

A dense tropical forest with tall, thin trees and lush green foliage, serving as the background for the text.

*Project*

*Tropical Forest and Climate  
Change Adaptation  
(TroFCCA)*

Climate, Climate Variability and Climate  
Change in Central America

Review of experiences, actors and needs in tropical forest  
climate change vulnerability and adaptation in Central  
America

Consultancy Report

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## **Climate, Climate Variability and Climate Change in relation with forest ecosystems in Central America.**

**Review of experiences, actors and needs in tropical forest climate change adaptation in Central America.**

### **Consultancy Report**

#### **1. Background**

Tropical Forest and Climate Change Adaptation: Criteria and Indicators for Adaptive Management for Reduced Vulnerability and Long-term Sustainability Project (TroFCCA), has as over all objective to promote adaptation of tropical forest to adverse effects of climate change through the assessment of impacts and the development of criteria and indicators for adaptive management for reduced vulnerability.

The project will be developed in selected pilot regions in South East Asia (Indonesia); West Africa (Burkina Faso, Mali, Ghana) and Central America (Costa Rica, Honduras y Nicaragua).

TroFCCA will focus on the evaluation of climate change impacts in tropical forest and forest dependent communities in the selected areas and the development of adaptive management strategies.

This Consultant Report is aimed to contribute with the conceptual development of TroFCCA's Central America (CA) component with information about the topics of climate variability, climate change detection, vulnerability assessment and actors, to support the identification of possible working areas, scale for the analysis and methodologies for the assessment of climate and climate change forest systems vulnerability and adaptation.

The objective is to provide an inventory of needs in the identification of climate change and climate variability, vulnerability analysis and adaptation options related with forest developed in the Central America, with particular focus on the TroFCCA-CA selected countries.

The Report focus on previous experience in climate change detection, vulnerability assessment and potential actors for climate change adaptation strategies and policies framework development.

Description of present climate variability in CA is presented as well as processes and on-going initiatives related with climate change assessment and identification of adaptation options.

Actors and lessons learned that could provide information for Global Climate Group (GCG) for the identification of platforms and mechanism for incidence in the Region are also suggested.

The report has particular focus on the TroFCCA CA selected countries (Costa Rica, Honduras y Nicaragua).

## 2. General Description of the Central American Region

A tropical isthmus connecting North and South America, Central America is located in the center of the American continent, between 8° 97 North and 17° 50' N. and 79° 53' W and 90° 55' W. It is strip of land of 553,000 Km<sup>2</sup> bounded by the Caribbean Sea at the East and the Pacific Ocean at the West. The land is rugged, and dominated by a string of volcanic mountain ranges, running Northwest-Southeast, that reaches elevations of 4220 m. (Tajumulco volcano, Guatemala). The mountain range divides the Region in two watersheds the Pacific and the Caribbean. Politically is divided in seven (7) countries: Belize, Costa Rica, El Salvador, Honduras, Nicaragua, and Panama; with 35 millions inhabitants and a growth rate of 2.4%, it shelters multicultural and multilingual societies.

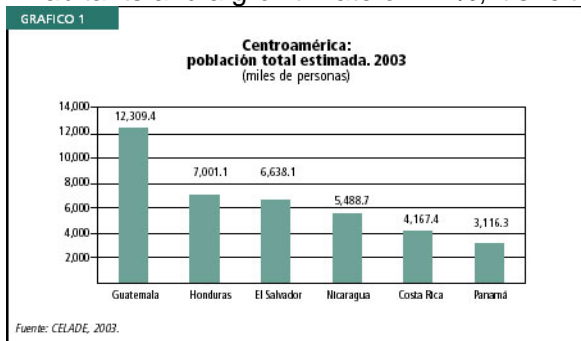


Fig.2.1. Central America Population distribution by country

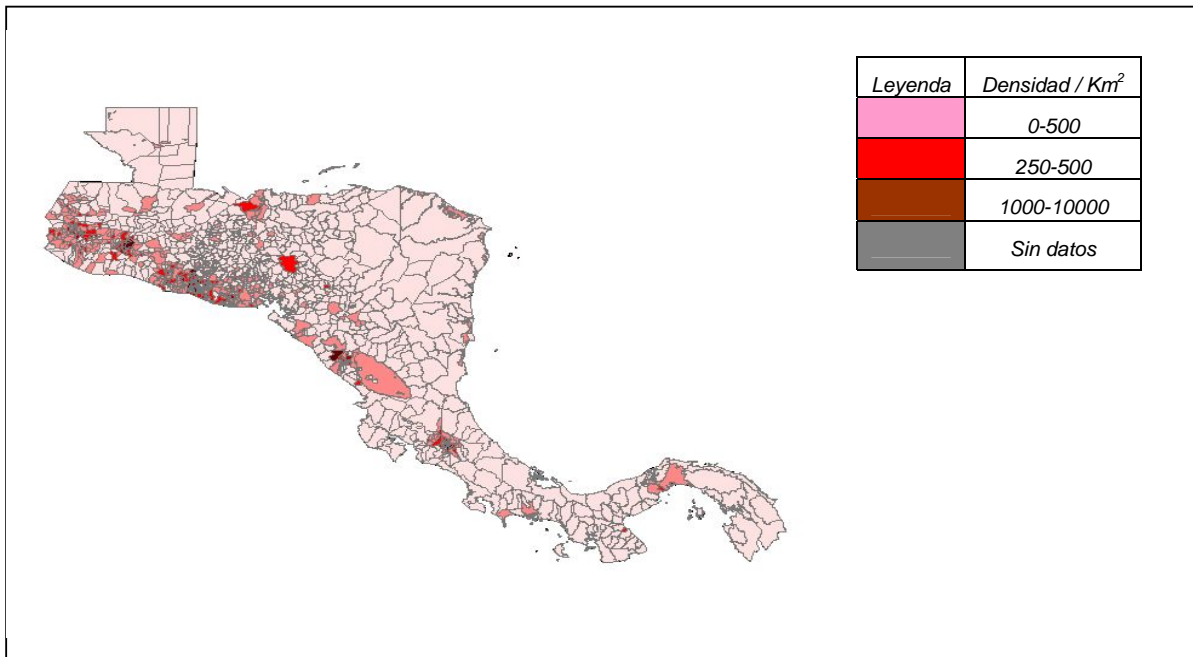
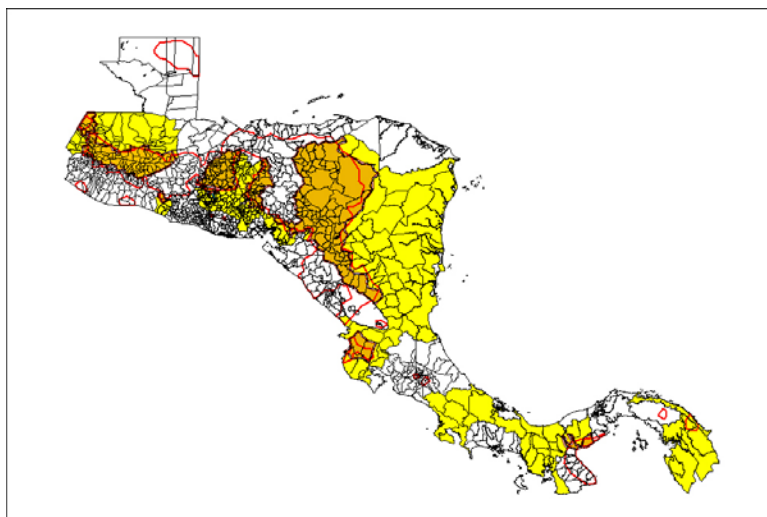


Fig. 2.2. Population density per km<sup>2</sup>, 1990-1999. Source: UNEP, 1999

*Per capita* GNI of CA countries varies in a range between USA \$410 and USA \$3570. About half of the Region's populations live in poverty. Poor population concentrates in areas prone to drought and floods and near the borders.

<b>País</b>	<b>(GNI/cap.) US\$</b>
Guatemala	1.680
Honduras	760
Belize	2.730
Nicaragua	410
El Salvador	1.920
Costa Rica	3.570
Panama	3.080
<b>Central America</b>	<b>2021.4</b>

*Table 2.1. Central American Countries. Gross National Income. Source: World Bank, 2001.*



*Fig.2.3. Municipalities with high poverty indexes and drought prone areas (red line). Source: Map of Municipalities from the Estado de la Región Report, modified by Berkel C. Approaches to a methodology for drought monitoring.*

*Technical Report for CRRH (2003). (Power point presentation).*

The Isthmus is characterized by its great biodiversity and large areas of humid tropical forest. Forest covers approximately 181 million hectares, 35% of its total territory (1996 estimate). Eight percent of the world's mangrove surface and the planet's second largest barrier reef form are found in the Region. Central America contains almost 12% of the Latin American and Caribbean coasts, including 567,000 thousand hectares of mangrove, 1,600 km of coral reef, and 237,000 km<sup>2</sup> of continental shelf. The coasts host almost 22% of the region's population and produce at least US\$750 million through fishing activities, directly provide work to 200,000 people, and are inhabited by at least 250,000 indigenous peoples who depend directly on their resources (CCAD, 1998).

It is estimated that 27% of the regional territory is over-utilized, 22% is underutilized, and 51% correctly utilized. Between 1990 and 1995 more than two million hectares of forest were lost. Deforestation has diverse and deep-rooted causes, ranging from cultural to economic patterns: the clearings made for agricultural activities and cattle raising, extraction of wood, use of firewood for cooking, and urbanization. For example, in 1996, 92% of the total wood production was used for firewood, and the remaining 8% was for industrial usage (CCAD, 1998). Land cover in the region is presented in Annex I.

Central America possesses plenty water resources with a mean of 31.064 m<sup>3</sup>/capita, these resources are contained in 120 major basins, 23 of them, representing 10.7% of the resource and equivalent to 40 % of the territory are share by two or more countries (CRRH, 2004).

País	Recurso Hídrico disponible per cápita m <sup>3</sup> /cap.	
Guatemala	12.121	
Honduras	15.211	
Belize	64.817	
Nicaragua	38.668	
El Salvador	2.876	
Costa Rica	31.318	
Panama	52.437	
<b>Central America</b>	<b>31.064</b>	
Brasil	32.256	= C.A.
Estados Unidos	8.906	29 % C.A.
Reino Unido	2.471	8 % C.A.
Suiza	7.427	24 % C.A.
Sudáfrica	1.187	4 % C.A.
Holanda	5.758	18 % C.A.
México	4.742	15 % C.A.

Table 2.2. Central America Water Capital Distribution Per country (Source: CRRH/SICA. 2003)

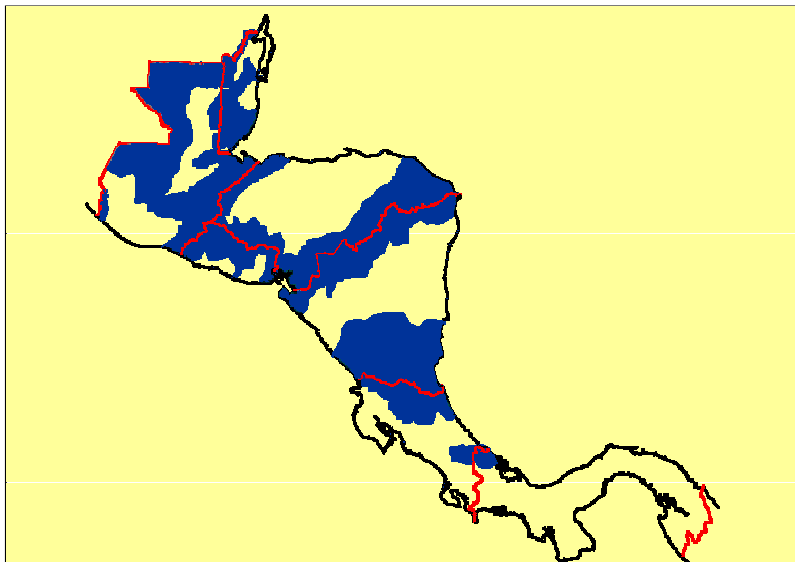


Fig 2.4. Central America Multinational basins (Source: CRRH/SICA).

The Region is extremely vulnerable to climate variability. It is estimated that in the period 1960 – 1999, hydro-meteorological events have caused the Region, 57.000 deaths, 30 billions US\$ in losses and the life conditions of 10 millions. According to ECLAC (1999), in 1997-1998, drought associated with El Niño-Southern Oscillation (ENSO) event and hurricane Mitch produced a 2.7% reduction in the Region's GNP.

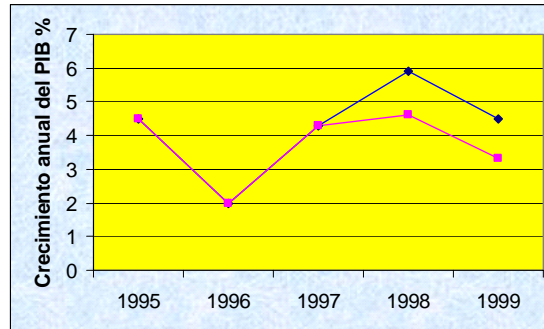


Fig.2.5. Central America Regional GNP in the period 1995-1999. (Source: Economic Commission for Latin America (ECLAC). 2000)

Because climate clear impact in economic and social welfare in the Region, need for assessments and adaptation is clearly recognized at highest political level; political concerns has been expressed in decisions of the CA Presidential Summits. In particular the XX Presidential Summit (Ciudad Guatemala, 1999), adopted the Strategic Framework for the reduction of physical, social, economic and environmental vulnerabilities to natural disasters, that includes a strategy focused in three areas: vulnerability reduction, integrated water management and prevention and control of forest fires. Vulnerability reduction strategy directs action to climate and climate change vulnerability reduction. Similar recognition was reflected in the decision of XXII Summit (San Jose, Costa Rica 2002), regarding Food Security Regional Strategy.

Climate change interest and concerns in the political agenda have been also expressed in the Central American Alliance for Sustainable Development (ALIDES) and the establishment of the Central American Commission for Climate Change (1994).

### 3. Climate in Central America

Central America is located in the tropical zone of the Americas within the Trade winds belt. Interaction between the Trade (Easterly) winds and Region's complex terrain; defines different rainfall regimes for the Caribbean basin (windward) and the Pacific basin (leeward). In the Caribbean side it rains almost all year, with one maximum in summer in the northern part (July an August) and two relative (July-August and December-January), in the southern part.

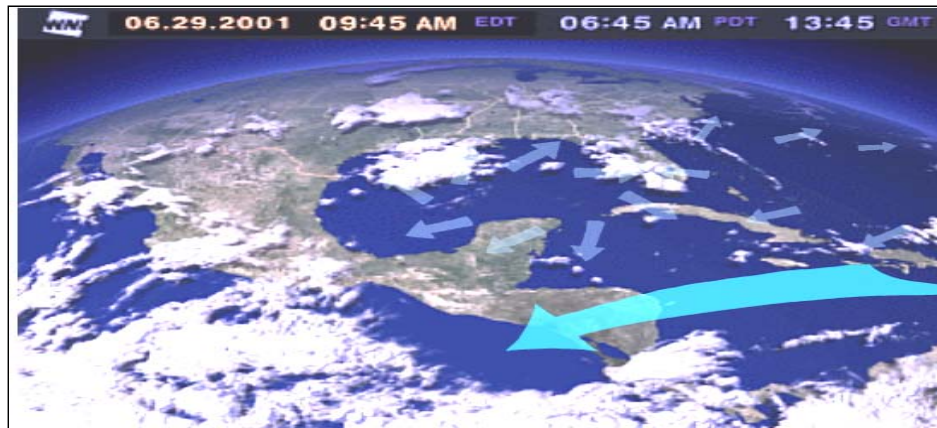


Fig.3.1. Predominant air flow over Central America. Source: Ramirez, P. y Brenes, A. 2001

In the Pacific basin annual cycle of precipitation is dominated by a dry season extending from November to April/May and a wet season lasting for the rest of the year, with maximums in June and September-October. The strengthening of the easterlies in July, that produces a maximum in precipitation in most of the Caribbean side of Central America and Southern Mexico, results in a marked Mid Summer Drought (MSD) in the Pacific side (Magaña *et al.*,1999).

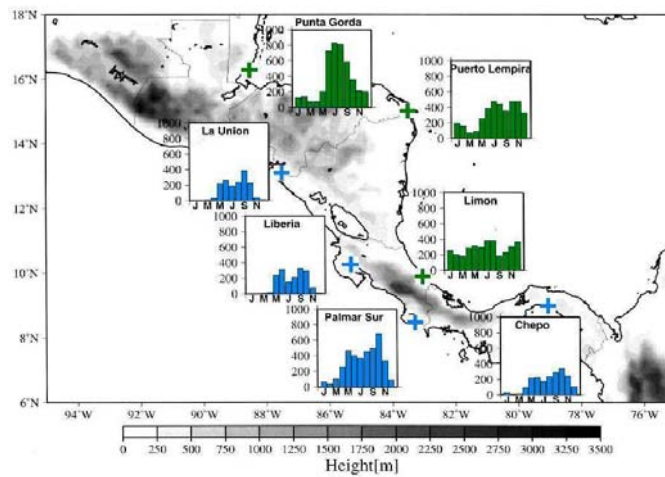
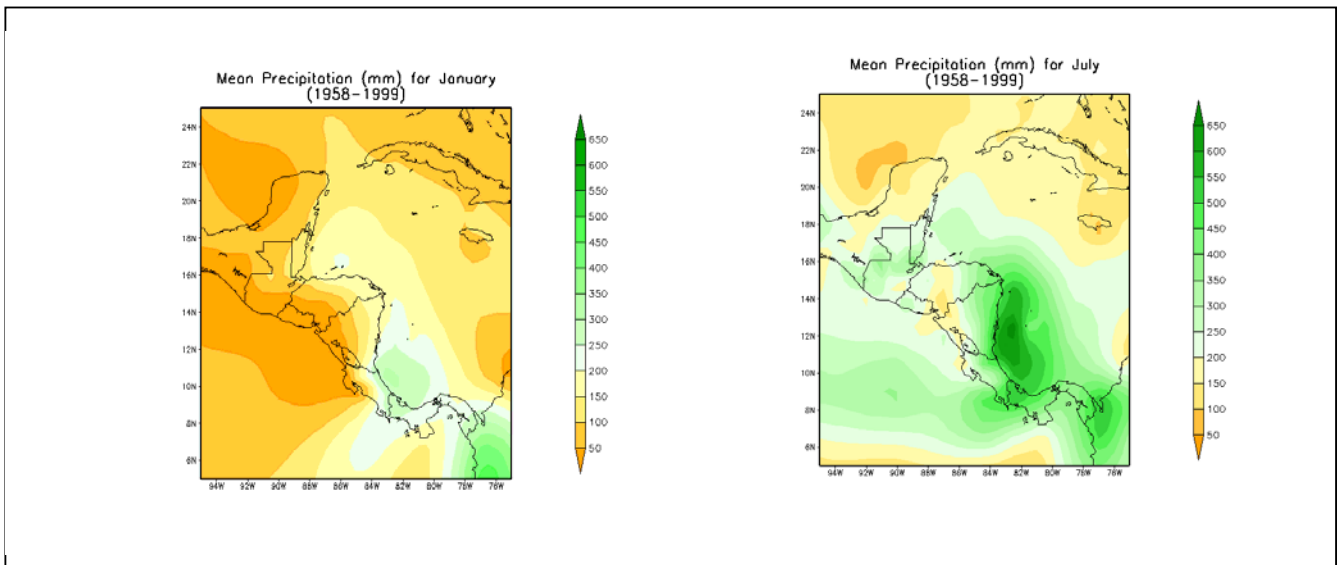


Fig.3.2. Monthly rainfall distribution in Central America. From: Magaña *et al* (1999)



*Fig.3.3. Seasonal differences in mean rainfall distribution over Central America  
From Magaña et al (1999)*

Strong seasonality in Central American climate could be observed in the January vs. July rainfall distribution showed in figure 3.3 above. Temperature regimes are strongly related to the described cycle of precipitation.

The temperature mean annual cycle in Central America presents a minimum during January mainly associated to strong trade winds and a maximum during April, before the summer rains, also associated with a decrease in magnitude of the trade winds (Portig,1976, cited by Alfaro, E. 2001). In the Caribbean side a second temperature minimum around July, associated with high values in cloud concurrent with the increase again of trade winds and the appearance of a low level jet over the region (Amador /et al./, 2000). In the Pacific side this is also the period of the Mid Summer Drought (Magaña, et al, 1999), in which a secondary minimum in cloud covertures is associated increase in temperature.

Daytime temperatures reach their maximum values before the onset of the rainy season and decreases towards January, due to the combination of radiative forcing and latent heat releases. Minimum temperatures show a different cycle, with maximum values in July when cloudiness associated to the rainy season reduces nighttime radiative cooling. The lowest minimum temperature values occur during the boreal winter although most locations, especially those located in the Pacific coast, experience a secondary minima in phase with the Mid Summer Drought.

The Central American air surface temperature shows homogenous variations in two important aspects: the annual cycle and the seasonal variations. Alfaro, E (2000) suggests that in general eastern Pacific (mainly) and Atlantic variability in both inter-annual and decadal scales, has a clear positive influence over the air surface temperature in Central America, in which warm (cold) SSTA events are correlated with warm (cold) air temperature anomalies events. This remote or local connection could be active through several processes like the modulation of the size and SSTs magnitude of

the warm pool near Central America or by inducing some anomalous troposphere patterns (e.g. PNA or wind shear).

Climate Variability is the cause frequent droughts and floods. Dry years in CA are associated with anomalies in atmosphere general circulation like those occurring during El Niño-Southern Oscillation (ENSO) events. In the last 50 years 9 events, extending between 12 and 36 months each, have impacted Central America causing drought in the Pacific Basin. Events with important economic and social consequences impacted Central America in 1926, 1945-46, 1956-57, 1965, 1972-73, 1982-83, 1992-94, 1997-98 (Ramírez, P. 1999). Cold SST in the Caribbean, and the Gulf of México seems to be associated with dry conditions that could also originate drought like the one the Region experimented in 2001 (Ramírez, P. and Brenes, A., 2002). Drought prone area is shown in figure 2.4.

Cold air masses from continental North American penetrating in the Caribbean, during the winter season produce intense rainfall that cause floods in Caribbean basin of CA, particularly in the Northern coast of Honduras, and easterly planes in Nicaragua, Costa Rica and Panama. During July and August Easterly Waves have the same effect. Hurricanes and tropical storms moving in the Caribbean in summer and fall produce the same effect in the Pacific Basin. Between May and October occasional intensification of Inter tropical Convergence (ITCZ) produces intense rainfall in both basins and almost the whole Region.

The Northern part of CA, more likely the northern coast of Honduras, and Belize, have higher probability of experiment direct impacts of hurricanes like strong wind, intense rainfall and sea surges. In the last four decades the Region experienced the impact of at least two major hurricanes affecting simultaneously two or three countries. Trajectories of disturbance with higher impact are presented in fig. 3.5.



A list of hydro meteorological events that have impacted the Region in this period is presented in Annex II.

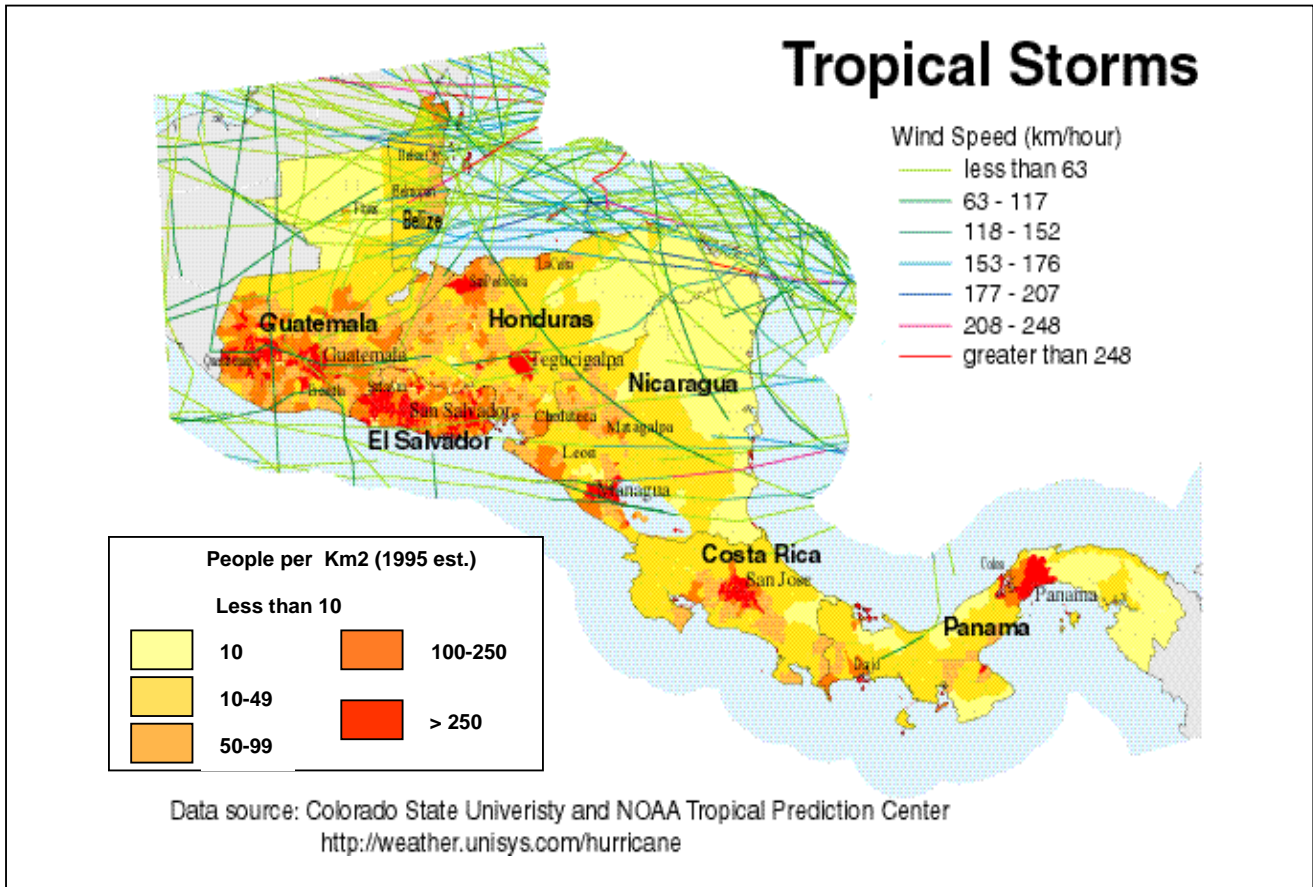


Fig. 3.5 . Tropical Disturbances with direct impacts in Central America

#### 4. Climate Variability in Central America

Climate in Central America shows its variability mainly in rainfall. It accuses high inter-annual variability; examples of this high - variability could be observed in figures 4.1 and 4.2 that show normalized annual rainfall anomalies for sites in Guatemala and Panama in the north and south ends of the Region. The sequences of dry and wet periods in the long term record is noticeable as it is the increased frequency of years with less than rainfall normal years in the last two decades.

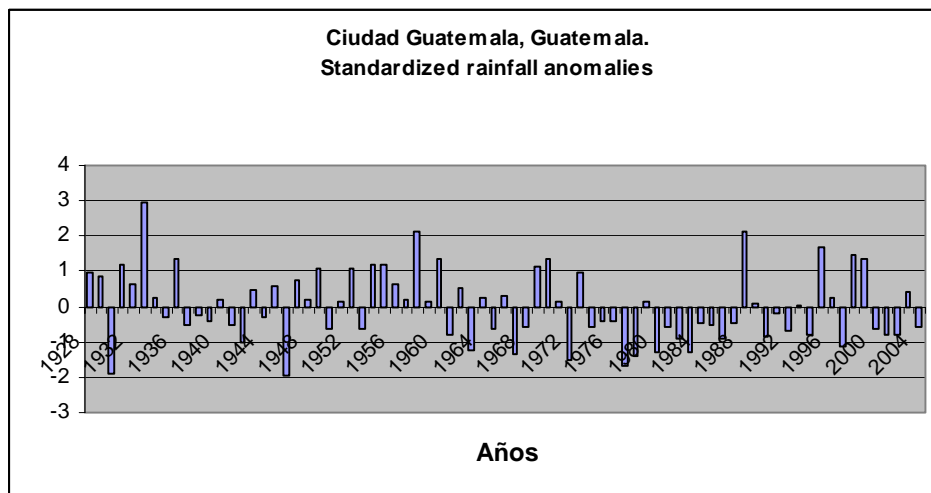


Figure 4.1. Standardized annual rainfall anomalies in Ciudad Guatemala, Guatemala. (Data from Instituto de Sismología, Vulcanología e Hidrología, INSIVUMEH)

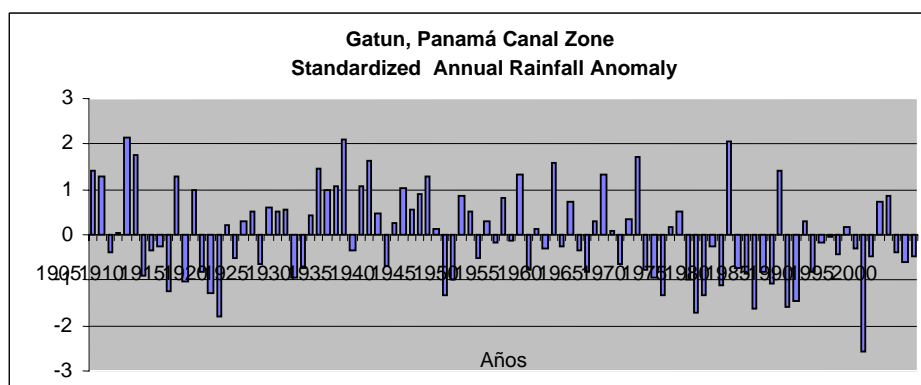


Figure 4.2. Standardized annual rainfall anomalies in Gatún, Panama Canal Zone. (Data from Panamá Canal Authority, Department of Meteorology)

It is recognized that climate fluctuations are the consequence of the combination of low-frequency variations, both intra-annual (less than a year) and inter-annual (more than a year) and decadal timescales that explains weather variations.

Climate in Central America results of the interaction of oscillations with different spatial and temporal scales, like the Pacific Decadal Oscillation (temporal scale of decades and more than 1000 Km. spatial scale) that combines with more frequent also large spatial scale variations like El Niño-La Niña Inter-annual cycles or intra-annual fluctuation like the Madden Julian Oscillations (MJO), main oscillation influencing weather in the tropics<sup>1</sup>

Delgadillo /et al. /(1999), showed that most of the climatic variations in Central America derive from the non-seasonal variations that accompany inter- annual and inter- decadal

<sup>1</sup> The MJO affects the entire tropical troposphere but is most evident in the Indian and western Pacific Oceans. The MJO involves variations in wind, sea surface temperature (SST), cloudiness, and rainfall.

changes in the Tropical Atlantic and Pacific Oceans and their interactions with the overlying troposphere.

Interaction between oscillation with different frequencies make climate forecast in the Region a complex matter, however even if dynamical forcing mechanisms for climate are not completely understood, in the last decade, the influences of some of these factors in defining rainfall variation in the Region has been object of increased research interest.

Research focused on factors influencing climate variability in the Region have produced pieces of evidence that are being used in the attempts to develop regional models or methods for climate forecast and GCMs outputs downscaling; inter alia:

- Strong climatic association, through teleconnection mechanisms, with the east equatorial Pacific (El Niño region, mainly) and tropical north Atlantic (TNA) reported by Enfield, 1996; Waylen, et al, 1996 and Alfaro, E. J, 2000.
- Tropical Atlantic sea surface temperature anomaly (SSTA) more strongly associated with rainfall over the Caribbean and Central America than is tropical eastern Pacific SSTA ( Enfield, D.B., and Alfaro, E. J., 1999),
- Response of air surface temperatures over Central America to oceanic surface changes (Alfaro, E. J, 2000).
- Effects of Trade winds easterly jet (Amador, J., 1998)
- Relation between additional latent and sensible heat transfer from the ocean to the atmosphere associated with bigger (smaller) size of the warm pool in the Central American Pacific side influencing positively (negatively) air surface temperature in almost all the region ( Alfaro, E. J. and Lizano, O., 2001).
- Evidence about cycles of around 35 years in cyclonic activity in the Atlantic ocean and the Caribbean (Goldenberg, S. B. *et al*, 2001).
- Above normal hurricane activity beginning with 1995, contrasting with the generally below-normal activity observed during the previous 25-year period (1970-1994) or during the 1950s and 1960s. (Goldenberg, S. B., *et al*. 2001)

Efforts to understand the patterns of climate variability on seasonal, decadal and longer time scales over the Region and steps toward their predictability are important contributions to the evaluation of present climate effects in ecosystems, and could provide useful information for interpretation and internal analysis of climate change models output in the generation of climate scenarios for TroFCCA.

## **5. Climate Change Evidence**

Evidence of positive trends in air surface temperature in the last decades was reported by Gomez, I. y Fernández, W. (1996) for sites in Costa Rica, later Alfaro, E.J. (2000) reported that trends in the last 30 years were in agreement with the global temperature pattern that supports the idea of global warming.

Exploratory analysis looking for evidences of trends in climate variables or changes in variability that could be associated with climate change in the Region was carried out by Amador, J.A., Mora, G., Rivera, E (2004). Their work compared changes in daily extreme temperatures mean and standard deviation between the sixties, seventies and eighties in Costa Rica and Honduras. Results showed that since a generalized positive trend could be found in minimum temperatures, trends in the maxima did not present homogeneous patterns between different geographical areas. Examples of the differences in the change of statistics between decades in two different observational points are presented in figure 5.1 and 5.2.

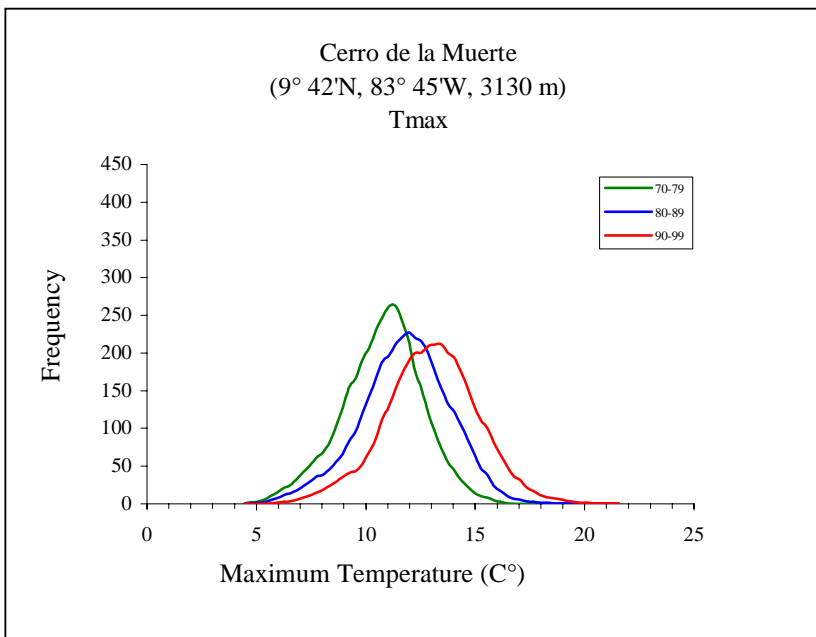


Figure 5.1. Frequency distribution of maximum temperatures in Cerro de la Muerte, Costa Rica, in the periods 1970-1979, 1980-1989 and 1990-1999. (From Amador J.A., Mora, G., Rivera, E .2004).

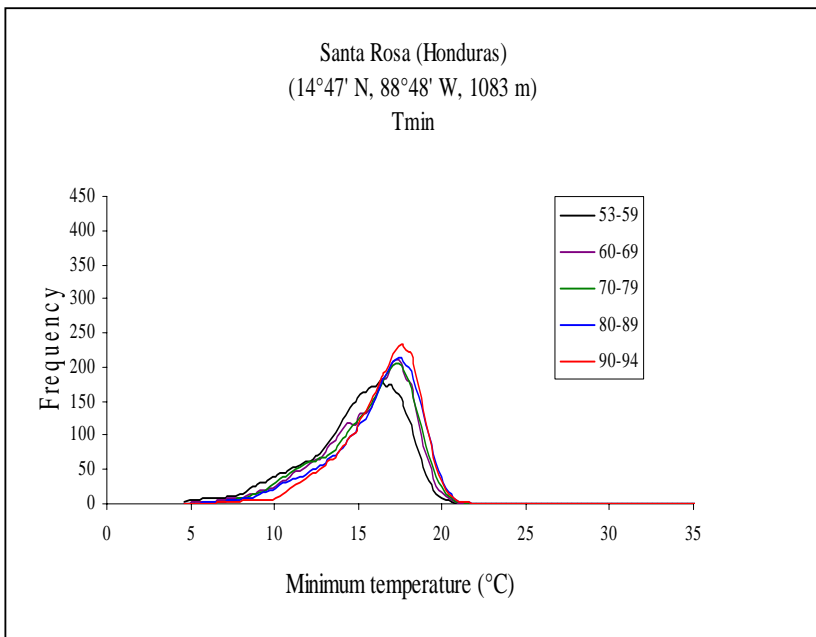


Figure 5.2. Frequency distribution of minimum temperatures in Santa Rosa de Copan , Honduras, in the periods 1953-59, 1960-69, 1970-79, 1980-89 and 1990-94. (from Amador, J.A., Mora, G., Rivera, E .2004)

Positive trends in mean annual temperature in the last three decades (1.1° C, 0.8° C, 0.7°C) were reported by Centella, A., L. Castillo y A. Aguilar, (1998), in time series in El Salvador with the eighties showing the higher positive anomaly.

Recent analysis of regional indices for the identification of climate change in Mesoamerica and Northern South America based in data series 1961-2003, concluded that the area is following a warming trend and that the annual percentage of warm days and nights has significantly increased by 2.5% and 1.7% per decade respectively; conversely the number of cold days and nights has decrease at a rate of -2.2% and -2.4%.(Fig 5.2). Changes are greater during summer and fall than during winter and spring (Aguilar E. *et al.* 2005).

Temperature extremes were found to have increased at significant rates of 0.2 C/decade for maximum temperature and 0.3 C/decade for minimum temperature , what means a positive trend of 0.1 °C/decade in diurnal temperature range.

Regarding rainfall, Centella, A., Castillo L. and Aguilar, A., (1998) found a decreasing trend of 0.38 mm/yr in the 1961- 1990 in data from El Salvador, however the trend proved to be statistically not significant. The trend in El Salvador rainfall seems to depend on the decrease in precipitation in the September-November quarter, then authors considered that, however small, could be of importance because of it happens in the quarter of major vegetation development. They also informed of rainfall series showing alternate drier than normal and wetter than normal periods.

Also Aguilar, E. *et al* 2005, reported that regionally averaged precipitation does not have a significant trend, though, a number of observation points clustered in the southwestern side of CA show a decrease trend. The amount of rainfall coming from extremes do show a significant positive trend of 18.1 mm/decade in extreme events (values over the 90 % percentile) and 10.3 mm/decade for very extreme events (values over 95% percentile). Rainfall amount in rainy days also shows an increasing trend at a rate of 0.3 mm/decade.

Same analysis for temperature indices showed a variety of changes in extreme values during the last 40 years in Central America and northern South America and changes in temperature with much higher degree of spatial coherence.

Trends and variability in daily ranges and extremes reported by Aguilar, E. *et al.* (2005) are the type of analysis that should be of interest for the assessment of impacts of changes in climate on forest ecosystems components.

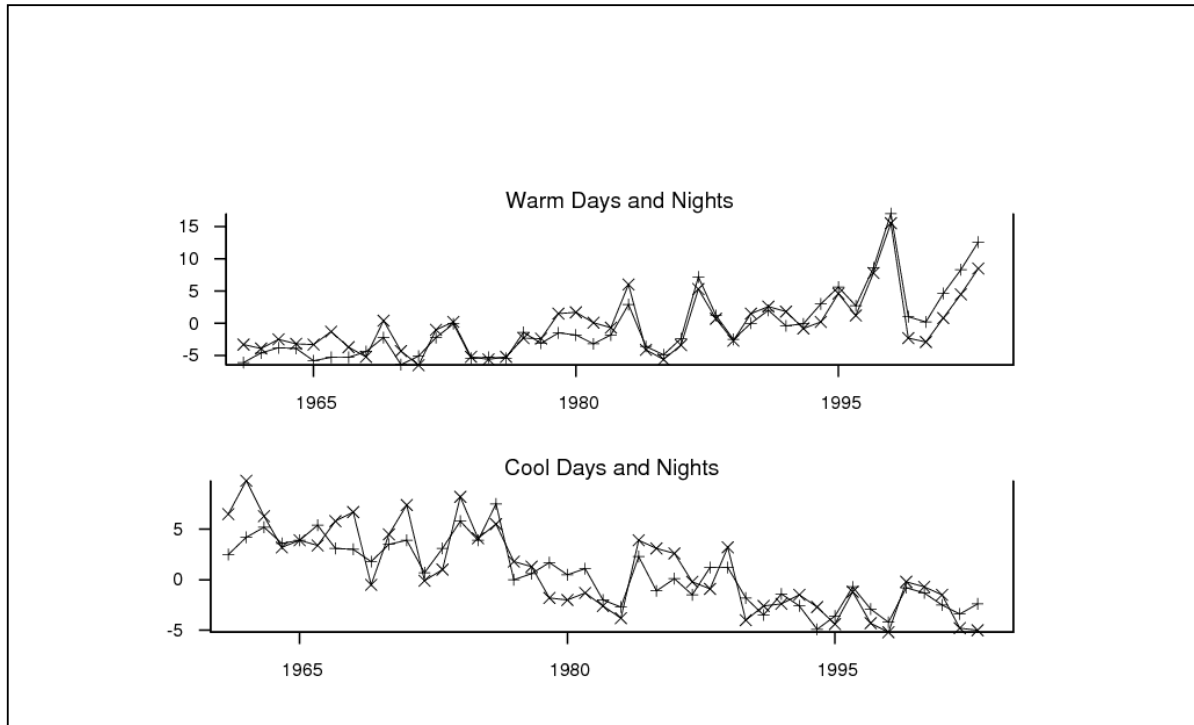


Fig 5.3. Regional trend in daily extreme temperatures over Mesoamerica and Northern South America (Aguilar et al, 2005)

Integrated analysis for time series data are able to reflect features of change but may mask subregional or site trends then, for TroFFCA CA estimations of climate change impacts on tropical forest systems need more detailed and *in-situ* estimations of changes in variables like daily ranges or frequency of extreme values, especially threshold values for species in the selected areas will be needed.

Several authors have considered the hypothesis that with warming of the SSTs, the tropical North Atlantic is entering a phase of enlargement and intensification of the cyclonic seasons due to increased evaporation off a warmer ocean leading to more water vapor available for precipitation, (Goldenberg et al., 2001). In a region impacted by easterly trade winds like Central America, warmer oceanic surface to the east could be expected to increase precipitation as the correlation between several indices and sea surface temperatures (SSTs) implies.

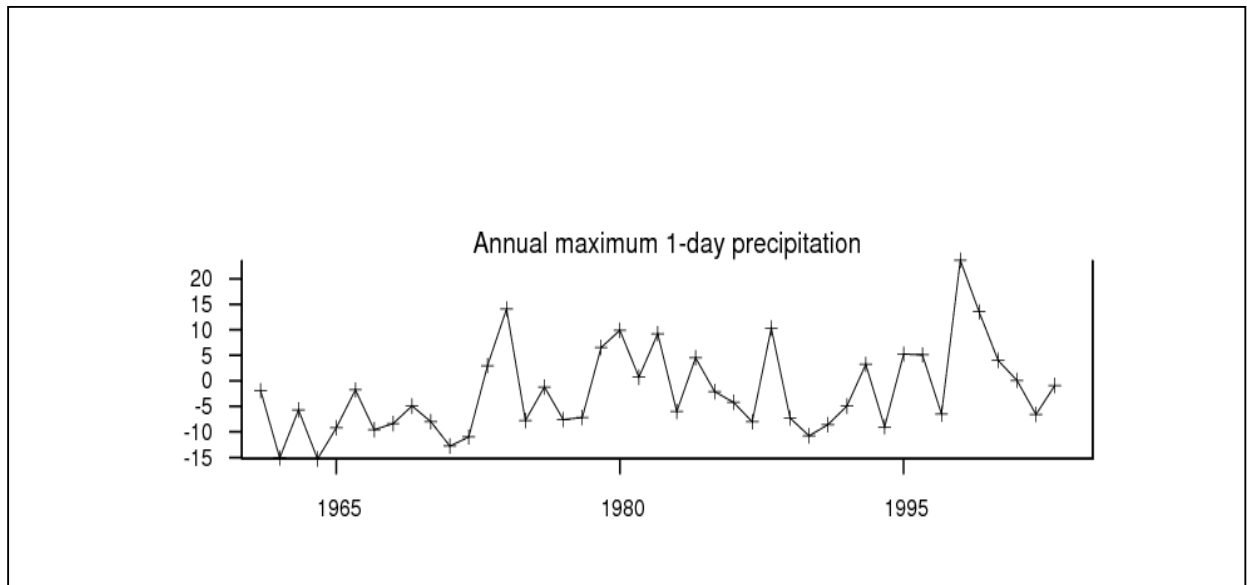


Figure 5.4. Regional annual anomalies (in mm) for to 1971-2000 for maximum one-day rainfall (RX1day) for 1961-2003. (From: Aguilar E., Peterson T.C, Ramírez P. et al, 2005)

## 6. Climate Change Assessments and Scenarios Previous Work

Central American countries signed the UNFCCC in Rica in 1992 ratified them accordingly. In compliance with article 4.1 of the Convention, countries with the support of international cooperation started climate change vulnerability assessments as previous work for the preparation of First National Communication to the UNFCCC CoP.

The first of such type of initiatives the Central America Climate Change Project developed by Comité Regional de Recursos Hídricos (CRRH) and Comisión Centroamericana de Ambiente y Desarrollo (CCAD), with the support of the US Country Studies Program, developed climate scenarios for CA as first step for vulnerability assessment.

Global Climate Models (GCMs) are tools to simulate the impact of atmospheric changes on future climates. They produce scenarios not predictions of future change. Some of the more used GCMs are ECHAM (Hamburg) Model, (Germany), HADCM2, (UK), and GFDL (USA), Canadian Climate Center Model (CCC).

In CA, sensibility of Canadian Climate Center Model (CCC), United Kingdom Meteorological Office Model (UKMO), United Kingdom Meteorological Office Model run 1989 (UK89), Goddard Institute for Space Studies (GISS), Geophysical Fluid Dynamics Laboratory (GFDL), Hadley Centre Models (HADCMGHG y HADCMGHS) were tested against local climate data to explore the their ability to catch Region's mean climate features.

The models performed well at simulating past and present patterns of climate at the global scale; however results were of much less use at the regional and local scales because of their coarse grid size.

Costa Rica, Honduras and Nicaragua with the support of other cooperation projects (The Netherlands Climate Change Project, Costa Rica National Meteorological Institute (IMN)/ Ministry for Environment and Energy (MINAE), Project PNUD-GEF Hon/97/G31/SERNA, Project PNUD-GEF-NIC/98/G31/MARENA, Nicaragua,) updated climate scenarios for their First National Communications using MAGICC and SCENGEN<sup>2</sup> so their results can be adjusted with local data to verify models performance.

SCENGEN uses these results, together with results from a set of coupled Atmosphere/Ocean General Circulation Models (AOGCMs) and detailed baseline climatology, to produce spatially-detailed information regarding future changes in temperature and precipitation, changes in their variability, and a range of other statistics. Outputs were obtained for IS-92a (optimistic), IS-92c (moderate) and IS-92d (pessimistic) GHGs emissions scenarios.

Best simulation of main climate features in the Region was obtained with Hadley's HADCMGHG y HADCMGHS HADCM2 "transient" model which was used to estimate climate conditions for 2010, 2030, 2070 and 2100 (Campos, M. 2000).

The model starts simulation with 323 ppmv atmospheric CO<sub>2</sub> concentration and assumes doubling by 2075. This models have 2.50° x 3.75° resolution, around 278 x 416 Km, then model output gives only 5 points for Central America (Figure 1).

Areas of TroFCCA countries included in each square are :

Region I -approximately Yucatan peninsula, Belize, North-eastern Guatemala and Northern Caribbean coast of Honduras), Region II – Western Caribbean coast of Honduras, Region III – Pacific side of Guatemala, El Salvador, Pacific basins of Nicaragua and Costa Rica and Region IV – Atlantic Autonomous Regions of Nicaragua, Northern Plains and Caribbean plains of Costa Rica - .

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<sup>2</sup> MAGICC and SCENGEN are coupled, user-friendly interactive software suites that allow users to investigate future climate change and its uncertainties at both the global-mean and regional levels. MAGICC carries through calculations at the global-mean level using the same upwelling-diffusion climate model that has been and is employed by the IPCC

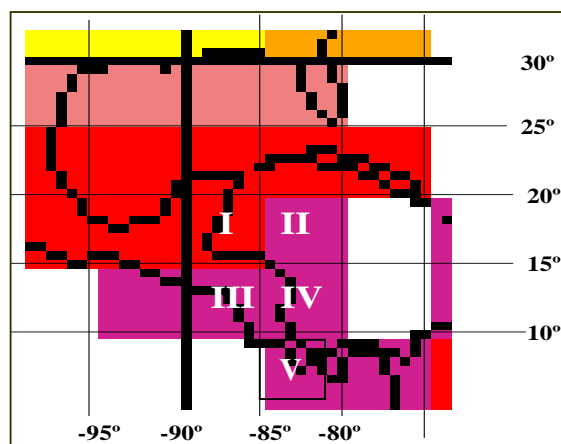


Figure 6.1: 5° x 5°, latitude - longitude squares including Central America for SCENGEN model runs. (Campos M. y Argueñal F, 2000)

Summary of estimations of mean annual temperature and rainfall for the three countries and the four time horizons are presented in Table 6.1.

Escenario climático	Pesimista										Optimista										Horizonte de tiempo	
	Precipitación (%)					Temperatura (C)					Precipitación (%)					Temperatura (C)						Año
	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V		
Costa Rica			-12.1	-11.8	-3.8			1.2	1.2	1.1			-10.0	-9.8	-3.1			1.0	0.9	0.9	2030	
			-18.5	-18.1	-5.8			1.9	1.7	1.8			-13.7	-13.4	-4.3			1.4	1.2	1.3	2050	
			-33.9	-33.1	-10.5			3.4	3.0	3.2			-18.2	-17.8	-5.7			1.8	1.6	1.7	2100	
Nicaragua			-14.5	-14.1				1.5	1.3				-12.4	-12.1				1.3	1.1		2030	
			-21.0	-20.5				2.1	1.9				-16.2	-15.8				1.6	1.5		2050	
			-36.6	-35.7				3.7	3.3				-21.0	-20.5				2.1	1.9		2100	
Honduras	-11.8	-11.2	-14.5	-14.1		1.3	1.0	1.5	1.3		-10.1	-9.6	-12.4	-12.1		1.1	0.9	1.3	1.1		2030	
	-17.1	-16.3	-21.0	-20.5		1.9	1.5	2.1	1.9		-13.2	-12.6	-16.2	-15.8		1.5	1.2	1.6	1.5		2050	
	-29.8	-28.4	-36.6	-35.7		3.3	2.7	3.7	3.3		-17.1	-16.3	-21.0	-20.5		1.9	1.5	2.1	1.9		2100	

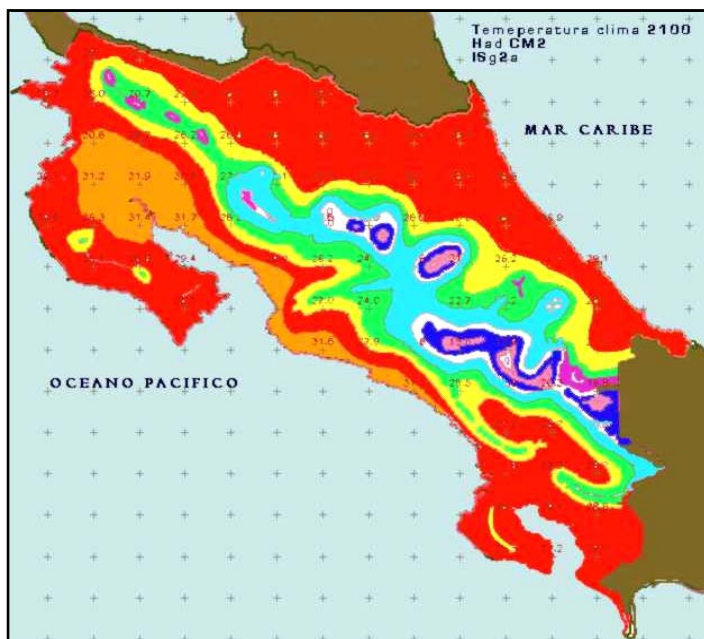
Table 6.1: Changes in annual mean precipitation and temperature for the four regions under pessimistic and optimist scenarios for time horizons 2030, 2050 y 2100 (Results are differences from baseline climatology 1961-1990) Campos, M. s.f.

Results from climate scenarios obtained are summarized in National Communications as follow:

In Costa Rica, under the IS92a scenario for the year 2100, the results show a small increase in precipitation for the southeastern Caribbean region and an important decrease—close to 25%—in the northwestern Pacific region area that already experiences water problems as a result of El Niño and an increasing demand from infrastructure for tourism and irrigation. Under the same climate scenario, mean temperature in Costa Rica is expected to rise by more than 3°C by 2100. Tendencies in actual climate series (1957-1997) show already an increase of 0.4°C every 10 years for

the Central Valley area. This last estimation however may reflect signals other than the one related to climate change (MINAE-IMN, 2000).

For Nicaragua under the IS92a emissions scenario, mean temperature for the Pacific watershed would be expected to rise, ranging from 0.9 for the year 2010 to 3.7°C for the year 2100, and precipitation would decrease by 8.4% for the year 2010 and 36.6% for the year 2100. For the Caribbean watershed, mean temperature would increase, ranging from 0.8°C for the year 2010 to 3.3°C for the year 2100, and precipitation would decrease in a range between 8.2% for the year 2010 and 35.7% for the year 2100 (MARENA, 2000). Suggestion is made that this will imply an additional pressure on productivity sectors and human activities.



*Fig.6.2. Costa Rica mean temperature for year 2100 based on model HADCM2 and IS-92a scenario. The Netherlands Climate Change Project. Costa Rica National Meteorological Institute (IMN)/ Ministry for Environment and Energy (MINAE)*

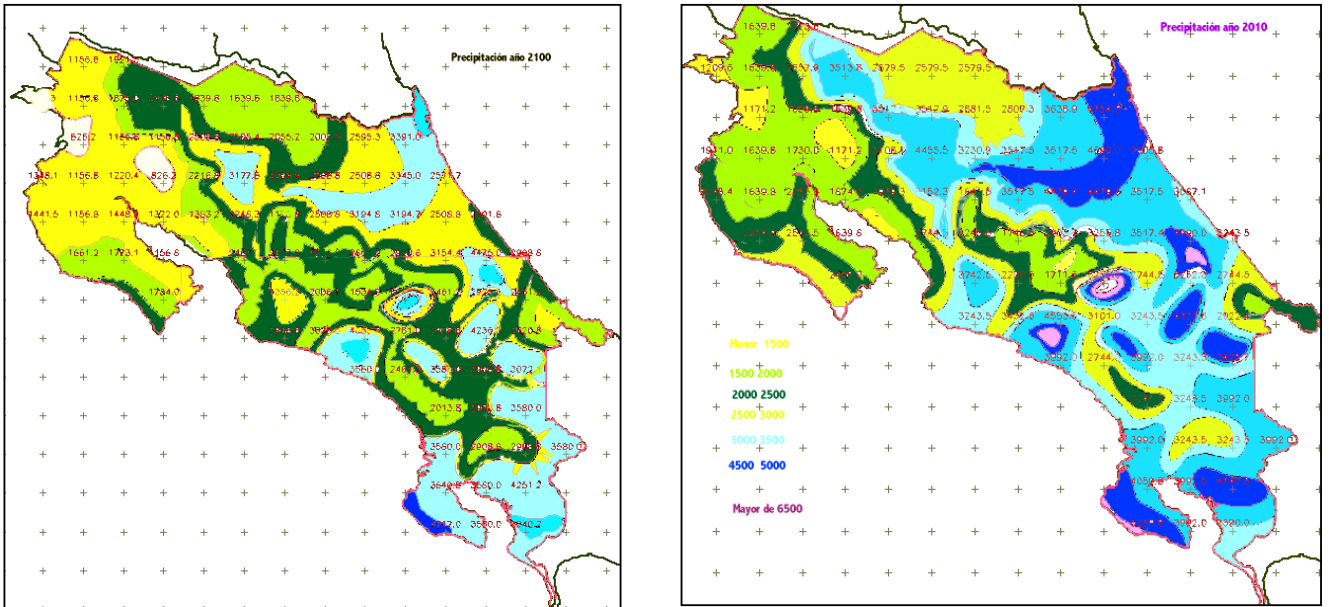


Fig. 6.3 .Costa Rica, mean annual rainfall for year 2100 and 2100 based on model HADCM2 and IS-92a scenario. The Netherlands Climate Change Project. Costa Rica National Meteorological Institute (IMN)/ Ministry for Environment and Energy (MINAE)

Results of climate simulations for Honduras show increase in mean temperature and decrease in precipitation for the whole country with lesser changes in the area included in region II (Caribbean coast) and higher in region III (Central and Pacific side approximately). With the pessimistic scenario, rainfall changes range between 11.2 % in region II to 14.5% in region III by 2030 and between – 28.4 % and -36.6% by 2100 in the same regions. Temperature increases are estimated in a range of between +1.0° C. in region II and +3.7 in region by 2030 and between +2.7° C and +3.7 ° C by 2100.

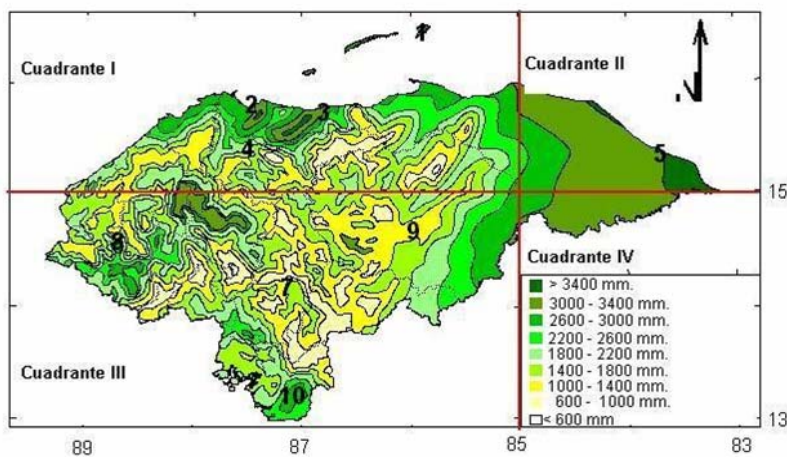


Fig.6.4. Annual mean rainfall estimated for 2030 in Honduras under IS-92-a pessimistic scenario. (Source:SERNA, 1995).

Optimistic estimations for changes in precipitation varies between -9.6% in region II and -12.4% in region III by 2030 and between -28.4 and -36.6% by 2100 in the same regions. Temperature changes estimated with this scenario varies between +1.5° C and +2.1° C.

All changes are referred to precipitation and temperature means obtained from the 1961-1990 period.

The HADCMGHG model coarse resolution resulted inadequate for the small dimensions of the countries and therefore unable to capture sub-regional differences in climate or singularities induced by its complex topography. Since no better tools were available at the time, those results were used for vulnerability assessment for First National Communications.

Most recently the Assessment of Impacts and Adaptation to Climate Change (AIACC) regional project for Central America up-dated the climate change scenarios for Central America.

Scenarios were developed using the same methodology as Viner y Hulme (1992) and Centella *et al* (1998a). This method combines the results of global emissions models to produce inputs for GCMs under the different assumptions of GHG emissions or climate sensibility.

The process involved: definition of global GHG/aerosols emissions scenario, ii) development of climate reference scenario (baseline climatology), iii) transformation of GHG emissions into projected global warming and sea level rise, iv) selection of best GCM and v) combination of global projections with regional climate patterns.

From the 40 possible GHG emissions scenarios proposed by IPCC (2000), **A2-ASF** (pessimistic) y **B2-MESSAGE** (moderate) were chosen as those more able to reflect the regional circumstances and possible evolution of emission driven forces: demography, development and technology (Echeverría, J., 2004)

1961- 1990 period was used as reference period for baseline climatology (1961-1990 is compatible with WMO and IPCC norms). Reference climatology was constructed with data obtained from CRN073-IAI Project compiled by Centro de Ciencias de la Atmósfera de la Universidad Autónoma de México (UNAM). This data base contains monthly temperature and monthly total rainfall in the period 1958-1999 interpolated in a 0.5°(30 minutes) x 0.5°(30 minutes) latitude x longitud grid.

Emissions/concentrations profiles and changes in temperature and mean sea level were also calculated with **MAGICC**<sup>3</sup> using **A2-ASF** y **B2-MESSAGE** as reference.

Results with MAGICC produced an estimation of +1.5°C (A2 y B2) by 2050 and between +2.6°C(B2) and 3.6°C(A2) by 2100 (compared with 1976 values). Sea level rise was estimated in 18 cm by 2050 and between 37cm (A2) and 44 cm (B2) by year 2100.

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<sup>3</sup> MAGICC (Model for the Assessment of Greenhouse-gas Induced Climate Change), is a computer programme develop in Climate Research Unit of the University of East Anglia, United Kingdom described by Wigley (1994).

Through validation with the reference data set (**CCC1TR, CSI2TR, ECH4TR, GISSTR, HAD2TR**) 5 out of 17 SCENGEN<sup>4</sup> models were selected as the ones showing higher correlation, less square mean errors and less differences with respect to reference rainfall and temperature climatology. HAD2TR showed the best performance for each criteria but following the recommendations of Hulme *et al.*(2000), ensemble of the 5 was taken.

Assuming that changes forecasted will distribute homogeneously over each pixel area, SCENGEN outputs were downscaled using the reference climatology in four points representing North and South Central America (Tela-Honduras; Papalón-El Salvador; Palmar-Costa Rica; Limón-Costa Rica).

Detailed explanation of the complete process developed is presented in Alvarado, L. F. (2005).

Results from this work showed less change in temperature and rainfall obtained with this new simulation than those obtained with IS-92a, IS-92c, IS-92d, and HADCM2 model (Campos, 1998) based in more pessimistic emissions scenarios.

Table 6.2 compares the results from “more pessimistic” scenario reported by Campos and Arguena, 1998 and the latest reported by Alvarado L. F. (2005).

Time Horizons	TMP (°C)			PCP (%)		
	C98	A05	A05-H2	C98	A05	A05-H2
2010	0.8	0.3	0.4	-6.9	-1.2	-2.1
2030	1.3	0.8	0.9	-11.8	-2.8	-4.9
2050	1.9	1.3	1.5	-17.1	-4.4	-7.7
2100	3.3	3.3	2.7	-29.8	-11.5	-20.1

*Table 6.2. Comparison of climate changes under “more pessimistic” (annual means) estimated for Northern Central America obtained with three different approaches C98: Campos(1998); A05: Models ensemble Alvarado L.F. (2005) and A05-H2: with Had2tr95 (Alvarado L. F. (2005). From Alvarado L.F. (2005).*

In the table it could be noticed the significant difference between the 1998 temperature change estimations and the ones obtained with more elaborated methodology in 2005, showing an apparently over-estimation in the previous scenarios. Also a 20 years lag between 1998 estimations and 2005 for the first decades but a tendency of results to converge towards 2100.

In the case of precipitation, differences are bigger and 2005 estimate resulted less pessimistic than 1998's. Alvarado attributes the differences to the update of algorithms and parameters in the MAGICC/SCENGEN models combined with the selection of new emissions scenarios.

The magnitude of the changes are smaller than those of the 1998 simulation, therefore it is concluded that C98 is more pessimistic than “moderate” **A05-H2**, and “**optimistic**” **A05** (Alvarado, L. 2005)

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<sup>4</sup>

Combining the projected annual changes with climatology, monthly and spatial patterns of rainfall were also estimated for the same areas.

The work described above is the more detailed estimation of future climate performed in the Region to the date, and could provide a good platform for natural systems vulnerability assessments, however the problem of spatial resolution for detailed analysis of natural systems persists.

In an attempt to overcome the resolution limitation of results obtained with HADGCMs, experiments with PRECIS (**P**roviding **R**egional **C**limates for **I**mpact **S**tudies)<sup>5</sup> is being carried out at Instituto Meteorológico Nacional (IMN) in Costa Rica as part of UNDP Adaptation for Climate Change, Phase II Regional Project.

Simulation with the model covers Mesoamerica and the oceans around it. The model was run to simulate climate evolution between 2070 to 2100, using SRES A2 scenario. The experiment showed that PRECIS model simulates appropriately inter-annual changes in rainfall and spatial pattern over Central America. Comparison of outputs obtained for October 1983 showed that the model is also able to simulate current climate features.

PRECIS output reflects better intra regional differences in climate patterns, making it more useful to generate future climate scenarios for vulnerability assessment. Currently work is being done with the Hadley Center to obtain transient scenarios for 2010, 2020, 2030 and 2050 (Jorge Barrantes, IMN, personal communication). An example of PRECIS 6 hours rainfall intensity and temperature outputs with a resolution of 40 Km x 40 Km for Central America is presented in ANNEX IV.

Other experiment with PRECIS run by Mark Mulligan (s.f.), over an area that included Mesoamerica (Mexico to Colombia), estimated temperature and precipitation changes. Summary of mean differences for temperature and monthly rainfall totals in 2050 compared with 1990 for each Central American country are presented in Table 6.3.

Country	Changes in mean temperature (°C)	Rainfall difference (mm/month)	General scenario
Costa Rica	1.08	13.33	Least warming, strong drying
Guatemala	1.13	- 3.72	Little warming, least drying
Honduras	1.28	-0.61	Strong warming, little drying
Nicaragua	1.36	-8.20	Strong warming and drying
Panama	1.08	-13.33	Little warming, least drying

Table 6.3. Summary of estimations made with PRECIS for Central America (from Mulligan, M., 2005).

<sup>5</sup> PRECIS stands by Providing Regional Climates for Impact Studies It is a climate model developed by Hadley Centre in UK that run in PCs.

## 7. Options for TroFCCA

Climate change is, for the most part, projected to add to existing, rather than create new problems. Of particular concern are the problems of malaria, hunger, water shortage, coastal flooding, and threats to biodiversity (Parry and Livermore, 1999; Parry et al., 2001; Arnell et al., 2002; King, 2004 in Goklany, I, M., 2005).

According to the project document submitted to EC the overall TroFCCA objective is “to promote adaptation of tropical forests to adverse effect of climate change”. The project document states that Central America Region will focus on the vulnerability of forest to flooding and droughts.

A simplified framework of the TROFCCA project derived for Central America by the project team from the project document is shown in the following figure 7.1

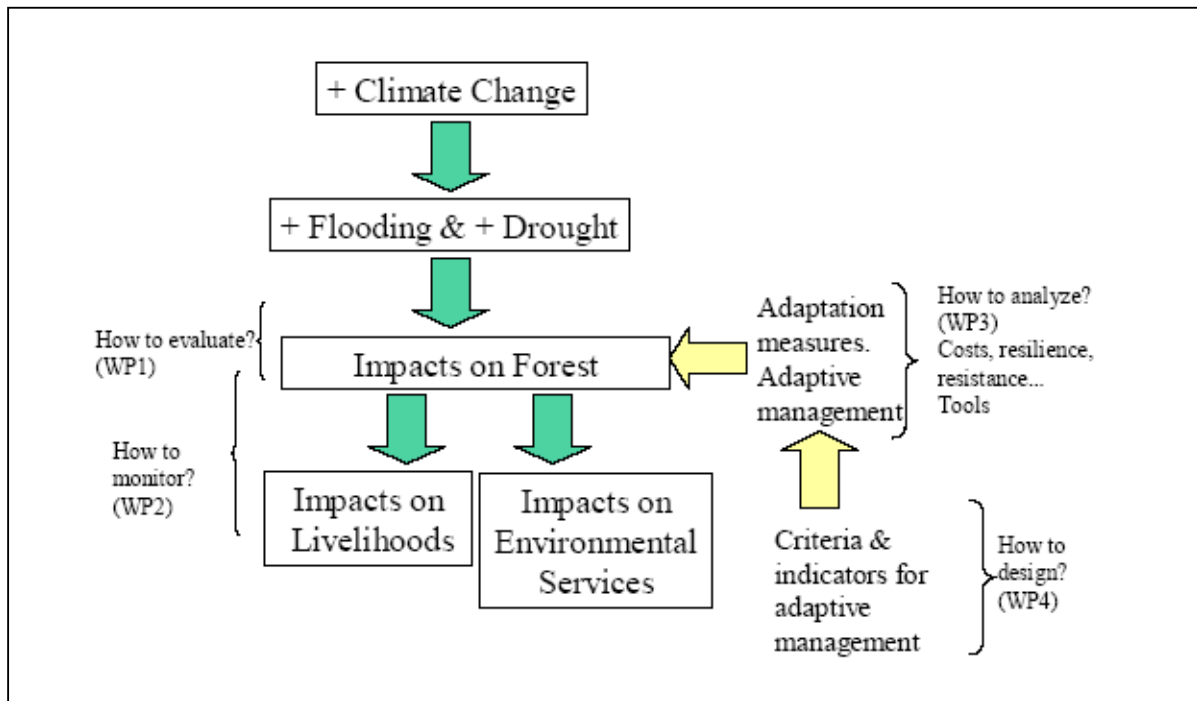


Fig. 7.1. Framework for TroFFCA.

From: Tropical Forest and Adaptation Climate Change-TROFCCA, CIFOR-CATIE EU project.. Report of the Preliminary Meeting held at CATIE on August 8-9

In order to include the very important and relevant role of forest for developing societies and economies, asses climate change and climate variability threats to forest compared to threats and promote a policy relevant dialogue about adaptation, TroFCCA CA team proposes a systemic approach, dealing with all landscape components, all society sectors, and their interactions. To follow this approach the group defined 12 steps.

1. Interest of society (sectors and development policies)

2. Goods and environmental services (G/S) important for previous point
3. Ecosystem functions that produce the G/S mentioned in previous point
4. Parameters of forest ecosystems responsible for the ecosystem functions mentioned in previous point
5. Climatic parameters that may influence the parameters mentioned in previous point
6. Selection of case studies and specification of 2 last points
7. Climate scenarios
8. Impacts of future climate on the ecosystem functions that produce the relevant G/S (point 3 =f(point 7))
9. Impacts of future ecosystem functions on relevant G/S point 2=f(point 8))
10. Vulnerability of the priority sectors defined in point 1 (point 1 = f(point 9))
11. Interest of society for reducing vulnerability defined in previous point
12. Adaptation

(Locatelli, B y Vignola R., 2005)

Options for climate analysis, scenarios, monitoring, data needs and actors for approach based in the mentioned steps follows:

#### 7.1 Interest of society (steps 1 and 2)

Relevant for TroFCCA CA identification of society priorities are the decisions of XX Presidential Summit (Ciudad Guatemala, 1999) that adopted the Strategic Framework for the reduction of physical, social, economic and environmental vulnerabilities to natural disasters. The Framework assumes the implementation of plans to be developed at regional and national levels in three areas: vulnerability reduction, integrated water management and prevention and control of forest fires. The Framework demands that plans are designed and coordinated at regional level with the support of Regional Integration Agencies, but executed by national agencies responsible for corresponding work areas.

Policy priorities for environment and development is also expressed the Mesoamerican Agenda for Sustainable Development (ALIDES), which objective is the promotion of actions for economic growth, poverty reduction, and environment sustainability.

Guidance for the assessment of society interest, sectors and development policies related referent to forest may be obtained from Central American Forestry Strategy (CAFS) prepared in 2001 by CCAD with the cooperation of United Nations Development Program (UNDP), Food and Agriculture Organization (FAO) International Union for Nature Conservancy (IUNC) and the Plan the Action Forestal (PAF) that is a consensus agenda for the development of policies, institutional changes, and consultancy fora with NGOs (Jorge Rodriguez CCAD-UICN, personal communication, July 2005).

Regional Policies Frameworks in forest services related issues like, forest conservation and management, water services or food security may be also found in the Regional Water Plan (PACADHIR), the Regional Strategy for Food Security, and the Regional Plan for Reduction of Vulnerability to Natural Disasters, that are the result of ample consultations with stake holders and actors in the field.

## 7.2 Climate Data for TroFCCA (step 5)

Improved knowledge about climate variability, intensity and frequency of events, or threshold values facilitates the identification of climate impacts and adaptive measures. Analysis of climate variability in relation with forest ecosystems or on the factors that disturb forest will require further analysis of climate variables to verify or establish those relations.

Within TroFCCA CA tasks, those oriented to advance the knowledge and the gathering of new information, likely to improve the understanding about how forest systems in the selected areas are impacted by climate, and how climate affects other forest disturbance factors need to be included in the planning.

Monitoring programs and analytical tools needed to develop this understanding should include *in-situ* climate monitoring of relevant climate variables which values could be further associated with data from standard observations networks for the extrapolation of findings or results.

Climate analysis in the Region faces long term data series limitations. Number of climate observations have change in the last decades as consequence of the periods of social and economical instability the Region went through.

Efforts made in the last years by IAI Cooperation Network Program CRN-73, produced a quality controlled in a 0.5 degree by 0.5 degree of latitude/longitude grid (0.5° x 0.5°) data base over Mesoamérica for the period 1958- 1998 that is available to researchers. Available in the web is also the data gathered by Johnson et al, for the period 1950-1999, covering area from southern Mexico to Panama compiled by Johnson et al (2003) that could be accessed at [http://climate.geog.udel.edu/~climate/html\\_pages/Tropics\\_files/README.tropic\\_precip\\_clim.html](http://climate.geog.udel.edu/~climate/html_pages/Tropics_files/README.tropic_precip_clim.html)

Scenarios improvement and GCM outputs downscaling could benefit from these resources.

More detailed data in the selected work areas will be needed to establish relations between climate and forest elements or disturbance factors. Daily data and in some points, hourly data is available in the NMHs in the three countries. Data for research can be obtained without cost under research collaboration agreements with the institutions.

Observation points in forest areas are scarce then the project should consider investment in equipment for climate monitoring. Cost of this investment could not be estimated since the type of research or assessment to be developed has not been established either the number of observation point fixed.

The selection of areas to work will depend on the results of the consultation to identify society interest and priorities regarding G/S that are provided by forest, but, to the extent they provide the conditions for testing of hypothesis or research assigned in the work plan, the basins included in the Capacity Building for Adaptation Phase II Project, (Aguan River in Honduras, Tamarindo River in Nicaragua and northern slopes of the

Central Valley in Costa Rica ) could be consider, because the mentioned project will generate information about present conditions, current vulnerability, actors and group of interest that will help to establish the baseline for TroFFCA CA analysis of impacts.

Satellite rainfall estimations from different sources are available in internet; but for Central America and the Caribbean area, satellite estimations have not been completely calibrated and significant differences with real values are common depending of the cloud types associated with different type of meteorological phenomena; because of that, possible use of this sources will demand resources for monitoring and calibration of satellite data with *in-situ* observation during the initial period of work.

### **7.3 Actors**

TroFFCA CA activities will need to involve actors at regional and national level in the areas of climate, forest, policy design and implementation and research. Some of the actors at regional and national level that may play a role in the development of TroFFCA activities are listed below:

#### **7.3.1. Climate variability and climate change monitoring and assessment**

A wide range of institutions in the region are involved in climate monitoring, climate variability analysis and the development of climate change studies, however with different level of effort; between them. To collaborate or create synergies with, TroFFCA CA may consider the following actors:

Data, climate and climate change evaluation and monitoring:

National Meteorological Services (NMHS) in the 3 countries are involved in climate monitoring and climate change studies. Instituto Meteorológico Nacional (IMN) in Costa Rica is assigned with the responsibility of the National Climate Data Base. It has also de human and technical capacities for climate models products interpretation and assessment.

IMN has started the process for the preparation of country's Second National Communication to UNFCCC CoP. Consultation of sectors to be included for vulnerability assessment and identification of adaptation options is under development. In parallel it is carrying-out the Costa Rica's component of GEF-UNDP "Capacity Building for Stage II Adaptation in Central America, Mexico and Cuba". In the project Costa Rica prioritized the vulnerability analysis of water resources. The analysis focused in a pilot area in country's Central Valley, the mostly dense populated area of the country. It has develop its own methodology for risk assessment for water resources based on 15 demographic, housing, poverty, and land condition and hazard indicators.

In Honduras climate monitoring and forecast is the responsibility of the Servicio Meteorológico Nacional (SMN) that belongs to the Civil Aviation Authority. It runs basic climate observation network since SERNA's Division for Water Resources manages a real time rainfall observation network (23 telemetry hydrological stations), that constitutes country's best resource for climate monitoring for watershed management.

Capacities for climate vulnerability studies, particularly to sea level rise have been created in the Biology Department at the Universidad Nacional Autónoma de Honduras,

with the USA/EPA Country Studies Program. The UNAH group contributed with the analysis of sea level rise risk that was included in Honduras First National Communication. Leader person Dr. Mirna Marin is an expert as well as experienced negotiator in international climate change fora. The group could be a party to consider for risk assessment of coral reefs or coastal ecosystems for analysis of insurance as adaptation option

Capacities for climate change vulnerability and adaptation assessments are being also built by Honduras component of GEF-UNDP "Capacity Building for Stage II Adaptation in Central America, Mexico and Cuba" in the Office of Climate Change in SERNA.

In Nicaragua, the National Institute for Territorial Studies (INETER) has a comprehensive climate data base; it has also capacity for climate variability analysis. The Office for Clean Development and Climate Change (ONDL) has qualified professionals in climate change matters and coordinates the work of the technical group that is been working in climate change issues for some years. ONDL is responsible for the preparation of the Second National Communication and is executing the Nicaragua component of the "Capacity Building for Phase II Adaptation in Central America, Mexico and Cuba" project.

#### Climate Change Scenarios

Regional scenarios climate modeling and climate model downscaling, technical group in IMN Costa Rica has developed capacity for climate risk assessment and for the development of climate scenarios using PRECIS. In the last months it run an experiment simulating 6 hours cumulative rainfall with PRECIS for the period 2072 - 2100. Currently the Development Unit is working with Hadley Center experts to obtain scenarios for 2010, 2030 and 2050. PRECIS 40 Km x 40 Km. resolution outputs will significantly improve climate change estimation for vulnerability analysis. Results are expected for October 2005 (Jorge Barrantes, IMN, personnel communication).

School of Physics (LIAP-DFAOP), Center for Research in Geophysical Sciences (CIGEFI) at the University of Costa Rica is a consolidated scientific group with ample experience in climate studies in Mesoamerica. The group has evaluated the performance in the Region of the top named GCM outputs with regional climate patterns and has identified those who reproduce better the current climate patterns. They have also capacity for Statistical Downscaling, using PRECIS or ECHAM-4<sup>6</sup> for boundary conditions.

Research work in topics of climate change with special interest in the Mesoamerican and Caribbean Region is currently developing also at other research centers in the area like the Department of Atmospheric Research in the Universidad Nacional Autonoma de Mexico (UNAM), the Climate Studies Group in the Department of Physics of the University of West Indies (Jamaica) and NOAA's Atmospheric and Oceanographic and Meteorological Laboratory in Florida USA (AOML). All these research efforts will contribute to the understanding of trends and key forcing factors to be consider in the down-scaling of climate change scenarios for Central America and the Caribbean.

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<sup>6</sup>. ECHAM4/OPYC3: model developed in co-operation between the Max-Planck-Institute for Meteorology (MPI) and Deutsches Klimarechenzentrum (DKRZ) in Hamburg, Germany

GEF/UNDP Project “Capacity Building for Phase II Adaptation to Climate Change in Central America Mexico and Cuba, implemented by Center for Water in the Humid Tropics of Latin America and the Caribbean (CATHALAC) is developing regional climate scenarios using PRECIS and MM5<sup>7</sup>. Results are expected to be available during the second semester of 2005; they are expected to be applied in the impacts assessment in the selected basins in each country. The number of parameters or variables to be simulated is in process to be decided. (M. Sc. Joel Perez F, climate expert advisor for the Project, personnel communication, August 2005).

Because PRECIS was developed specifically to help developing countries in the assessment of their vulnerability to climate change, it is likely that agreements with any or both institutions could be achieved for the use of their results in TroFFCA CA.

The future level of economic development or technological change assumed in the scenarios should be consistent with the ones assumed for policies and strategies for adaptive management. In this respect Echeverria, J. (2004) estimates on most likely economic and population scenarios for Central America and relation with IPCC assumptions for emissions scenarios, could be considered key piece of information in the design phase and in the development of criteria and indicators.

## **8. Policy design and implementation.**

Costa Rica

A Climate Change Commission was created by Presidential Decree in 1974 under the authority of the Minister of Natural Resources and Environment. The Commission have not acted in the long term. IMN is the focal point for UNFCCC and IPCC focal point. Climate change assessments and National Communication activities are carried out by the Development Unit in IMN. Mitigation. MDL projects are promoted and supervised by the Costa Rica Office for Joint Implementation (OCIC), also in IMN and headed by its Director.

IMN is responsible for scientific aspects of climate change activities in the country since 1991. It has carried out the national GHG inventories and vulnerability assessments for the First National Communication; because of that long sustained activity, it has a consolidated, well qualified group for climate change vulnerability assessment, identification of adaptation options. In its capacity as convener of the National Commission for Climate Change is also an important actor for policy-makers advice.

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<sup>7</sup> MM5 is the latest in a series of a mesoscale model used by Anthes at Penn State in the early 70's that was later documented by Anthes and Warner (1978). It includes (i) a multiple-nest capability, (ii) nonhydrostatic dynamics, which allows the model to be used at a few-kilometer scale, (iii) multitasking capability on shared- and distributed-memory machines, (iv) a four-dimensional data-assimilation capability, and (v) more physics options.

[www.mmm.ucar.edu/mm5/overview.html](http://www.mmm.ucar.edu/mm5/overview.html)

In the last year and as one of the activities in the Adaptation Phase II Project, the Unit has worked a Base Group of Actors that presently works as a multi disciplinary group for the permanent discussion and identification of adaptation options. A consultation with key stakeholders and climate experts about the sectors to be included in the Second National Communication to UNFCCC CoP will be convened in the first week of September 2005. It is expected that the same will provide the information necessary for further discussion on adaptation strategies, and procedures to mainstream adaptation policies into national plans.

#### Honduras

In Honduras climate change matters are the responsibility of the Office for Climate Change in the Ministry of Natural Resources and Environment (SERNA). The Office has assigned the responsibility for the coordination of all climate change related activities and national activities related with UNFCCC commitments and the Montreal Protocol.

A Committee for Climate Change with representatives from the Honduras Commission for Forests (COHDEFOR), Commission for Contingencies (COPECO), Honduras Municipalities Association, representatives of the Private Enterprise Chamber, the Council for Sustainable Development and the Citizens Forum plus the heads of the climate change and MDL offices (SERNA, National Plan for Adaptation Phase II. Project, 2003). The Commission has not acted lately and all climate change activities are being carried out by the Climate Change Office (*Lic. Carlos Estrada administrator, personnel communication, July 2005*).

The Minister of SERNA is the national representative with UNFCCC. The Climate Change Office is responsible for climate change and mitigation activities. It is the focal point for UNFCCC assessment and technical advice to negotiators. The Projects Unit in the Office promotes and executes all projects that have as their objective the accomplishment of country's commitments with UNFCCC.

Also in SERNA, the MDL Unit run jointly by SERNA's Energy Division, and the National Honduras Council for Forests (COHDEFOR), has as its responsibility the advise and guidance to MDL projects developers.

#### Nicaragua.

The Ministry of Natural Resources and Environment (MARENA) is the national institution responsible for climate change activities. Activities are carried out by the Office for Clean Development and Climate Change (ONDL by its acronyms in Spanish). The office head is the focal point for the UNFCCC and IPCC. The office is also responsible for the promotion of MDL projects.

### **9. Regional Level Policy Decision Frameworks**

Central American countries (Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, and Belize) have marked differences between them in terms of *per-capita* GNP, demography, growth rates, institutional capacities and social and political situation, therefore, projects or initiatives with regional scope should consider these differences in their planning.

In spite of the diversity, the seven countries in the Region had worked a process of political, economic, social, cultural, and ecological integration through the Central American Integration System, a process of integration aimed to complement the individual efforts.

The Central American Integration System (SICA) was created by the Protocol of Tegucigalpa which was signed by the Summit of Central American Presidents (including Panama and Belize as observer) in that city (capital of Honduras) in December, 1991. The Protocol came into force in February, 1993 and has been ratified by all member States.

The SICA as a system approach has the long term objective of transforming Central America in a Region of Peace, Liberty, Democracy, and Development, and is composed of elements such as intergovernmental decision making bodies, community organs, and specialized agencies.

The main intergovernmental decision making bodies are the Summit of Presidents (the Prime Minister of Belize is an observer) and the Council of Ministers. The latter includes Councils of Ministers of many branches (economy and trade, education, housing and human settlements, health, public infrastructure and transportation, etc.) and is coordinated by the Council of Ministers of Foreign Affairs.

Other bodies, include the Consultative Committee, the body that allows participation of civil society in the process composed of 20 organizations that represent business, labor, academic, cooperative, peasant, indigenous, and women sectors, totaling approximately 14 million direct affiliates. Also included are Technical Secretariats for the Economic Integration (Permanent Secretariat of the Treaty of Economic Integration-SIECA), Social Integration (Secretariat for Social Integration-SISCA), Cultural Integration (Coordination for Educational and Cultural Integration-CECC), and Ecological (Commission for Environment and Development-CCAD). The SICA specialized agencies coordinate matters such as monetary, development bank, health and nutrition, telecommunications, public administration, air navigation, industrial technology, water, zoo sanitation, among others (Calvo-Drago, Jorge D. 2000).

The Presidential Summits decisions are the guidance for policy in the seven countries in matters that concern the Region and become the regional agenda. Summit decisions are legally binding for Central America public sector and of guidance for private sector.

Development of steps 11 and 12, should take into account the above mentioned mechanisms, since they constitute the better organized and institutionalized mechanism for policy orientation and consultation in the Region.

Concerning particular areas of work that TrofCCA CA will involve, regional organizations responsible for the coordination of activities related with water resources, CRRH, and environment, CCAD, should be considered key actors.

Founded in 1968, the Comité Regional de Recursos Hidráulicos del Istmo Centroamericano (CRRH), is the Secretariat of the Central American Integration System (SICA) responsible for coordination of activities in weather, climate and water resources, In the Regional Strategy for Vulnerability Reduction in Central America approved by the

XX Presidential Summit in Guatemala City, it was assigned with the responsibility to improve the weather and climate information available to decision makers for the reduction of risks associated with climate variability.

CRRH coordinates activities with 28 organizations distributed in all the countries including the National Meteorological and Hydrological offices. It has been the coordinator and facilitator of the previous vulnerability assessments. It is also the Technical Secretariat of Water Consultative Committee, instance for consultation and harmonization of regional initiatives addressing water issues and mechanism for the advancement of the Regional Plan for Integrated Water Management (PACADHIR).

Created in 1989 by the Presidential Summit the Commission for Sustainable Development and Environment (CCAD) is the instance for regional cooperation regarding rational use of natural resources, pollution control, and the re-establishment of the environment equilibrium to guarantee better life quality for Central America people.

CCAD was the promoter of the Alliance for Sustainable Development (ALIDES). Coordinated by CCAD, the Regional Forest Council is the organization that channels technical analysis and resources to ministerial decision level. Central America Forest Council (CAFC) as regional decision body executes CAFS through Forest National Technical Committees, which channel technical resources and strategies at country level

The Council advises decision makers on regional strategies and policies related with forest. It has facilitated the consensus for a common agenda on forests, accepted by all governments in the Regional Action Plan for Forests (PAFT). It has also a continuous role in the promotion of sector policies and institutional reformation. Through its national councils it also constitutes the consultation mechanism with the NGO and private sectors on the matter (*Ing. Jorge Rodriguez, UICN, facilitator of Regional Strategy for Forests, personnel communication*).

CCAD facilitated the development of the Mesoamerican Agenda for Sustainable Development, executes the Mesoamerican Biological Corridor and the Project for Sustainable Use and Conservation of the Mesoamerican Reef System. Jointly CCAD and CRRH had coordinated and executed climate change projects and had regional networks of experts and stakeholders as well as data bases and information resources that could be of use for activities for TroFCCA CA.

Policy Analysis and Sustainability Assessments.

Due to its experience supporting the design and implementation of a Central American XXI Agenda, a long term strategy for the development of the Region and its insertion in global economy, INCAE's Latin American Center for the Sustainable Development and Competitiveness (CLACDS) is an organization that may provide important contribution to the project.

## **10. Conclusions**

The overall TroFCCA objective is to promote adaptation of tropical forest to adverse climate change, through the development of a framework for assessing the impacts and cost of climate change on tropical forest ecosystem, criteria and indicators of adaptive

forest management for forest ecosystem, livelihoods depending of them and human systems in general vulnerability reduction.

The achievement of this objective is proposed to work packages (WPs) that focus on the evaluation of impacts of climate change in tropical forest systems and tropical forest livelihood (WP1), the development of tools for monitoring these impacts (WP2), development of standards and tools for adaptation measures and forest adaptive management to reduce vulnerability to climate change (WP3, and WP4) and to test practically and disseminate information about those tools through policy –science dialogues (WP5).

In the case of the Central America, and approach in 12 steps to take into account the developing priorities for societies and forest role in them, assess climate change and climate variability threats to forest compared to threats, and promote a policy relevant dialogue about adaptation, is being proposed by the project design team. The starting point for the development of this approach in what refers to climate variability and climate change vulnerability assessment and identification of adaptation options, could be summarized as follows:

- Climate change impacts on forest ecosystems or forest dependent livelihood has not been considered in the previous vulnerability assessment and therefore there are not methodologies or approaches tested in the Region that could be used as a platform for impacts assessment in TroFCCA project.
- Climate scenarios available have coarse resolution for the type of analysis in selected areas that the project may accomplish; however, best resolution scenarios may be obtained from the results of other climate change projects likely to be available in time for the beginning of project activities. There is an opportunity for collaboration with the groups or organizations executing them.
- The creation of climate baselines and scenarios for the specific evaluations or assessment that TroFCCA should develop will depend on the type of analysis intended, therefore even if the results of the other projects will be made available, resources should be kept in the project budget for the specific analysis that will be needed.
- Assessment of vulnerabilities of key components or indicator species in particular forest systems in the selected areas, or the influence of climate and climate change in forest disturbance elements, likely to be included in the project, will need particular climate and scenarios information.
- There are at least two regional climate data bases with 0.5° x0.5° resolution available for research, that the project could use for its own analysis with no cost.
- Regarding the impacts and vulnerability assessment, due to the uncertainty about the specifics of analysis to be carried out by the project, at the moment this report is being written, it is not possible to estimate the cost. Consultations with climate experts in and outside the Region, a provision in the range of at least USA \$ 100,000 to 120,000 has been suggested.

- Human and technical capacities for scenarios development downscaling and climate variability analysis are established at IMN Costa Rica, and University of Costa Rica.
- In - country technical and organizational capacity for vulnerability assessment is present in the governmental Offices for Climate Change in the three countries. They are interested parties since they have assigned the responsibility for Second National Communications, which should have specific considerations for sectors like forests which were not included in the FNC. There is also capacity for the same type of work in some universities.
- Contextualize TroFCCA activities in the regional agendas is considered important by the project team. The Region has policy frameworks and agendas approved at highest decision-making level that provide guidance to recognized society priorities.
- Mainstreaming the adaptation policies into national and regional development strategies and policies at regional level could mean an overlap between national and regional agendas; interaction or collaboration with appropriate technical agencies of SICA like CCAD, CRRH or CODEFOR, responsible for the coordination of these agendas could be a mechanism to caveat the problem.
- SICA agencies have networks and in-country consultation mechanisms at regional level, that could be also a resource to facilitate consultations or mainstreaming policies. Collaboration with these organizations could help the identification and involvement of existing human networks at regional country and local level that may be crucial to overcome the bottlenecks and make adequate allocation of resources.
- National follow-up and monitoring, along with connectivity resources and training for those regional networks, could help the establishment of adequate environment for communication among public officers responsible for the implementation of the regional agenda, and scientist involved in the project, in both national and regional levels.
- In the development of TroFCCA activities for implementation structure and science-policy dialogue, the potential of the already existent networks and bodies should be take into a account, since they constitute the better organized and institutionalized mechanism for policy decision and consultation in the Region.

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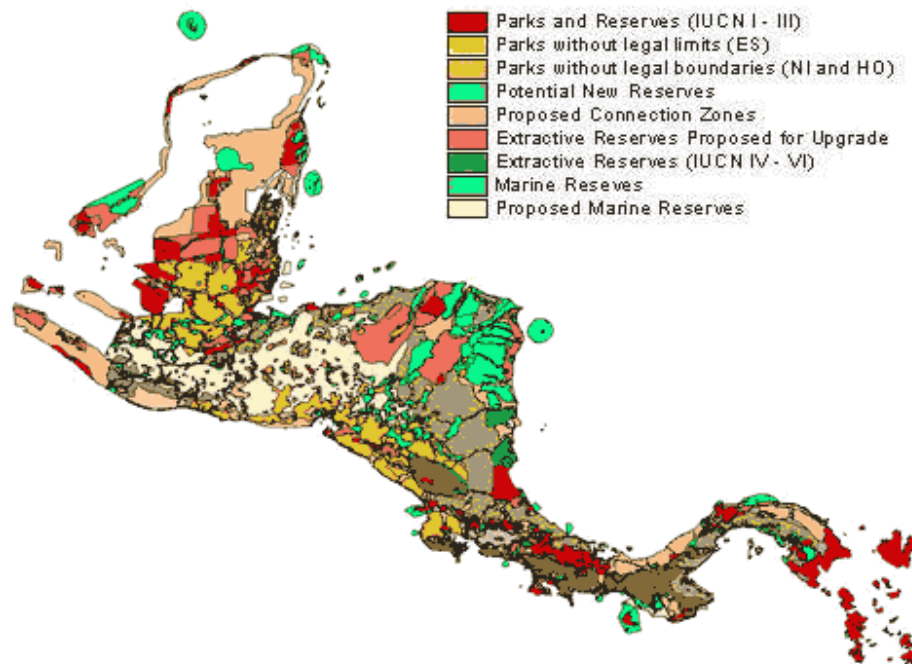
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## ANNEX I

### Central American Vegetation/Land Cover Classification and Conservation Status



This mapping project assessed the degree to which both existing and proposed terrestrial protected area networks protect/would protect landscape-level biodiversity, which are represented as vegetation types delineated from remotely-sensed imagery. A comprehensive, standardized, and thematically appropriate map of Central American vegetation and landcover types was developed by classifying AVHRR imagery (Advanced Very High Resolution Radiometer imagery -- 1 square kilometer resolution) using advanced digital image processing routines and expertise provided by a Central America Vegetation Working Group. The map identifies 17 remaining natural vegetation types. The classification accuracy of the map is estimated to exceed 80 percent. The data accurately reflect conservation status up to 1995.

Using a gap analysis approach, a map of existing and proposed protected areas was overlaid on the vegetation map to analyze the protection status of vegetation types. Eleven of the 17 vegetation types were found to be under-represented (<10% of their total area contained in parks) and of these, eight vegetation types were found to have less than 5% protection. A similar analysis of the protection status of ecoregions revealed that eleven of the 16 ecoregions are inadequately protected. Eight ecoregions have been extensively converted (<40% original forest remaining) from pre-colonization states.

*This work was supported by PROARCA/CAPAS (Proyecto Ambiental Regional de*

*Centroamerica/Central America Protected Areas Systems*), a conservation partnership of the [Central American Commission on Environment and Development \(CCAD\)](#), the [U.S. Agency for International Development \(USAID\)](#), the [International Resources Group, Ltd. \(IRG\)](#), [The Nature Conservancy \(TNC\)](#) and [Winrock International](#). This work was primarily funded by the United States Agency for International Development (USAID). Components of this work were additionally supported by [The Nature Conservancy \(TNC\)](#) and [NASA](#).

Read more **about the project** and the GIS data sets:

<ftp://ftp.ciesin.columbia.edu/pub/data/conservation/PROARCA/readme.txt>

**Download** the data in ArcInfo export format (.ee0):

<ftp://ftp.ciesin.columbia.edu/pub/data/conservation/PROARCA/PROARCA.zip>

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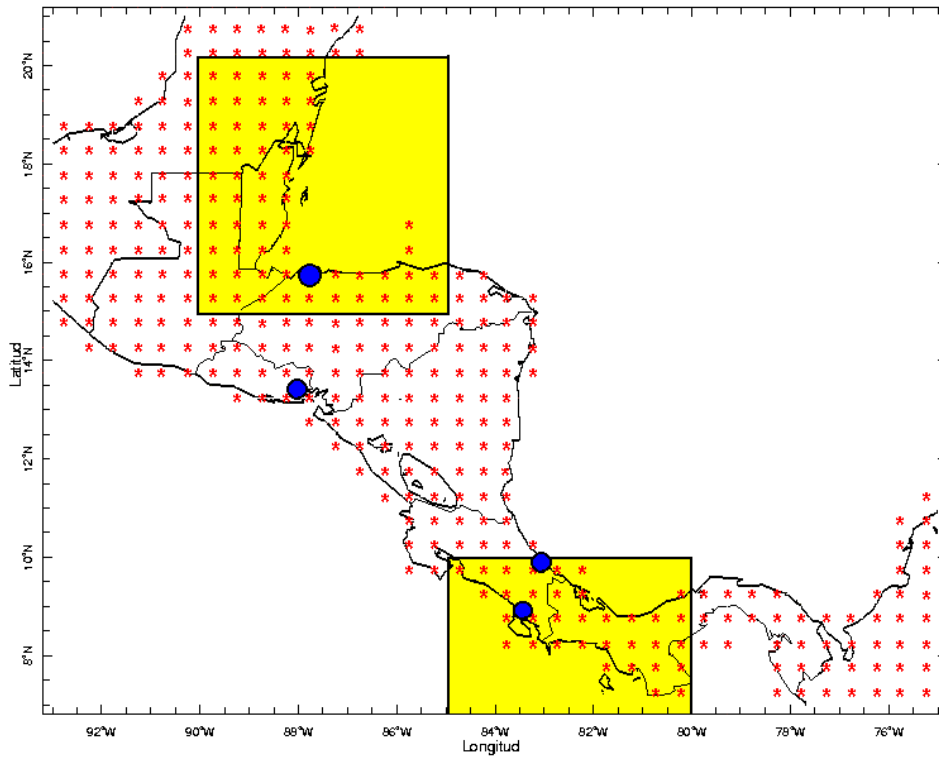
## ANNEX II. Disasters associated to climate in Central American Isthmus

YEAR	COUNTRY	EVENT	DEATH	ECONOMIC IMPACT (US\$)
Oct-61	Belize	Hurricane Hattie	275	150,000,000
Nov-66	Panama	Floods	120	-
xxx-68	El Salvador	Floods	14	5,000,000
Sep-69	Guatemala	Hurricane Francelia	269	1,600,000
Sep-69	El Salvador	Hurricane Francelia	-	19,000,000
Sep-69	Honduras	Hurricane Francelia	-	15,000,000
Jan-70	Panama	Drought	-	380,000
Apr-70	Panama	Floods	48	6,000,000
Apr-70	Costa Rica	Floods	23	75,000
Sep -71	Nicaragua	Hurricane Edith	35	2,968,000,000
May-73	Costa Rica	Earthquake-landslide	26	4,000,000
Sep-74	Belize	Hurricane Fifi	-	1,331,000,000
Sep-74	Honduras	Hurricane Fifi	8,000	2,147,000,000
Sep-78	Honduras	Hurricane Greta	-	-
Nov-78	Panama	Floods	19	-
Jul-80	El Salvador	Floods	9	101,000,000
Jun-82	Honduras	Floods	130	-
Sep -82	Guatemala	Tropical Depression Paul	855	-
Sep -82	El Salvador	Floods	631	-
Sep -85	El Salvador	San Salvador Volcano's Landslide	400	1,600,000,000
xxx-86	Guatemala	Landslide	75	10,000,000
Feb-88	Costa Rica	Floods	7	-
Oct-88	Costa Rica	Hurricane Joan	28	400,000,000
Oct-88	Nicaragua	Hurricane Joan	121	60,000,000
Oct-88	Panama	Hurricane Joan	7	-
Nov-90	Honduras	Floods	15	-
Oct-90	El Salvador	Floods	17	19,500,000
Aug-91	Costa Rica	Floods	1	-
Aug-91	Panama	Floods	12	-
Jul-92	Panama	Tornado	12	-
Aug-92	Nicaragua	Floods	-	25,000,000
Oct-92	El Salvador	Floods	2	-
Jun-93	El Salvador	Landslide	20	-
Aug-93	Honduras	Tropical Storm Bret	-	-
Aug-93	Nicaragua	Tropical Storm Bret	-	-
Aug-93	Costa Rica	Tropical Storm Bret	313	7,700,000
Sep -93	Honduras	Tropical Storm Gert	1	-
Sep -93	Nicaragua	Tropical Storm Gert	27	-
Nov-93	Honduras	Floods	37	-
Dec-93	Costa Rica	Floods	174	-
Oct-94	Honduras	Floods	5	-
Nov-94	Costa Rica	Tropical Storm Gordon	150	-
Oct-94	Costa Rica	Tropical Storms Opal and Roxanne	13	-
Oct-95	El Salvador	Floods	5	-
Feb-96	Costa Rica	Floods	9	157,000,000
Jul-96	Costa Rica	Hurricane Cesar	40	53,000,000
Jul-96	Nicaragua	Hurricane Cesar	9	-
Nov-96	Honduras	Tropical Storm Marcos	7	-
May-97	Honduras	Drought	-	-
May-97	Nicaragua	Drought	-	93,000,000
May-97	Costa Rica	Drought (El Niño)	-	-
Oct-98	Panama	Hurricane Mitch	2	91,000,000
Oct-98	Costa Rica	Hurricane Mitch	4	988,000,000
Oct-98	Nicaragua	Hurricane Mitch	2,863	3,794,000,000
Oct-98	Honduras	Hurricane Mitch	6,600	388,000,000
Oct-98	El Salvador	Hurricane Mitch	240	748,000,000
Oct-98	Guatemala	Hurricane Mitch	268	-
Oct-98	Belize	Hurricane Mitch	-	-
TOTAL		63 Eventos	21,785	15,242,255,000

### ANNEX III

Selected points for points for downscaling of sea level rise and changes in temperature and rainfall :

(Tela-Honduras; Papalón-El Salvador; Palmar-Costa Rica; Limón-Costa Rica).



## ANNEX IV

### EJEMPLO DE UN EXPERIMENTO EN PRECIS<sup>8</sup>

*El acceso a escenarios climáticos detallados es particularmente vital para los países en desarrollo, donde el stress económico incrementa la vulnerabilidad a los cambios climáticos. En orden de ayudar en ese sentido el “Hadley Center”, ha desarrollado el PRECIS(Providing Regional Climates for Impacts Studies).*

En Costa Rica se ha conseguido realizar una corrida completada de un experimento utilizando el modelo regional PRECIS. Tal corrida se realizó del periodo 2070-2100, utilizando el escenario SRES A2, para valores horarios cada 6 horas, pronosticando las variables: la intensidad de la lluvia horaria y la temperatura, ambas al nivel de 900 mb.

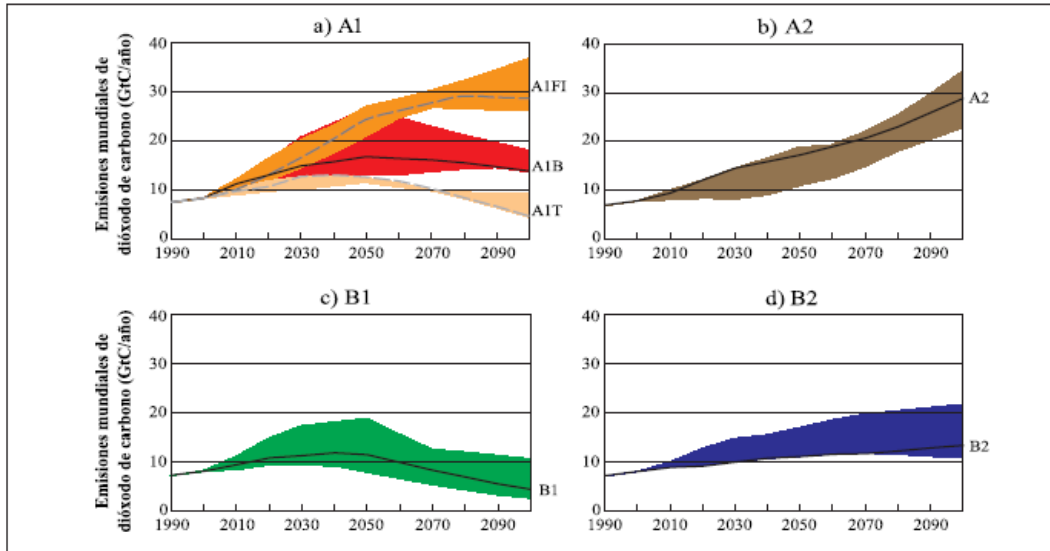
A fin de ilustrar los alcances del escenarios SRES A2 se muestra su descripción y un gráfico que muestran las emisiones de dióxido de carbono para tal escenario.

#### ESCENARIO SRES A2

La familia de líneas evolutivas y escenarios A2 describe un mundo muy heterogéneo. Sus características más distintivas son la autosuficiencia y la conservación de las identidades locales. Las pautas de fertilidad en el conjunto de las regiones convergen muy lentamente, con lo que se obtiene una población mundial en continuo crecimiento. El desarrollo económico está orientado básicamente a las regiones, y el crecimiento económico por habitante así como el cambio tecnológico están más fragmentados y son más lentos que en otras líneas evolutivas.

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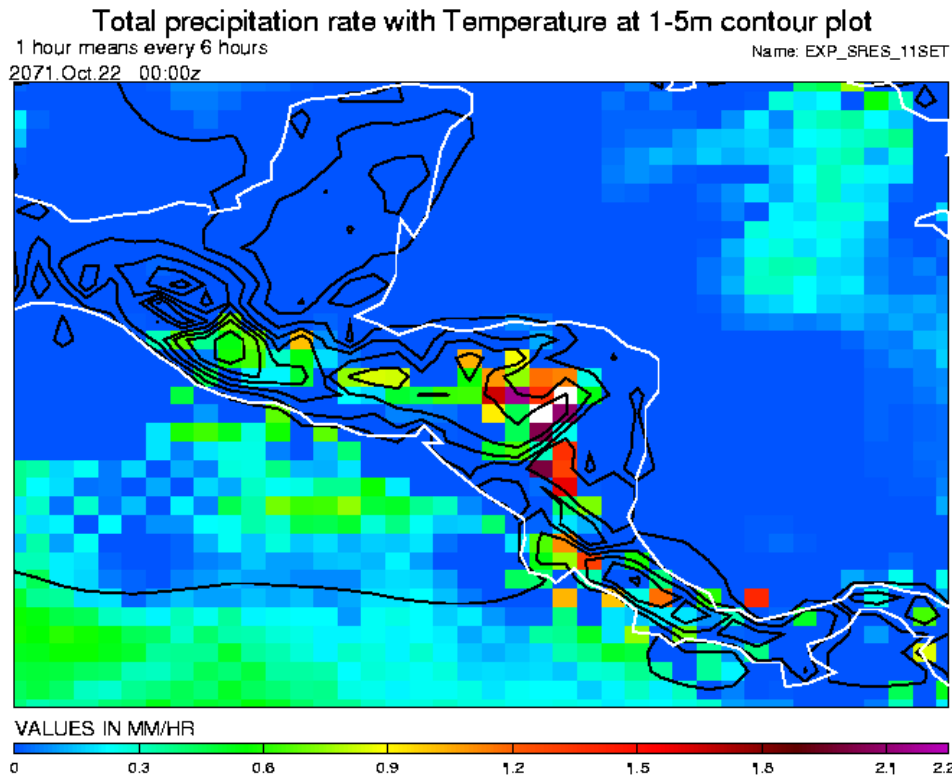
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**Figura 3:** Emisiones anuales totales de CO<sub>2</sub> provenientes de todas las fuentes (energía, industria y cambio de uso de las tierras) entre 1990 y 2100 (en gigatoneladas de carbono (GtC/año) para las familias y los seis grupos de escenarios. Los 40 escenarios IE-EE aparecen clasificados en función de las familias (A1, A2, B1 y B2) y de los seis grupos de escenarios: el A1FI, de utilización intensiva de combustibles de origen fósil (que incluye los escenarios de alto nivel de carbón y de alto nivel de petróleo y gas), el A1T, de combustibles predominantemente no de origen fósil, el A1B, equilibrado, de la Figura 3a; el A2 de la Figura 3b; el B1 de la Figura 3c, y el B2 de la Figura 3d. Cada franja de emisiones coloreada indica el repertorio de escenarios armonizados y no armonizados dentro de cada grupo. Se ofrece un escenario ilustrativo para cada uno de los seis grupos de escenarios, incluidos los cuatro de referencia (A1, A2, B1 y B2, en líneas de trazo continuo), y dos escenarios ilustrativos para A1FI y A1T (líneas de trazos).

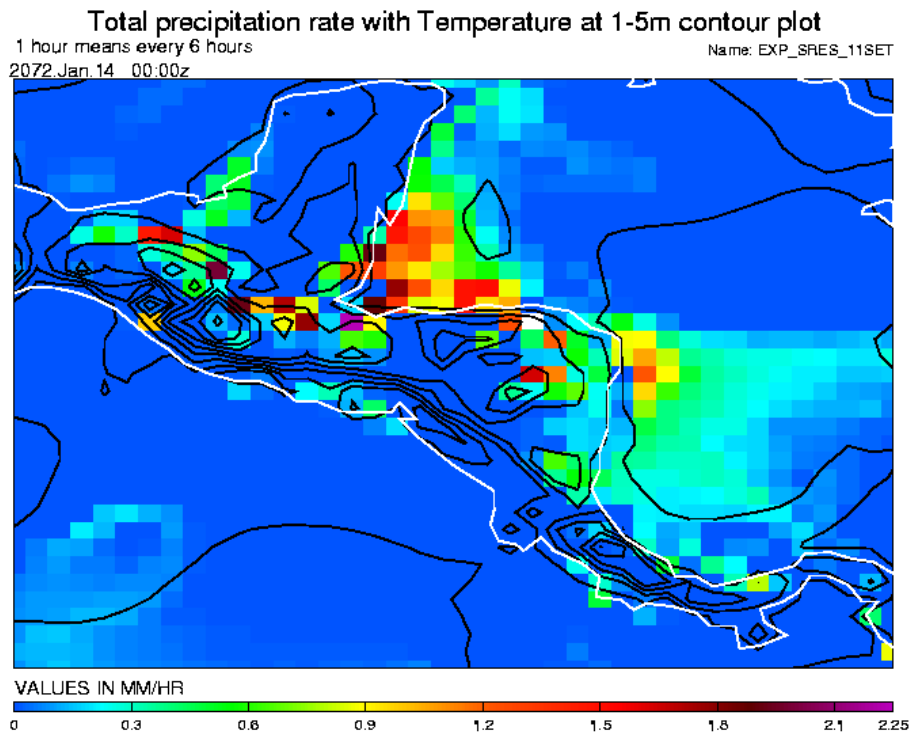
La región escogida para el experimento es Centroamérica y los océanos alrededor con parte de México.

A continuación se muestra uno de los resultados, donde la lluvia se da en milímetros por hora y la temperatura en grados centígrados. Se trata de la lluvia media para cada 6 horas y la temperatura a 1.5 metros. En este primer gráfico se muestra el día 22 de octubre del año 2071 a las 00:00 GMT.

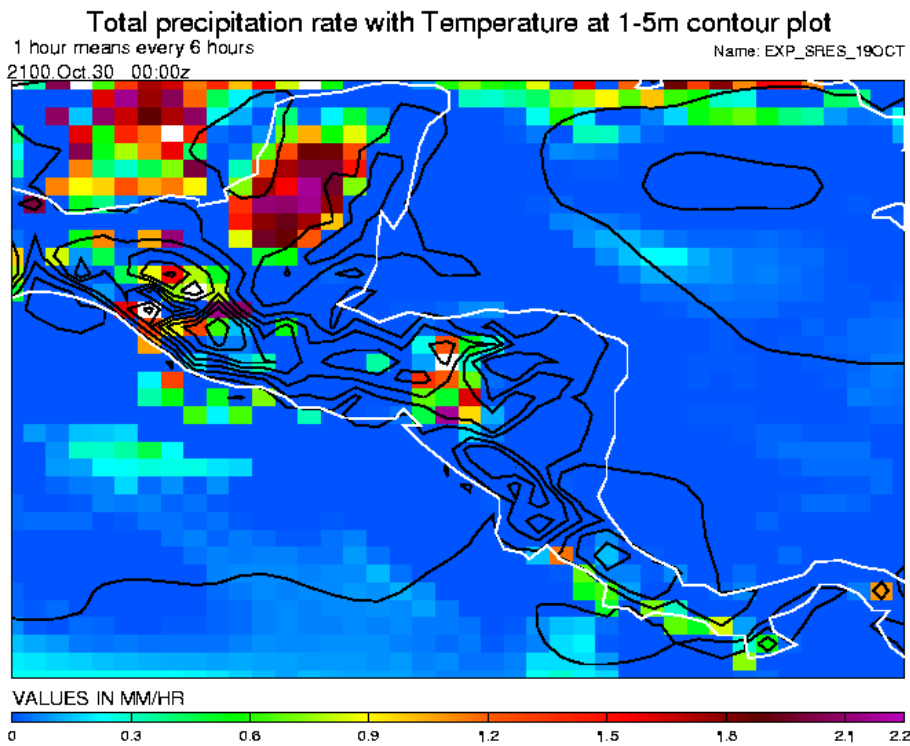


Se infiere que el patrón lluvioso es correspondiente con el mes, “octubre”, con un incremento de la lluvia asociada con la ITC al sur de nuestro país y una disminución de la lluvia en las costas del Caribe y en la Zona Norte. Se deduce que se debe mejorar la presentación de la temperatura pues las isolíneas no tiene número que las identifique.

Tal modelo simula en forma correcta los cambios interanuales, tal como se muestra en la figura siguiente, la cual se trata del 14 de enero del año 2072. La actividad lluviosa se traslada al Caribe y los gradientes térmicos disminuyen.



Si nos remontamos al año 2100, octubre 30 a las 00:00 GMT, se puede visualizar un panorama un tanto cambiante con menor impacto de la ITC, más actividad en el Golfo de México, menor lluvia en Costa Rica, lo que podría concluir un inicio de la estación seca más temprana.



Pero en realidad no solo se han corrido experimentos en tiempo futuro sino se tiempo pasado, tal es el caso que se presenta a continuación, tratándose del 21 de Octubre del año 1983, un panorama un tanto diferente con respecto al 2100!!!.

### Total precipitation rate with Pmsl contour plot

1 hour means every 6 hours  
1983.Oct.21 00:00z

Name: EXP\_SRES\_BASE1

