PloS one,* 10(4), p.e0122599.

136 United States Department of Agriculture Research Service. 2012. Atlas of Guatemalan Crop Wild Relatives [ONLINE] Available at: http://www.ars.usda.gov/Services/docs.htm?docid=22225/ Accessed 24 May 2016.

als. The ability of having a large genetic pool allows for certain genes to be more resilient to disease and external forces than a few single genes that might be more prone to infection or climate change; thus, increasing the resilience of the crop and food supply.

Soil bioengineering and plant diversity

Most of the Central American population lives in valleys and plateaus between steep hills and mountains. The hazards from living in around valleys with steep gradients put many lives at risk from landslides and flash floods. Controlling soils on steep gradients is typically achieved by the natural vegetation that acts as an anchor preventing landslides of the top soil occurring. The best solution to reduce the risks of steep gradients for communities is soil bioengineering, which is a technique that can be used to stabilise slopes and manage watersheds by planting suitable plants.

While contributing to disaster risk reduction, the technique can also contribute to habitat restoration particularly if using native plant species. Plant species vary in their ability to stabilize soil and control surface-water flow, so plant diversity and native species have an important role to play for such techniques by providing a pool of locally-adapted plants with different characteristics[137,138].

Petrone and Preti (2008) conducted a study to identify suitable native plants for soil bioengineering in Central America, particularly Nicaragua. The study identified three local plant species out of four tested as being suitable both in terms of survival and growth rate: *Gliricidia sepium*, *Cordia dentata* and *Jatropha curcas*.[139] Further looking at the financial sustainability of soil-bioengineering activities, the same authors conclude in another study that such nature-based techniques were not only technically feasible but also economically sustainable.[140]

Identifying species that are best suited for their survival and growth enables local species to flourish and to restore the local biodiversity to its natural state. Local species are better adapted for the stabilisation of the soil that would have a higher probability of preventing future disasters from occurring. Allowing vascular plant roots to control the gradient of the top soil from being washed away or collapsing promotes the species best suited to the specific characteristics of the local environment. Thus, it is essential to understand the species diversity when using bioengineering due to the specific characteristics and local ecosystems that are present in the region.

The interaction between biodiversity and Eco-DRR is an essential process where natural ecosystems and species are used to create natural barriers, thus avoiding future disasters. The overall benefit from understanding how biodiversity plays a crucial role in the reduction of risk is critically important. The region in the last few decades has suffered from several large-scale disasters that will only get worse with the onset of climate change. The case examples presented for the biodiversity case for Eco-DRR are to provide an understanding towards how the diversity of species plays a role, and the characteristics that are vital to understand the functionality of preventing future disasters. Identifying the biodiversity in each case is essential towards restoring and maintaining the ecosystem that acts as a natural barrier to disasters.

5.4 Economic case for Eco-DRR

Before initiating this section, it is important to mention that at a regional level, and for focus countries, only a handful of detailed case studies provide evidence that economic investment in ecosystems can reduce the risk of natural hazards. However, some detailed studies evaluate the value, goods and services of protected areas, which will be described below.

The delicate balance between biodiversity and the economy has been heavily affected due to the constant need for resources to feed the exponential growth of the human population. Just like all animals, humanity is dependent on the essential resources that

137 Ghestem, M., Cao, K., Ma, W., Rowe, N., Leclerc, R., et al. 2014. A Framework for Identifying Plant Species to Be Used as 'Ecological Engineers' for Fixing Soil on Unstable Slopes. *PLoS ONE* 9(8): e95876. doi:10.1371/journal.pone.0095876

138 Oldfield, S. and Olwell, P. 2015. The Right Seed in the Right Place at the Right Time. *BioScience* 65(10): 955-956.

139 Petrone, A. and Preti, F. 2008. Suitability of soil bioengineering techniques in Central America: A case study in Nicaragua. *Hydrology and Earth System Sciences Discussions*, 5(1), pp.379-403.

140 Petrone, A. and Preti, F. 2010. Soil bioengineering for risk mitigation and environmental restoration in a humid tropical area. *Hydrology and Earth System Sciences*, 14(2), pp.239-250.

ecosystems provide for their survival; on the other hand, their constant use reduces the synergy of natural ecosystems. Ever since the agricultural revolution, humans have been able to harness and control the growth of crops to avoid scavenging to survive when resources were scarce. However, since the turn of the 20th century, the space and demand to maintain an unsustainable growth has pushed natural ecosystems to the brink of collapse, resulting in Earth's possible sixth mass extinction.[141]

The mismanagement of land use for economic gain has accelerated extinction in the past few decades as a consequence of destroying ecosystems through gasoline powered chainsaws and the improvement of agriculture techniques during the green revolution over the past century.[142] It is fundamental to create a sustainable balance between the growing resource demands of local communities and the diversity of ecosystems and species.

Local communities can benefit substantially by improving the economic management plans that benefit the protection and restoration of biodiversity by taking into account the economic advantages of biodiversity. Recovery from major natural hazards is typically slow and economically demanding, potentially pushing developing nations deeper into poverty.[143]

The use of economic analysis for the Eco-DRR methodology in the region is rare since many of the studies revolve around the economic analysis of prevention and/or recovery from disasters, rather than the economic benefits of risk reduction from ecosystems and biodiversity. Regionally, only a handful of case studies use an economic model to evaluate the cost effectiveness of ecosystem services in addressing DRR.

The most common methodology used to assess the cost-effectiveness of ecosystems is cost-benefit analysis, an economic tool that provides several outcomes to understand their impacts and their costs. It compares the values of each outcome to assess and measure the benefits over the cost of each impact. The project that provides the highest benefits over costs, including environmental and social costs, is considered the most worthy of investment.

The integration between biodiversity and economic benefits from an Eco-DRR perspective is instrumental towards protecting the environment while alleviating economic damage. Cost-benefit analysis could benefit the Eco-DRR approach, thus potentially protecting the natural ecosystems. For example, on the Caribbean island of Dominica, the use of a cost-benefit analysis helped strengthen its financial management and assure future ecological biodiversity in two national parks.[144]

The biodiversity and watersheds found in Dominica's national parks are vital for the economy and well-being of the small island nation. The improvement of the financial management of the national parks can help them prepare for climate change through increasing the resilience of forests to change, undergoing vital ex-situ research, collaborating, cooperating, and sharing best practices and knowledge with others to improve the parks' functionality and finances.

The national parks previously did not have any, or very few, full-time and directly employed staff; however, the new plan for economic management would expand the technical staff to run and protect the national parks. By improving the budgets and management of the national parks of Dominica, it was possible to distribute and predict future projections of how the parks may become self-sufficient and economically viable, as shown in Table 9.

141 Ceballos, G., Ehrlich, P., Ehrlich, A.D., Garcia, A., Pringle, R.M. and Palmer. M. 2015. Accelerated modern human-induced species losses: Entering the sixth mass extinction. Science Advances, 1(5) e1400253.

142 Pinstrup-Andersen, P. and Hazell, P.B.R. 1985. The Impact of the Green Revolution and Prospects for the Future. Food Reviews International 1(1). 1-25.

143 The World Bank. 2012. Latin America: Putting disaster preparedness on the radar screen. Available at http://www.worldbank.org/en/news/feature/2012/10/09/desastres-naturales-america-latina-crecimiento-riesgo. Accessed on 2 September 2016.

144 Bynoe, M., Donneil, D. and Peralta, A. 2014. The use of Benefit Cost Analysis to assess Adaptation and Mitigation Interventions in the Caribbean: Case Studies. The Commonwealth and Caribbean Community Climate Change Centre. Belmopan, Belize.

Table 9. Summary budget for the implementation of the management plan for Morne Trois Pitons National Park.

Summary by budget category	EC$	EC$	EC$	EC$	EC$	EC$
Budget Category	Year 1	Year 2	Year 3	Year 4	Year 5	Subtotal
Personnel						
Staff Training	60,000	60,000	75,000	75,000	60,000	330,000
Boundary Marking Programme	180,000	100,000	80,000	20,000	20,000	400,000
Zoning Programme	60,000	-	90,000	90,000	50,000	290,000
Visitor Use Programme	-	70,000	-	-	-	70,000
Infrastructure Design and implementation	110,000	55,000	55,000	65,000	55,000	345,000
Legislation and Regulations	-	5,000	-	-	-	5,000
Scientific Research and Monitoring	62,423	116,000	32,000	41,000	36,000	239,423
Monitoring	30,000	30,000	35,000	32,000	41,000	168,000
Surveillance and Enforcement	10,000	10,000	10,000	10,000	10,000	50,000
Communication, Education and Public Awareness	80,000	80,000	80,000	80,000	80,000	400,000
Community Outreach and Livelihood Development Programme	40,000	40,000	40,000	40,000	40,000	200,000
Other Operating Expenses	18,000	18,900	19,800	20,800	21,800	99,300
Budget Category Totals EC$	**550,423**	**584,900**	**516,800**	**542,800**	**413,000**	**2,594,723**

Source: MTPNP Management Plan, 2011. **EC$ (East Caribbean dollar). 1 EC$ = 0.37 US$**

Dominica's national parks established how the predicted scenarios for each year would perform according to investment in different programmes as shown in Table 9. The financial predictions, seen in Figure 6, demonstrates how the potential outcome on each year's gains and losses enable the parks' economic situation to be managed. Based on the economic projection, the park managers can evaluate and plan accordingly towards the financial gains in the budget of the national parks under projected future economic situations.

The direct protection of Dominica's forests contributes towards the financial benefits while at the same time minimising future hazards. Managing the financial aspects of the national parks benefits the ecosystem by financing the parks' ability to function and gain profit while contributing towards the protection of its biodiversity.

The net cumulative outlook that best benefits is the 3% discount rate from the report, which indicates that the income from national parks could range in the next fifty years from US$ 117.2 million to US$ 123.6 million as seen in Figure 6. The direct financial improvement of the parks' services plays a crucial role towards the reduction of risk by helping the biodiversity of the park ecosystems.

By investing in the protection of the ecosystems and management of the economic status of Dominica's national parks, this contributes directly towards the protection of ecosystems that in the long term will reduce the risk of natural disasters from affecting the small island's water supply. The improvement of the economic status of Dominica's National Parks is based on the ecosystem services of protection of the water resources by capturing and filtering water, increasing the carbon sink, providing a valuable cultural service through tourism.

However, cost-benefit analysis is not the only economic methodology. During the Convention of Biological Diversity 2010 conference in Nagoya, a global study, The Economics of Ecosystems and Biodiversity (TEEB) was launched as a way to utilise biodiversity as a tool to protect ecosystems through benefitting decision-makers by displaying the evaluation of nature's true economic value and the best way to approach its use.[145] The TEEB approach does not directly involve the reduction of natural hazards, but it does play a role in recovering and protecting natural areas for economic gain that indirectly reduce the risk of hazards.

145 The Economics of Ecosystems and Biodiversity. Available at http://www.teebweb.org/about/the-initiative/

The use of DRR in TEEB is an indirect response as it does not take into consideration the reduction of hazards; on the other hand, it does mitigate issues that help towards reducing the risk. In a case study done in Costa Rica, a hydrological fee for the conservation and protection of forests and watersheds to compensate local landowners was applied.[146] By implementing a new tax through the local water bill, payments for ecosystems services (PES) were provided to landowners in Heredia that conserved forests and planted forests around the watershed that collected and filtered water into the basin. The fundamental value was derived from the reduction of the watershed capacity to store water, resulting in increasing water cut-offs.

The benefits from an economic standpoint are that locals are being paid to protect and plant forests, which contributes to the conservation of the watershed as well. The project is seen as an exemplary case on how to use PES to support the conservation of ecosystems. With regards to risk reduction, the use of PES can be used to help locals receive payments that might help conserve vital ecosystems to avoid droughts, floods, sea barriers, erosion, and landslides. The PES is seen as an excellent way to help locals conserve their land, as it is more beneficial in the long run to conserve their ecosystem than to cut down forest and sell its products; a policy that has the potential to significantly reduce deforestation and degradation in Central America.[147]

One could potentially apply several methodologies to evaluate the economics of biodiversity using the Eco-DRR methodology. For example, a case study done in the Caribbean island of Barbados used the Economics of Climate Change Adaptation (ECA) methodology to mitigate against the increased risk of hurricanes and tropical storms on the Caribbean island.[148]

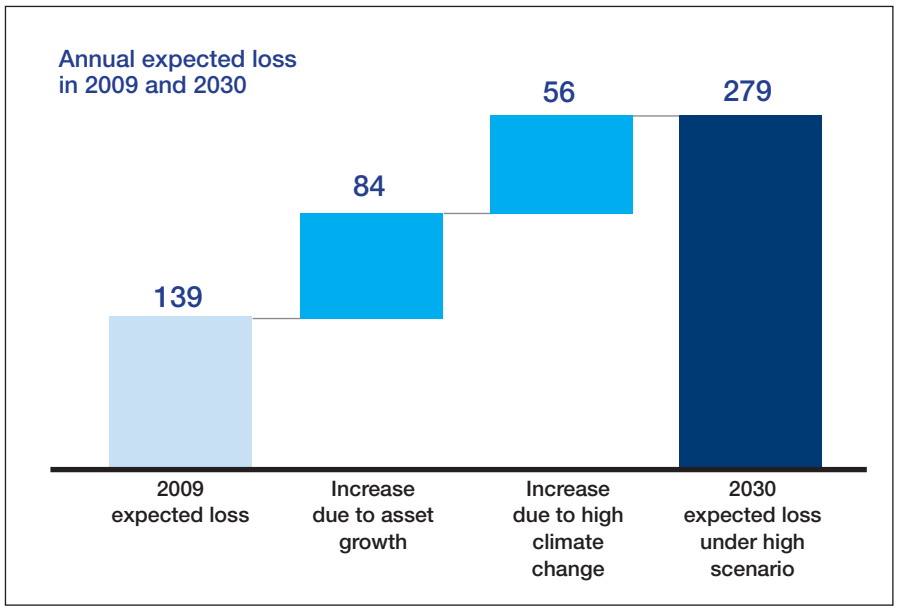
The Economics of Climate Change Adaptation, as defined in the report, includes the assessment of the potential losses in economic terms from climate change, its future projections and risks, and an assessment of the losses that could occur over a twenty-year period under several projected models on climate change. It is able to provide an economic evaluation of the outcomes based on scientific knowledge that could potentially occur with the increasing threat of climate change.

The use of Economics of Climate Change Adaptation in Barbados was in response to impending issues on climate change in the coming decades. Barbados is a small island in the Lesser Antilles of the Atlantic Ocean that is constantly at risk from storm related disasters. The threat of an increasing amount of hurricanes and tropical storms is an impending issue that over the next few decades has the potential to worsen as a result of climate change. The treat of hurricanes is a constant issue that has affected the island on numerous occasions in the past, so it is crucial to prepare economically for impending future disasters. (See Figure 6)

146 TEEB case by Redondo-Brenes, A. and Welsh, K. 2010. Procuencas Project, Costa Rica, available at: TEEBweb.org.

147 Kaimowitz, D. 2008. The prospects for reduced emissions from deforestation and degradation (REDD) in Mesoamerica. International Forestry Review, 10(3): 485-495.

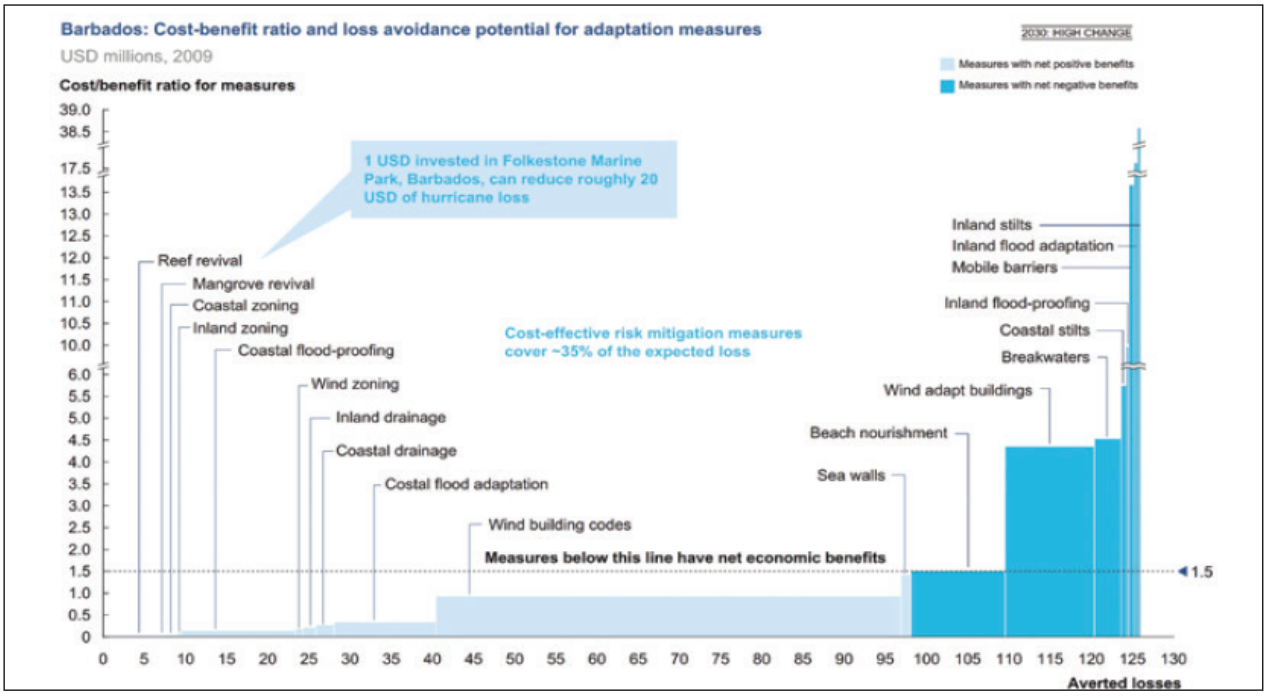
148 Murti, R. and Buyck, C (ed.) 2014. Safe Havens: Protected Areas for Disaster Risk Reduction and Climate Change Adaptation. Gland Switzerland: IUCN. Xii + 168 pp.



Source: ECA Working Group, CCRIF

Figure 6: Expected economic loss from climate change risk from today until 2030 in Barbados, taken from the Safe Havens: Protected Areas for Disaster Risk Reduction and Climate Change Adaptation.

The findings from the report on applying the Economics of Climate Change Adaptation in Barbados were that in 2009, the loss from disasters was about US$ 139 million, which accounted for about 4% of national GDP. In 2030, the potential economic loss is expected to rise to US$ 279 million, an increase of US$ $140 million from 2009, together with a potential to further reduce its GDP between 2-9%. (See Figure 7)



Source: ECA Working Group, CCRIF

Figure 7: Adaptation cost curve for Barbados: Cost-benefit ratio and loss avoidance potential for adaptation measure. The image was taken from the Safe Havens: Protected Areas for Disaster Risk Reduction and Climate Change Adaptation.

It was discovered that while using cost-efficient adaptation measures, the potential damages could be reduced by 35%, as seen in Figure 6. It was also demonstrated that the adaptive measures of coral reef restoration in the Folkestone Marine Park and ensuring reef and mangrove revivals could lower losses by US$ 20 million annually at a cost of US$ 1 million. In addition, up to 90% of the expected losses in 2030, under the high climate change scenario, can be averted by using cost-effective measures using risk mitigation initiatives.[149]

The utilisation of the Economics of Climate Adaptation methodology enables addressing specific issues of the economic losses caused by climate change. In Barbados, the methodology was able to demonstrate the economic benefits through investing in the improvement and restoration of the environment and ecosystems; for example, the economic benefits from investment in the Folkstone Marine Park and the improvement of mangroves highlights the economic development through climate change mitigation for future losses that could potentially be protected from further climate related disasters.

The frequency of more intense climate change events in the past few decades has been increasing together with the potential hazards for urbanised areas within coastal zones.[150] The need to protect these heavily populated areas from future hazards is a key driver to prepare before more frequent events hit the region. In this regard, the United Nations Environmental Programme (UNEP) has developed a training manual to implement a methodology on risk and vulnerability assessment in Jamaica.[151]

As previously mentioned, the project in Jamaica evaluates and contrasts the functionality of ecosystems, using evidence-based support in a disaster risk reduction assessment; in addition to climate change adaptation, this may encourage policymakers to make better-informed decisions that support sustainable management. Using the Risk and Vulnerability Assessment Methodology Development Project (RiVAMP), the evaluation found that ecosystems provided an important service towards the support and development of the local economy.

Seagrass, coral reefs, mangroves, sand dunes, forests, wetlands (peatlands) and other types of coastal vegetation all contribute to the economy by indirectly reducing the risk of how floods and storms might affect local communities. If the ecosystems were destroyed, then it would damage the economy through negative impacts on fisheries, tourism, agriculture and forestry. The key conclusion from RiVAMP is that governments will benefit from evaluating their ecosystems to understand how they contribute to the reduction of risk.

The conservation of the ecosystems in Jamaica would benefit economically from protection from hazards by investing in prevention rather than paying for recovery. The occurrences of hazards are increasing as a result of climate change, so it is economically more sensible to invest in preparing for such events, than to pay the price when they do occur.[152]

On the other hand, The Nature Conservancy and the Comisión Nacional de Áreas Protegidas (Mexico) elaborated a study entitled "The value of goods and services that natural protected areas provide to Mexicans."[153] Mexico possesses 34 million hectares under some category of protection, which represents 12% of its land area and 24% of its territorial sea. The budget for its management in 2008 was US$ 65.6 million. In addition, the Consejo Nacional Forestal (CONAFOR) invested US$ 7.3 million in federal protected areas between 2001 and 2004 and US$ 1.2 million in state protected areas through the Programa de Desarrollo Forestal (Profefor).

149 Caribbean Catastrophe Risk Insurance Facility (CCRIF) 2010. Enhancing the climate risk and adaptation fact base for the Caribbean, available at: http://media.swissre.com/documents/ECA+Brochure-Final.pdf.

150 Frich, P., Alexander, L. V., Della-Marta, P., Gleason, B., Haylock, M., Klein Tank, A. M., and Peterson, T. 2002. Observed coherent changes in climatic extremes during the second half of the twentieth century. Climate Research, 19(3): 193-212.

151 United Nations Environment Programme. 2010. RiVAMP Linking Ecosystems to Risk and Vulnerability Reduction: The Case of Jamaica, Results of the Pilot Assessment.

152 Bouwer, L. M. 2011. Have disaster losses increased due to anthropogenic climate change? Bulletin of the American Meteorological Society, 92(1): 39

153 Bezaury, J. 2009. El valor de los bienes y servicios que las áreas naturales protegidas proveen a los mexicanos. The Nature Conservancy. Programa México. Comisión Nacional de Áreas Naturales Protegidas. México.

Protected areas in Mexico contribute approximately US$ 3.4 billion to the national economy. For example, the fishing industry in the Mesoamerica Caribbean Reef System, which highlights the Biosphere Reserve Sian Ka'an in Quintana Roo, represents an annual potential value between US$ 150 and US$ 1,500 per hectare; while each hectare of mangrove contributes an annual average of US$ 37,500, with respect to fishing around the shores of Sonora, Sinaloa and Nayarit in the Gulf of California.[154]

As for mitigation against climate change, it is estimated that carbon stocks in federal protected areas represent a theoretical maximum value of US$ 28,112 million, while the state protected areas represent only US$ 6,061 million.[155]

Honduras also has an interesting case study of economic valuation in a protected area in 2013. The Secretaria de Recursos Naturales y Ambiente (SERNA) and the United Nations Environment Programme developed the study entitled "An economic evaluation of the ecosystem services provided by the Jeannette Kawas National Park, Honduras," as mentioned before under the project "Integrated management of coastal areas and sustainable management of mangroves in Guatemala, Honduras and Nicaragua."

Approximately 16% of the Honduran territory is coastal land and its associated ecosystems; however, the pressure of different economic sectors and weak institutional presence have threatened natural resources, leading to exploitation and degradation. Visualising the economic value of ecosystem services associated with coastal marine systems is important to raise awareness among the local communities about the importance of preserving their livelihood.

Promoting the role of coral reefs and mangrove forest in coastal protection against hurricanes is also aligned with the valorisation of these ecosystems for economic benefits. For example, they are important for commercial fish and as carbon sinks, in addition to the recreational values and tourism.

The contribution of ecosystems towards carbon sequestration, soil erosion control, natural biocontrol and improved groundwater quality is very significant. For example, the forests of the National Park consist of 1,742 hectares of mangrove forests and 19,900 hectares of tropical rainforests that capture 543,214 tonnes of CO_2 equivalent per year.

The area during the rainy and hurricane season receives waters ranging between 1 and 10 meters which increases the risk of flooding; however, the presence of the reef as a natural protective barrier and identifying vulnerable flood areas have avoided damages amounting to US$ 974,313 annually.

Laguna Los Micos-Quemada also provides the service of bio-purification of water, which also contributes to the retention of phosphate, nitrate, nitrate and chlorophyll A, which amounts to a benefit of US$ 4,428,698. In summary, the annual value of ecosystem services provided by the Jeanette Kawas National Park is US$ 21 million, including US$ 11.5 million in carbon sequestration, US$ 3.5 million in purification of drinking water, US $1.01 million in hurricane protection, US$ 1.01 million in tourism and US$ 0.8 million in agriculture production.[156]

The economic case for Eco-DRR in the focus countries is limited, due to the lack of projects that are directly involved in the reduction of risk that directly improves the economic value. Several cases can be adapted to use the Eco-DRR methodology, but the economic cases for Eco-DRR are more limited adaptations when compared to other regions and/or other local case studies. The adaptation of other methodologies can be taken into consideration as this report has done. The Eco-DRR methodology is still a relatively new concept that has not been fully applied in Central America or the Caribbean, at least for the economic cases, so the number of relevant studies remains limited.

In summary, several studies offer promising ways forward on the economics of DRR, such as cost-benefit analysis, the Economics of Climate Adaptation or TEEB. Other examples include RiVAPM in Jamaica where they used the economic aspects to evaluate

154 Aburto-Oropeza, O., Ezcurra, E., Danemann, G., Valdez, V., Murray, J., Sala, E. 2008. Mangroves in the Gulf of California increase fishery yields. Proc Natl. Acad. Sci. USA. 2008 July 29; 105(30): 10456-10459. Available at: www.pnas.org/content/105/30/10456.full.pdf+html

155 Idem [112]

156 Idem [117]

the prevention of future disasters; in Mexico and Honduras, the chosen methodology was an evaluation of the economic value of its natural ecosystems. Nevertheless, biodiversity remains essential for the restoration of natural ecosystems to reduce economic risks by reducing damage from future hazards.

6. Conclusions: Challenges and opportunities

6.1 Challenges

IUCN as an organisation seeks through its mission to influence policy-making and promote the implementation of cost-effective and integrated approaches such as Eco-DRR. The case studies illustrate opportunities to introduce such concepts in the region as a medium-and long-term process.

The region is highly vulnerable to climate change effects and to cyclic events as a product of climate variability such as the El Niño (Southern Oscillation) and La Niña. Economic and social elements that have an impact on the different degrees of vulnerability of the countries of the region were also mentioned.

It was also demonstrated that in the past and present different natural processes (mainly hurricanes, tropical storms and droughts) have significantly affected the region, from an economic and social standpoint, but also ecosystem health, which offers low resilience due to over-exploitation and degradation when faced with natural hydro meteorological events with medium to extreme intensities.

Even though Mexico, Central America and the Caribbean have worked tirelessly on generating policies and regulations in matters of natural resources, risk management and climate change, important challenges remain to be overcome.

On one hand it is necessary to strengthen governance and governability, locally as well as regionally, where governments and state organisations can work together with communities in such a way that strategies generated at an “office level” do not impose on local decision making, excluding local knowledge and community experience. Likewise, strengthening government entities by generating trust and credibility in civil society is fundamental for the success of plans, programmes and policies, so these need to include new methods of action, such as Eco-DRR as a way to strengthen the governance of communities vulnerable to natural hazards.

Another big challenge the countries face is to reduce poverty levels. Though this is not necessarily the cause of physical vulnerability, it is a condition that favours it. It is an important factor in the risk equation, as it is rural people living in poverty and extreme poverty who are the most closely linked to the direct and indirect effects of natural processes and their cumulative effects. In many cases, poverty leads people to degrade ecosystems, so it is important to raise awareness not only among local people, but also with local governments about the tangible and intangible value of natural resources. To develop projects with the Eco-DRR approach in the region will be very important to combat physical, economic and social vulnerability.

In order to diminish poverty levels, the countries must establish job creation policies, access to education and raise school leaving ages, as well as encourage support programmes for youths at social risk; it is necessary to also increase gender equality in job opportunities, especially for adolescent girls. Although Mexico, Central America and the Caribbean have made great efforts to implement some of the previously mentioned measures, many other factors must be addressed, for example, tax evasion; since this type of resource is important in order to count on budgetary funds to propel actions that benefit the living standards of the inhabitants of their respective countries.

The governments have fulfilled most of their duties derived from international conventions on natural resources, climate change, biological diversity and risk management. For example, the countries have devised their national communications for climate change, as well as possible scenarios and greenhouse gas inventories. However, in most cases, the available economic resources are not sufficient to promote more conservation action and even land management, so the level of progress is not always what is desired.

Another great challenge of the region is the implementation of a greater number of programmes and policies for conservation and restoration of ecosystems, as well as the establishment of more protected areas, especially coastal marine ones. These programmes must go hand in hand with integral management of solid and liquid waste policies, spatial planning, integral management of basins and responsible fishing practices, among others, and at the same time incorporate these programmes of conservation and recovery in the concept of Eco-DRR.

All of these efforts in the elaboration of a legal framework also require the interaction of sectoral policies on risk management and the elements that accompany them (spatial planning, basin management, urban planning, and good agricultural practices, etc.).

On the other hand, even important mangrove forest areas in the region, are not considered in the majority of cases as natural barriers against powerful waves and tropical storms, which is why timber and molluscs continue to be extracted. One of the few examples of mangrove forest restoration for extraction of molluscs and protection against waves is the sector of Barra de Santiago and Bahía de Jiquilisco in El Salvador, but this is an exception to the rule. The great challenge in this sense is to raise awareness in neighboring communities on the importance of this ecosystem, not only for commercial purposes, but to reduce the risks associated with hydro meteorological and oceanographic events.

In short, the countries of the region possess a great variety of ecosystems, life zones and ecoregions, which translates to an extraordinary amount of biological diversity. However, in order to achieve effective conservation and responsible use, the aforementioned policies must incorporate common central concepts so that governance, the use of natural resources, spatial planning, environmental health, and people's quality of life are implemented integrally and not independently, as in the current situation.

6.2 Opportunities

Although Mexico, Central America and the Caribbean are faced with great challenges and in some cases adversity, they also possess important opportunities, not just to grow socially and economically in a holistic manner, but also environmentally.

In relation to risk reduction, the region has policies and strategies based on the reality and current situation of each of the countries, on a regional as well as a local level. Even though in some cases the level of implementation and application of these instruments fails, at least a legal approach is in place. However, the policies and strategies of the region are in continuous construction, resulting in the opportunity to include new methodologies and concepts, such as Eco-DRR.

Another one of the great opportunities is that the countries of the region possess environmental legislation, while also being signatories of the most important international agreements on the subject such as the Rio Convention and Rio +20, Kyoto Protocol, Convention on Biological Diversity, Ramsar Convention, Hyogo Framework for Action and Sendai Framework for Action, among others.

Each of the countries makes important efforts in the application and implementation of these agreements, not just by reducing the generation of greenhouse gases, but also through payment for environmental services, expansion of protected areas on land as well as in the sea, contemplation of coastal-marine resources, investment in energy generation with clean technology, adaptation and mitigation of climate change protocols and strategies, ecosystem regeneration (montane and premontane forests, mangrove forests, wetlands, coral reefs, etc.) and in this way the region has begun to implement areas of responsible fishing practices and policies to eradicate trawling.

Some of the countries of the region such as Honduras, Haiti, Dominican Republic and Guatemala have been classified as the most vulnerable according to the Global Climate Risk Index, and are intimately linked to the effects of climate change. It is essential and urgent to develop and implement effective risk reduction strategies for these countries at greatest risk.

The opportunity lies in applying all legal, technical and scientific instruments that have been built, not just for adaptation and mitigation, but to include the concept of risk reduction based on ecosystems demonstrating the importance of restoring and conserving natural resources, not just for their use but as natural protective barriers in the face of hydro meteorological events of low to medium intensity.

Another key matter is that the majority of ecosystem restoration and risk management projects, as well as adaptation to and mitigation of climate change in the region, led by international organisations, seek and require accompaniment and community participation. Without such support, it would be impossible to execute the projects. The great opportunity in these projects lies in integrating not only local perspectives but also important matters such as natural resources, ecosystem services, economic activities, spatial planning, risk management, adaptation and mitigation of climate change, etc., from a holistic, not individual, approach.

While the methodology of Eco-DRR has not been fully implemented in the countries of the region directly, the constant action in policies and strategies for risk management, adaptation and mitigation of climate change, land management and regeneration of ecosystems, open up the opportunity for Eco-DRR to be included in the legislation of each country and at a regional level as a way to seek solutions to the physical and economic vulnerability of each country.

In conclusion, it is necessary to implement comprehensive solutions in the region to reduce the physical, economic and social vulnerability to extreme natural hazards, in such a way that the resilience and quality of life of people increases. These solutions must consider several elements, including environmental health, regeneration and recovery of ecosystems, community awareness of the importance of natural resources in their own livelihood, and the proper valuation of ecosystem services. This will promote the implementation of risk management policies. That is why Eco-DRR approaches emerges as a practical tool and a scientific support for addressing these integrated solutions.

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