Vulnerabilidad y adaptación al cambio climático de los pobladores rurales de la planicie costera central de El Salvador

Ministry of the Environment and Natural Resources (MARN)
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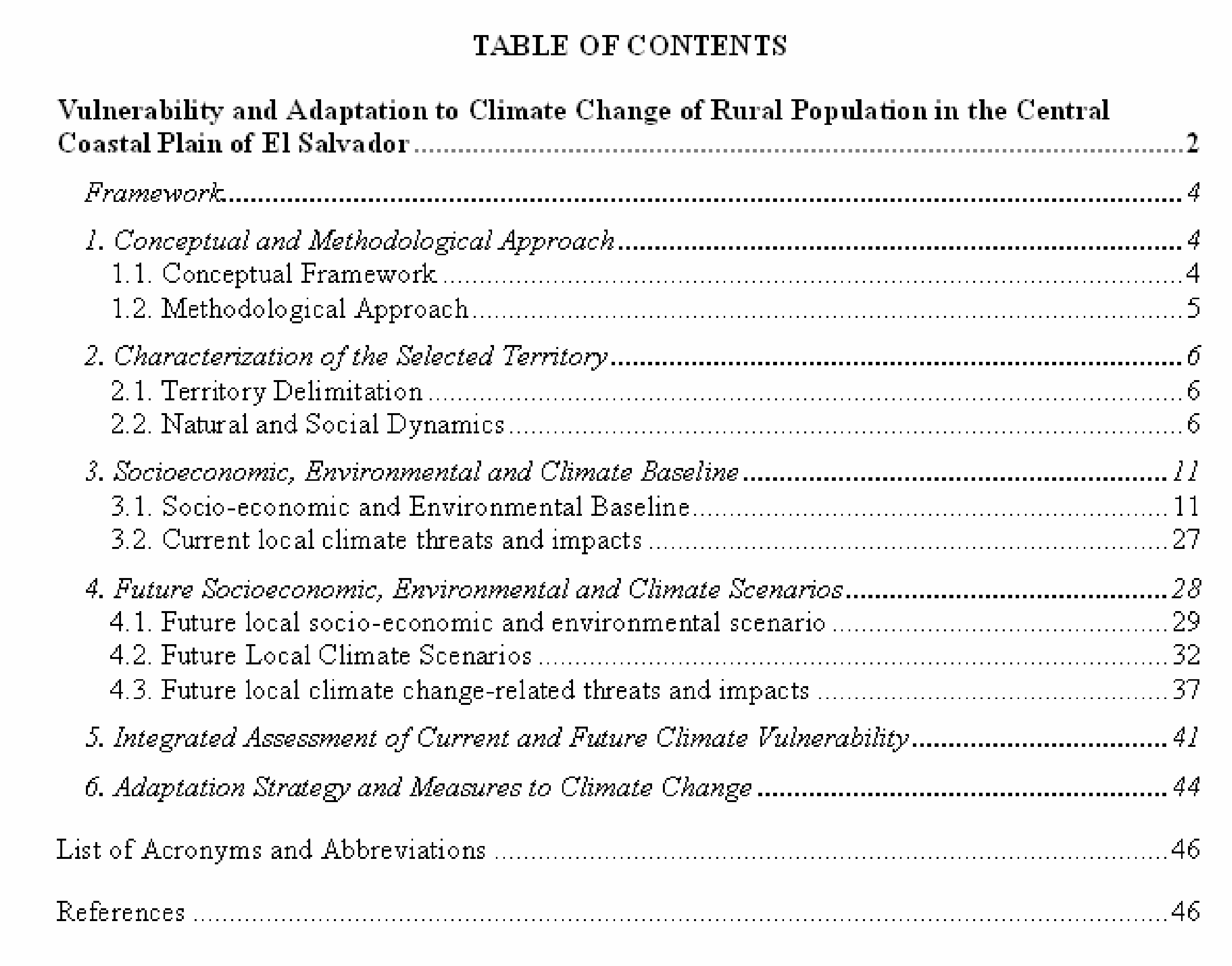
Vulnerability and Adaptation to Climate Change of Rural Population in the Central Coastal Plain of El Salvador

(VULNERABILIDAD Y ADAPTACIÓN AL CAMBIO CLIMÁTICO DE LOS POBLADORES RURALES DE LA PLANICIE COSTERA CENTRAL DE EL SALVADOR)

SUMMARY-TRANSLATION



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Framework

This report describes the process and results of an interdisciplinary study of current and future climate vulnerability in El Salvador, based on theoretical and empirical knowledge and the participation of local human population and organizations.

The purpose of the study was to develop, together with local populations, an adaptation strategy to climate change, based on an integrated assessment of socio-cultural, economic and natural factors that bring about current climate vulnerability in the selected territory, including future climate change.

The report is presented in six sections:

1. Conceptual and methodological approach.
2. Social and natural dynamics, with an atlas of 30 maps.
3. Socioeconomic and environmental scenarios, climate impacts and threats for the reference year 2004.
4. Future socioeconomic, environmental, and climate scenarios by 2015; including, local threats and impacts for the projected climate change.
5. Future trends of climate vulnerability and its explanatory variables, as well as of the system of socioeconomic, environmental, and climate indicators.
6. Local strategy for adaptation to climate change, including action lines and measures, in addition to responsibility for implementation.

1. Conceptual and Methodological Approach

1.1. Conceptual Framework

A systemic and interdisciplinary approach was adopted for the integrated assessment of climate vulnerability for the selected territory. This geographic space includes human settlements in which social, cultural and economic factors have a prevailing role. The selected territory was delimited and characterized by the natural, socio-cultural and economic environments of local inhabitants.

The vulnerability of the socio-natural system to climatic factors exposure was defined as a variable dependent on three explanatory first-order variables: climate exposure, resilience, and adaptive capacity. Exposure is addressed as a climatic threat to the territory. Resilience indicates the capacity of the system to resist and absorb shocks of natural or social factors and of recovering from disturbances or impacts. Adaptability is the system’s potential to evolve and adapt to changes without collapsing, by learning processes that enable it to increase its coping range and its self-organization capacity. Increase in the system´s resilience and adaptability constitutes the basis of a strategy for adaptation.

Explanatory second-order variables of exposure, resilience and adaptive capacity were selected and in turn linked, as an interface, to the related second-order variables that characterize each of the three environments of the selected territory, as depicted in the following table.

Variables **Order**	**Type of explanatory variables**							
First	Climate exposure (E)		Resilience (R)			Adaptive Capacity (A)		
Second **(interface variables)**	Temperature related climate extremes	Dry and wet climate extremes	Organization flexibility	Mechanisms of control	Structural coupling	Potential of resources	Innovation and experimentation	Organization complexity
Second **(interface variables)**	E-related variables characterizing the selected territory		R-related variables characterizing the selected territory			A-related variables characterizing the selected territory		

1.2. Methodological Approach

The development of the integrated assessment of climate vulnerability and the strategy for adaptation to climate change included the following phases:

a. Identification of the socio-natural system

b. Integrated assessment of current climate vulnerability

c. Integrated assessment of future climate vulnerability

d. Strategy and adaptation measures to projected climate change

Participation of local population and counterparts was very active and included consultation processes, field surveys, climate change awareness workshops, and processes of exchange, discussion and analysis.

Identification of the Vulnerable System and Current Vulnerability

To assess current climate vulnerability of the selected territory, a system of variables and indicators associated with each of the three environments was established, with a reference period corresponding to the year 2004. This system was linked to the three explanatory variables of climate vulnerability, using a composite index of vulnerability to estimate the magnitude of current climate vulnerability, or current CVI. The climatic exposure variable was addressed from different levels of threat associated with extreme temperature and precipitation events.

Integrated Assessment of Future Climate Vulnerability

The future vulnerability was evaluated by projecting the reference period to 2015. Reference indicators were estimated taking as a basis the local socio-economic scenario for that year. Subsequently, the future climate scenarios and five indicators of the Climate Threat Index, or CTI, were projected to 2015. Finally, the future vulnerability index, or future CVI, was calculated.

Development of the Strategy and Measures to Adapt to Climate Change

To develop the strategy for adaptation to climate change, its nature and scope were defined in the first place, including principles, beneficiaries, purpose and goals, as well as the geographical, chronological, and thematic scope and action lines. For the implementation of adaptation measures, both adoption and advocating areas were considered. For each objective, action lines and adaptation measures were defined, considering the future development of the system of indicators. Prioritizing of action lines was based on the values of the indicators, categorized as *very low, low, medium, high, and very high*, as these reflect their potential contribution to improving resilience and adaptability levels associated with the dimensions of each of the three territory environments.

2. Characterization of the Selected Territory

2.1. Territory Delimitation

The territory is located in the southeastern and paracentral region of El Salvador, as depicted in the atlas included in Appendix III. It covers part of the municipalities of Zacatecoluca (Department of La Paz), Tecoluca (Department of San Vicente), and Jiquilisco (Department of Usulután). The area of the territory is 1,152.5 km^2 (approx. 445 square miles). Its boundaries consist of the southern foothills of the San Vicente and Tecapa volcanoes in the North, the mangrove swamps and the Pacific Ocean in the South, the Jiquilisco municipality and Jiquilisco bay in the East, and the Jaltepeque estuary and its extension to the north near the city of Zacatecoluca in the West. In the coastal strip there are extensive areas of medium-low and low altitudes, between 2 and 60 masl[*]. To the north, the foothills of San Vicente and Tecapa volcanoes have slopes of moderate to high altitude, between 100 and 1500 masl. The peak of the San Vicente volcano reaches 2,300 masl.

The territory includes about 6,725 families, of which 3,125 live on the West bank of the Lempa River, and 3,600 on the East bank. Taking an average of 4 members per family, the population is estimated at 26,900.

The territory was defined taking as the main criterion the matching between the socio-cultural and economic dynamics of human communities, and the dynamics of the local natural systems. The study delimits the territory by first considering the geographical areas involving human communities, that is, where people have organized themselves into organizations involving local development processes. Three geographical areas are included from the eastern bank of the River Lempa whose residents are organized within the Coordinadora del Bajo Lempa, or CBL, and the Asociación Mangle. From the western bank three micro-regions were included whose residents are organized under the Grupo Bajo Lempa, or GBL, and the Association CORDES-San Vicente.

As a second step, the natural landscape of the central coastal region was considered, including four natural landscape sub-systems that have some degree of incidence in the natural dynamics of the territory: (i) Libertad – La Paz – San Vicente coastal plain, (ii) Usulután coastal plain, (iii) San Vicente volcanic massif and (iv) San Miguel-Usulután volcanic massif.

Thirdly, the hydrographic sub-river basins of El Pajarito, El Guayabo, Lempa River Low Basin, El Espino-Borbollón, El Potrero, Nanachepa, and Aguacayo were considered. These are watersheds whose dynamics affect or is somehow linked to the human settlements mentioned above.

2.2. Natural and Social Dynamics

Natural Dynamics

The study of the natural environment of the territory was addressed in such a way as to reflect the strong interactions between the natural and socio-natural dimensions. The territory consists of two natural landscape systems: the central coastal plain and a recent volcanic chain, with a total of four subsystems, mainly, two coastal plains and two volcanic massifs, respectively. The four subsystems were divided into a total of thirteen landscape units which identify estuaries; bays; alluvial plains; volcanic borders, foothills, summits, and parts of the volcanic massifs; as well as swamps.

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[*] Meters above sea level (m.a.s.l.)

Geological Characteristics

The geology of the territory is characterized by the San Salvador formation which is the most recent in the country. For the most part, the intermediate and lower parts consist of alluviums and sediment from the Quaternary period and are susceptible to seismic-related ground failure.

In hydrogeological terms, the San Salvador formation is home to the major aquifers in the territory. These aquifers have a great storage capacity, with phreatic levels oscillating between 7 and 2 meters (approx. 23-6.5 feet). Although there is easy access to the hydric resource, its availability is affected by its low quality. Also, since the formation has high subterranean transmissibility and surface permeability it is highly vulnerable to contamination and interaction with the marine-coast, making it susceptible to increased salinity from both natural processes and inadequate use.

The high northeastern region of the territory is an area of hydrological recharge, with highly permeable Quaternary volcanic material that facilitates the recharge of the lower ground aquifers. Older geological formations are present around the edges and higher lands of the San Vicente volcano and show areas of low permeability and lower recharge capacity. On the west, the middle and higher lands are part of the San Salvador formation and are areas of hydrological recharge and home to permanent local aquifers.

Lower lands were classified as being primarily Inceptisol—a soil property of mangrove swamps and transition forests. In addition, there is a low-slope area with elevations between 0 and 7 meters (approx. 0-23 feet), and of low to moderated permeability due to the lack of drainage and lime-clay strata.

The intermediate lands consist mainly of Entisols and of the alluvial plain. These lands are excellent for agriculture, but are limited due to their high vulnerability to floods. The medium-high and high lands are mainly red clay Ultisols or Alfisols, and are prone to rapid land-slides due to moderate-severe slopes or to erosion from lack of permanent vegetation cover. These lands are suitable for agriculture and possess good permeability if not deforested or used inappropriately.

Local Climate

Most of the territory is classified as a subtropical humid forest with a monsoon climate pattern of six rainy months and six continuously dry months. The annual mean precipitation varies from 1500mm in the coastal region to 1700 mm on the north (approx. 59-67 in). High temperatures range from 31ºC (87.8ºF) on the shore to 35º-36ºC (95-96.8ºF) north of the territory, while minimum temperatures vary from 23º-21ºC (73.4º-69.8ºF), correspondingly.

The territory is one of the areas of greatest vulnerability in the country and most affected by frequent extreme droughts and floods. Droughts occur every year, and some are associated with El Niño events. In addition, every year during the rainy season (July and August) there are 5-15 consecutive days without rain. Floods are associated with various causes, among which are activities related to the Inter-tropical Convergence Zone, or ZCIT, hurricanes forming in the Caribbean Sea or in the Pacific Ocean, and the La Niña event.

The seven sub-river basins in the territory all respond differently in terms of spatial and temporal distribution of rain volume, although each experiences the same precipitation regime and intensity of rain. A significant part of the territory is an area of a basin with the greatest direct impact in the country. This basin, which extends 18,246km² (approx. 7,045 square miles) and covers extensive parts of Honduras and Guatemala in its highest parts, could severely affect the territory during extreme meteorological events with the formation of major streamflows.

The sub-river basins located north of the littoral highway are in their higher and middle parts susceptible to soil erosion while their lower parts, where the greatest human communities in the selected territory are located, are very vulnerable to frequent annual floods. Lack of sub-basin slopes and drainage make these sub-river basins susceptible even to conditions of low precipitation. Two other factors that contribute to overflows and flooded areas were also identified: accretion of silt in low riverbeds, which lowers the capacity of flow, and the loss of forest protection due to riverside deforestation.

A thoroughly studied pattern of flood dynamics for the Lempa River was noted to have changed during the past few years affecting the volume and swelling of the river as well as the hydrological dynamics of the secondary rivers that cross it. While some riverbank areas experience no floods, others are affected by floods with around 5,455 m^3/s of volume, with a 5-year return period. In addition, frequency of extreme events occurring every 10 and 25 years, has increased.

In the last decade new areas have been affected by frequent floods, with a 2-year return period and 3,232 m^3/s of volume, due to the lack of maintenance and precarious conditions of the existing drainage and embankments. For flood risk minimization in the territory, the adequate management of the hydroelectric dam, including the intercommunication between local people and dam authorities, was recommended.

Agrological characteristics

There are eight types of agrological characterizations for the territory. The first three describe a fertile, low slope, moderate to high permeability, low salinity and limited erosion ground, present in the middle region of the selected territory and mainly used for agricultural activities. These types of soil are sensitive to flooding and drainage due to their interaction with nearby rivers.

The fourth type of soil has an increased slope and although apt for agriculture it is currently forested. The V, VI and VIII types describe land with steep slopes, thick texture, and susceptibility to erosion and dragging of sediment. These are present at the foothills of the San Vicente and Tecapa volcanoes in the high part of the sub-river basins and are scarcely used for agriculture. Type VII is saline soil found in the coastal fringe that acts as a base for the mangrove swamps and is recurrently exposed to disturbances.

Among a variety of important ecosystems, four were identified as being the most significant: the perennial alluvial forest, the connection between mangrove trees and estuaries, the fluvial system of fresh waters, and the marine-coast fringe. These offer local people such benefits as food, medicinal plants, scenic beauty, fresh air, animals, availability of water, and protection against floods, among others. Furthermore, there are at least five forested areas in the territory that have been selected as priorities for integration in the national system of protected natural areas of El Salvador, as well as portions of four conservation areas in the country.

Social Dynamics

The social dynamics of the selected territory was defined as the socio-cultural and economic activities of human society and approached by looking at the different development processes promoted by the aforementioned CBL and GBL organizations. These development processes are aimed at improving the economy of the families in such a way that will generate local development opportunities that ultimately result in local benefits derived from integration into the national economy. In some parts of the selected territory, the establishment of entrepreneurial initiatives is being promoted, and the profits are being used to establish more of such initiatives to improve the quality of life of local families.

Within the territory, land use for production is characterized by short-cycle crops. In addition to expanding traditional agricultural activities, local organizations want to promote horticulture by artisanal irrigation, raising cattle, and the cultivation of fruit trees. Other initiatives that were identified are: artisanal agribusiness, aquaculture, agro-forestry, and environmentally friendly tourism. Human communities that have organized for support of local development were grouped according to three micro-regions of the GBL organization and to three zones of the CBL organization.

Both the mangrove forests and secondary terrestrial forests were identified as important for the supply of animals and vegetables, as well as for food security and income of local families. Forests also serve as a barrier against floods and river swells, as mentioned above, and provide a habitat for a great variety of native and migratory species.

Livelihoods

Livelihoods associated with the primary sector of the local economy are production of basic grains, small-scale production of vegetables and bovine raising. The use of inefficient technologies in these activities results in low yields of grain, vegetables, milk and meat.

Production of sugar cane is also a significant livelihood source in the selected territory due to the amount of land that it involves and to the two main land property regimes: cooperatives of agricultural producers and land owners. Sugar cane harvesting is for some rural inhabitants the only job available during December and January, and was identified as having adverse impacts on forest ecosystems, vegetable cultivation, and neighboring human communities.

Traditional fishing and shrimp-aquaculture, as well as charcoal production are other important identified local livelihood. Activities associated with the secondary and tertiary sectors of local economy were described as beginning to appear. These include entrepreneurial initiatives for semi-organic production and for the processing of cashew apple[†] and dairy products. The proportion of the population in the territory within the service sector is low and limited to transportation, shops, or employees for local or municipal organizations.

The territory’s infrastructure consists mainly of small productive artisan centers built informally and with low quality foundations, tiled or wood roofs, and low cost and equipped work areas. The infrastructures are generally located in areas subject to soil flooding, floods, and with difficult access during the rainy season.

Initiatives for environmentally friendly tourism are being promoted in order to generate rural jobs, for environmental education and development of environmental awareness raising for the enjoyment of the scenic beauty, for sustainable waste management, and for cultural and local identity reappreciation and dissemination.

Local inhabitants have greater access to land and its resources after the Peace Accords, signed in 1992, which modified land property regulations. However, some people have not been able to improve their well-being due to lack of suitable financing, technology, technical assistance, knowledge, information, market research, and access to commercialization channels. Rural labor combined with sustenance production and other activities such as fishing and hunting have become relevant livelihoods in the selected territory.

Welfare

According to a 2003 socioeconomic survey, 50% of local population was identified as living under relative or extreme poverty conditions, with a low level of welfare, as follows:

- A great number of youngsters are traveling abroad in search of alternative income opportunities
- Moderate level of extreme poverty for three out of four municipalities included in the study
- Very low-level of quality for primary and secondary schools
- Precarious geographic coverage of health care services, non-permanent medical staff in health centers and lack of required medicine given in clinics
- Restricted drinking water network supply with many areas not being provided, as well as high level of contamination in water supplied by wells

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[†] Semilla de marañón

- Small-scale use of firewood, charcoal or propane gas for heating purposes by families, although an extensive electric energy network exists close to most local communities
- The majority of access roads, bridges and passage works cannot be crossed during the rainy season

The wide network of local social organizations present in the selected territory was identified as fulfilling the basic needs of local families and increasingly inspiring them to continue living and working in it. Local organizations also create incentives through projects for technology improvement and cultural and artistic programs in order to increase the quality of education and public health.

Flood Risk

Five levels were assigned to the risk level associated with floods arising from the Lempa River or from secondary rivers: *very high, high, moderate, low and very low*. Each level was given a period of return in years as well as flooding areas.

As an example, a *very high* risk level associated with flooding in the Lempa River was assigned a 2-year return period and a flooding area including human communities and agricultural plots. A *very high* risk level associated with flooding in the secondary rivers, on the other hand, has the same return period, but the flodding area assigned is that of human communities and infrastructure.

The two tables below show the return period and flodding areas for each risk level associated with (a) floods from the Lempa River and (b) floods from the secondary rivers.

Box 2.2-1: Levels of risk from flooding of the Lempa River

Level of flood risk	Return period (years)	Areas of flooding or flooded soil (basis for zoning)
Very high	2	Floods of human communities and agricultural plots
High	5	Floods of human communities, agricultural plots, and infrastructures
Moderate	5	Floods in agricultural plots and roads, as well as isolation of human communities
Low	5	Floods of agricultural plots
	10	Floods of human communities, agricultural plots, and infrastructures, as well as zones of flooded soil
	5	Flooded soil, isolated human communities only accessible by sea
Very low	25	Floods of human communities, agricultural plots, roads and infrastructures

Box 2.2-1: Levels of risk from flooding of the Lempa River

Level of flood risk	Return period (years)	Areas of flooding or flooded soil (basis for zoning)
Very high	2	Floods of human communities and infrastructure
High	5	Floods of human communities, agricultural plots, and infrastructures
High	2	Impact to human communities, agricultural plots, and infrastructures
Moderate	10	Floods of human communities, agricultural plots, roads and infrastructures

3. Socioeconomic, Environmental and Climate Baseline

3.1. Socio-economic and Environmental Baseline

In order to define the socioeconomic and environmental scenario for the baseline year 2004 in the selected territory, a system of variables and indicators was established, and the variables and indicators were grouped by dimensions for each environment. The socioeconomic and environmental baseline presents the current state of the selected territory in terms of weaknesses and strengths affecting climate vulnerability.

Current state of the socio-cultural, natural and economic environments for the baseline year were defined based on the assigned values to the indicators and variables of different order, categorized according to the level of contribution to resilience or adaptive capacity.

Socio-cultural Environment

The three dimensions for the socio-cultural environment are the normative, cultural, and psychosocial dimensions. The normative dimension deals primarily with the organization aspect of the local inhabitants and was addressed through the following variables: flexibility, scope and nature of local organization; alliances with local actors and agents that promote sustainable development; and the normative framework for the promotion of local sustainable development.

The cultural dimension refers mainly to cultural patterns related to human behavior and its corresponding variables were defined as follows: endogenous processes of local development; harmony between human activity and the natural dynamics; and the historical, cultural, and territorial identity.

Lastly, the psychosocial environment was defined as determining the level of satisfaction or dissatisfaction with respect to the material and spiritual needs of human population. The corresponding variables for this dimension are: quality of life, territorial functionality and security.

Integrated Analysis of the Socio-cultural Environment Dimensions

As for the normative dimension, the weaknesses observed were the lack of initiatives and of agents, both public and private, which promote local sustainable development; the lack of municipal regulations for the advancement of local sustainability, as well as the relatively low ability for making timely decisions.

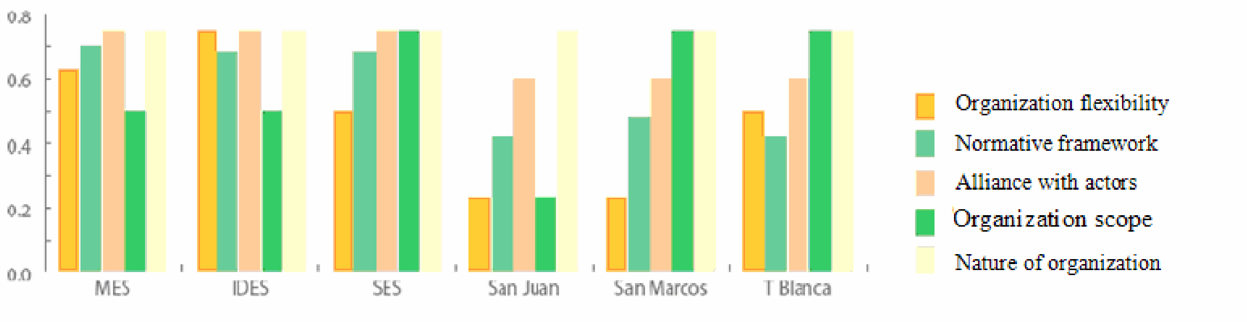

Figure 3.1.1: Explanatory variables of the normative dimension for the Socio-cultural Environment

Because of their complexity, extent, and high legitimacy, both the geographical scope and the nature of the development work being promoted by both local organizations, represented strengths for the normative dimension. The alliance with actors or with local, national or international agents corresponded to an observed medium to high level.

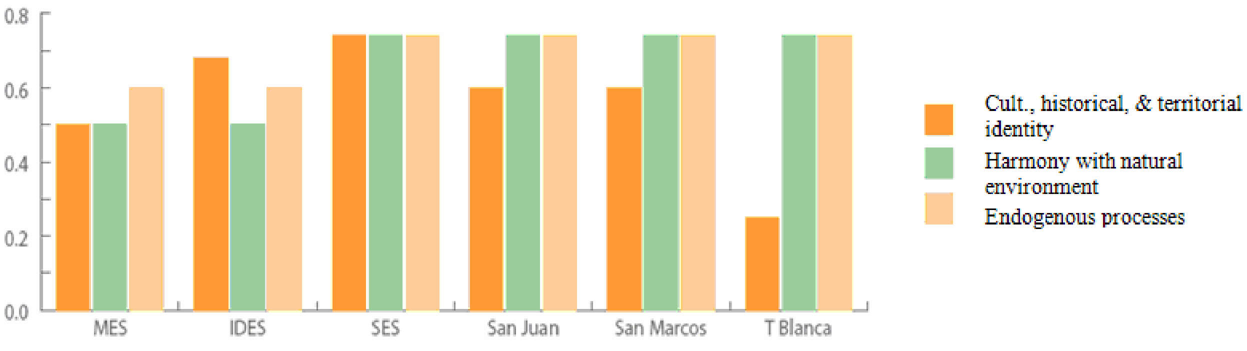

Figure 3.1.2: Explanatory variables of the cultural dimension for the Socio-cultural Environment

For the cultural dimension, the explanatory variables showed more strengths than weaknesses. Initiatives to strengthen the cultural, historical and territorial identity such as cultural tourism and agrotourism, presented high, medium, and low levels. The low levels were explained as the initiatives being at the very beginning or needing consolidation.

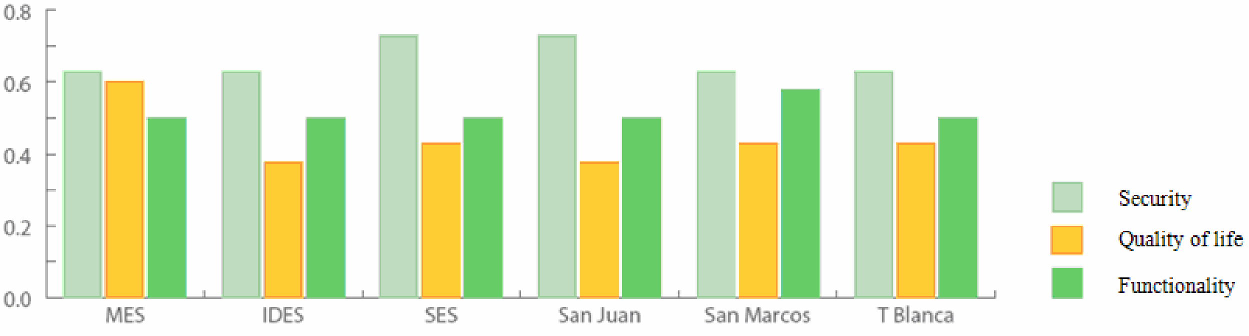

Figure 3.1.3: Explanatory variables of the psychosocial dimension for the Socio-cultural Environment

Regarding the psychosocial dimension, security with respect to delinquency represented the greatest strength. The selected territory has a high level of social organization and initiatives in place that promote non-violence, human rights, art and harmony with nature. With respect to functionality, the local flood Early Warning Systems, or SAT, were found to be effective and minimized the loss of life. The quality of life, on the other hand, was found to be low due to the lack of basic services and low levels of income.

Overall, the cultural dimension had the greatest strengths in both banks of the Lempa River for the selected territory. The figure below compares the level of strengths and weaknesses for each of the dimensions of the Socio-cultural environment.

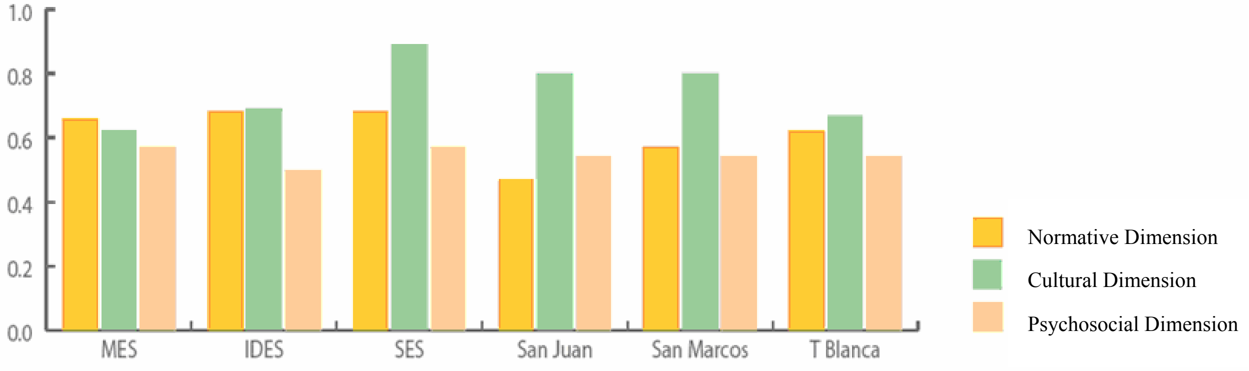

Figure 3.1.4: Level of strengths and weaknesses by dimension for the Socio-cultural Environment

Contribution of the socio-cultural environment to local vulnerability

The various variables that correspond to the three dimensions of the socio-cultural environment contribute to either strengthen or weaken both resilience and adaptive capacity to climate change of the selected territory. The following tables show the indicators and relationships between the explanatory variables of resilience and adaptive capacity with the explanatory variables for the three dimensions of the socio-cultural environment.

Indicators

1. No. of levels that participate in the strategic or operational decisions
2. No. of geographic levels for local development work
3. No. of thematic areas for local development work
4. No. of municipalities involved
5. CBL/GBL level of participation in alliances related to sustainable development
6. No. of public entities and projects
7. No. of participating non-government entities and projects

8. No. of municipal contributing ordinances
9. Endogenous level of the CBL/GBL development plans and programs
10. Endogenous level of the CBL/GBL development projects
11. CBL/GBL geographic influence on the promotion of endogenous local development
12. Contribution of local activities to conservation of the environment
13. Frequency of locally organized socio-cultural events
14. Contribution of local historical commemorations to strengthening local identity
15. No. of locally promoted tourism initiatives
16. Income level of the population
17. Level of access to basic services
18. Level of access to natural resources for food security of local population
19. Level of access to credit, technical assistance and training
20. Level of access to transport
21. Level of access to communications
22. Local and national SAT effectiveness in case of floods
23. Delinquency level

Sociocultural Environment

Dimensions	2nd Order Variables	Indicators
1. Normative	1.1 Organizational Flexibility	1
	1.2 Organization Scope	2
	1.3 Nature of the Organization	3
	1.4 Alliances to promote local sustainability	4,5
	1.5 Normative Framework	6,7,8
2. Cultural	2.1 Endogenous Processes	9,10,11
	2.2 Harmony with Environment	12
	2.3 Historical, cultural & territorial identity	13,14,15
3. Psychosocial	3.1 Quality of Life	16,17,18,19
	3.2 Functionality	20,21
	3.3 Safety	22,23

Vulnerability (Relationship with Sociocultural Variables)

Dimensions	2nd Order Variables	Sociocultural Variables
4. Resilience	4.1 Organization Type	1.1
	4.2 Control Mechanisms	1.5, 2.3, 3.3
	4.3 Structural Coupling	1.4
5. Adaptability	5.1 Resource Potential	3.1, 3.2
	5.2 Innovation and Experimentation	2.1, 2.2. 2.3
	5.3 Organization Complexity	1.2, 1.3

For the two banks of the Lempa River, both resilience and the adaptive capacity were found to have acceptable levels of strengths and weaknesses. The strength in resilience was associated with its control mechanisms and with its structural coupling. Adaptive capacity was found to have strengths in both the complexity of the social organization and in the promotion of innovation and experimentation.

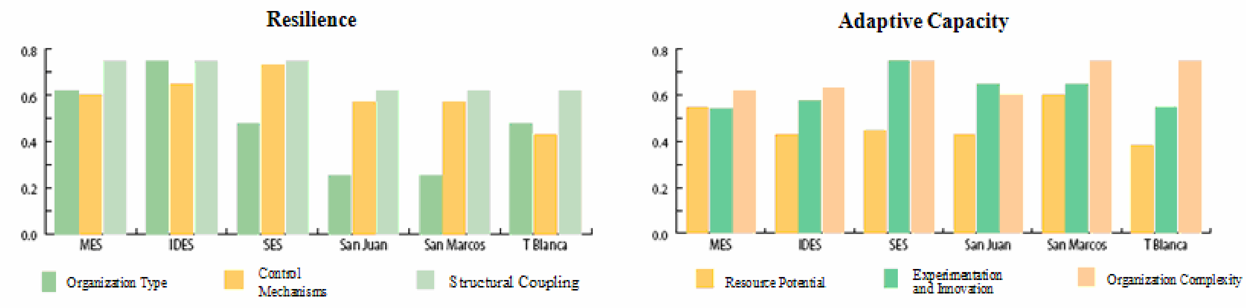

Figure 3.1.5: Variables of resilience and adaptive capacity for the Socio-cultural Environment

Adaptive capacity was weakest in terms of resource potential. In both banks of the Lempa River, both the functionality and quality of life of local families is low. There exists a weak social and economic infrastructure, low quality of health and education, poor access and provision of basic services and most of the population has access to only the basic food basket. In addition, there is no credit access and the human potential is restricted by the low educational levels, and the lack of technical assistance and training.

Resilience, on the other hand, is affected by the relatively slow process of decision making. This was explained by the high level of social participation, that although key to the local development process, could potentially debilitate the ability to respond fast to some threats or opportunities.

The Natural Environment

The natural environment was addressed through two dimensions: the natural and the socio-natural. The natural dimension is related to the natural landscape and ecosystems, to essential environmental functions, as well as to life and human activity supporting functions. The socio-natural dimension is associated with natural resources and environmental management for both banks of the selected territory.

The Natural Dimension

Two variables were defined for the natural dimension. The first is essential environmental functions defined as the morpholithogenic, hydroclimatogenic, and biopedogenic processes for natural systems in the selected territory; the second is life and human activity supporting functions which among other things facilitate the availability of natural resources for local economic production.

Due to the lack of data and information on morpholithogenic processes and based on the observed local physical processes, only indicators related to erosion and sedimentation of rivers and neighboring terrain; changes in rivers beds, streams, and tributaries; and ground seismic sensitibity, were chosen as morpholithogenic indicators.

Regarding the hydroclimatogenic processes only indicators associated with the volume of local rivers and land moisture levels were selected. This is explained from the fact that there is a lack of studies specialized on environmental sustainability of fluvial systems and on microclimate patterns of the selected territory and its interactions with large-scale climate dynamics.

For the biopedogenic processes, the selected variables correspond to the land agrologic potential, and the type of ecosystems, abundance of species, habitat, and cover for ecological corridors and natural areas.

Indicators for the life and human activity supporting functions describe the local availability of forest, aquatic, and marine species for use in food security, sale, housing, construction, energy, and production. In addition, they relate to the availability of rock and sand resources; water for families, agriculture, and livestock use; and the existence of forests for mitigation of river and stream floods.

The following tables show the relationship between the explanatory variables of resilience and adaptive capacity with the explanatory variables for the natural dimension, and the associated indicators.

Indicators

1. Sedimentation and erosion
2. Rivers and creeks that have changed their course
3. Seismic and geological susceptibility
4. Discharge of local streams
5. Soil moisture seasonal content
6. Soil agrological potential
7. Number of different ecosystems
8. Relative amount of vegetable and animal species
9. Threat of habitat loss
10. Coverage of environmental corridors and natural areas
11. Availability of vegetable species and forest products for human and animal food and sale
12. Availability of energy-related forest species for family use, production and sale
13. Availability of aquatic and marine species for human consumption and fishing potential
14. Level of scenic beauty for human welfare and tourism
15. Availability of forest species for consumption and sale (housing, health, fuel)
16. Availability of rock minerals and sand
17. Availability of water for family use
18. Availability of water for local production activities
19. Forest influence on flood mitigation
20. Flood frequency
21. Soil permeability and drain capacity
22. Soil salinity
23. Availability of and access to underground water
24. Conflict between actual and potential land use
25. Influence of hydroelectric dams on flood dynamics
26. Level of deforestation
27. Air pollution: risk of sugar cane ripening agents
28. Soil pollution: fertilizers, pesticides and waste
29. Level of exploitation of local land, aquatic and marine species
30. Contribution of protection works to flood mitigation
31. Protection of the existing natural areas

Natural Environment Variables

Dimensions	2nd Order Variables		Indicators
6. Natural	6.1 Essential environmental functions	6.1.1 Morpholithogenic processes	1-3
		6.1.2 Hydroclimatogenic processes	4,5
		6.1.3 Biopedogenic processes	6-10
	6.2 Functions that support life and human activities		11-19
7. Socionatural	7.1 Environment influence and prevalence		20-23
	7.2 Capacity for management and transforming the environment		24-31

Natural Environment and Vulnerability

Vulnerability Variables		Natural Environment Variables
1st Order	*2nd Order*	*2nd Order*
8. Adaptive Capacity	8.1 Natural Resources Potential	6.1
		6.2
9. Resilience	9.1 Structural Coupling	7.1
		7.2

Integrated Analysis of the Natural Dimension

With respect to the essential environmental functions, the weaknesses found relate to the cycles of adaptation of the natural systems and to anthropic processes of environmental degradation. These include tectonic and volcanic earthquakes and frequent extreme climate events that occur as part of the natural climate variability and, on the other hand, deforestation and air, water, and land contamination.

Manifestations associated with the weakened essential environmental functions include the increase of land sedimentation and erosion, the change in the river or stream beds due to hydrologic imbalances, and the apparent decline in the volume of rivers during the dry season.

The preservation and coverage of species and natural habitats showed medium to low levels; nevertheless, it was noted that there exists efforts from local actors and organizations to encourage expansion of permanent vegetative coverage, conservation of species and habitat, and sustainable management of forests.

Both the high level of conservation for the diverse ecosystems and the good level of visual quality of the natural landscapes within the selected territory were considered strengths as well as genuine opportunities for local development.

As regards the life and human activity supporting functions, one of the strengths mentioned for this variable of the natural dimension are the programs currently being promoted for embracing sustainable forms of environmental production and consumption. It was noted, however, that there exists high pressure from external agents that conduct non-sustainable use of the local natural systems.

Weaknesses included a low level of availability and access to natural resources in most of the zones and micro-regions of the selected territory, and also the limitations imposed on local population by current normative framework that establishes the type and level of access to natural resources such as land, water, energy, and animals. It was determined that current patterns of human intervention over nature could threaten and possibly collapse natural systems if these continue.

The figure below summarizes the strengths and weaknesses for the natural dimension of the Natural Environment for both banks of the selected territory.

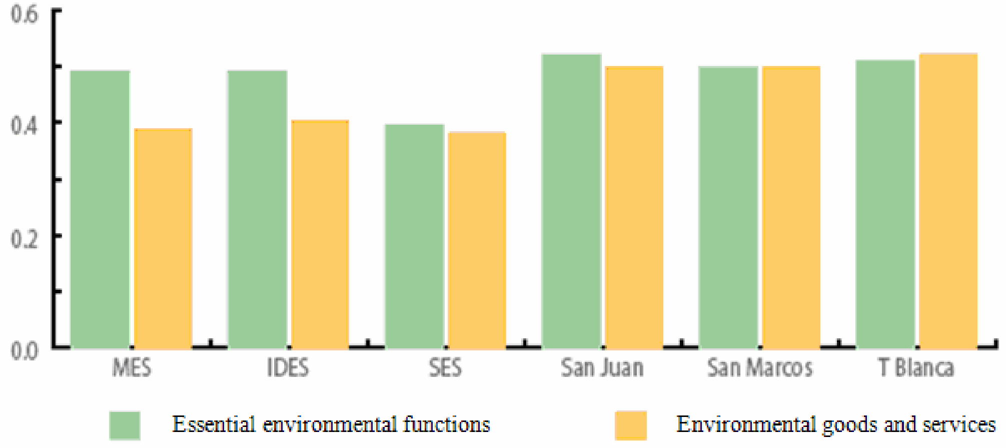

Figure 3.1.6: Level of strengths and weaknesses for the natural dimension of the Natural Environment

The Socio-natural Dimension

The socio-natural dimension was addressed using two variables: environmental influence and prevalence, and capacity of environmental management. Environmental influence and prevalence refers to the potentialities, restrictions and limitations that natural systems impose on human activities within the economic and socio-natural environments. The capacity of environmental management relates to the way in which human activities control or affect natural environment

The indicators for the first of these two variables are associated with the incidence of floods, salinization, permeability and land drainage capacity, and the availability of water from aquifers in quantity and quality. The indicators for the capacity of environmental management variable are land use; hydroelectric dam management incidence; water, land, and air pollution; species exploitation, flood mitigation works; and protection of natural areas.

As regards the strengths of environmental influence and prevalence, it was found that the majority of micro-regions and zones are not significantly exposed to land salinization processes. Furthermore, there exist regions and micro-regions that have conditions of good land permeability and drainage, as well as a low level of exposure to floods.

A major weakness found is the low level of water availability in aquifers, which are mostly affected by water pollution.

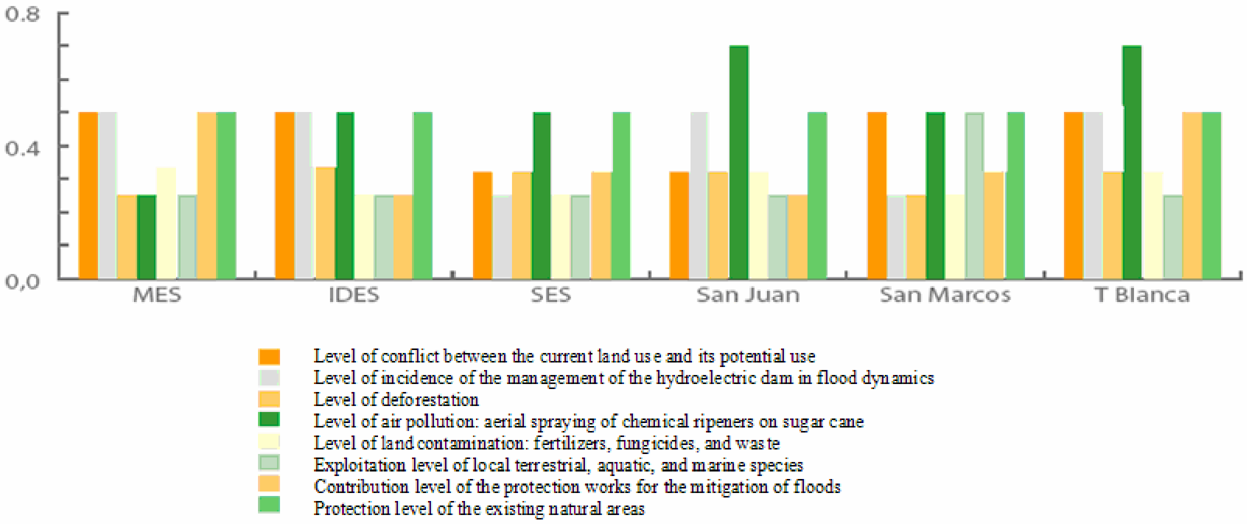

Figure 3.1.7: Contribution to the natural resources and environmental management capacity of the Natural Dimension

With respect to the environmental management capacity the main strengths found were as follows: low air contamination in some geographical areas of the selected territory, moderate level of conflict between actual and potential land use, level of protection of natural areas, and extensive legal standards for the restoration, conservation, and sustainable management of natural areas within the selected territory.

Major weaknesses include the relevant level of land contamination, species exploitation, and high indices of deforestation in some areas.

Integrated Analysis of the Natural Environment Dimensions

The comparative analysis of strengths and weaknesses for both the natural and socio-natural dimensions identified a majority of strengths for the natural dimension. These were related to the contributions from the state and dynamics of the essential environmental functions.

Low values corresponding to the socio-natural dimension reflect the major harmonizing and coupling weaknesses that exist between the intervention patterns and management of the selected territory and the dynamics of natural system.

Contribution of the Natural Environment to Local Vulnerability

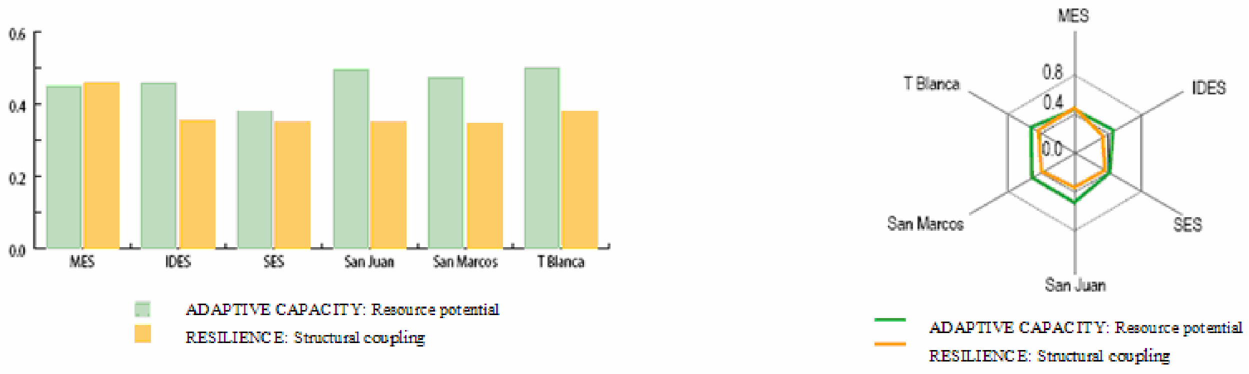

Figure 3.1.8: Natural environment contribution to adaptive capacity and resilience of the selected territory

Adaptive Capacity

The explanatory variable related to adaptive capacity for the natural environment is the natural resources potential. The existence, magnitude, and sustainability of this variable depend on, among other factors, the current state and past trends of the essential environmental functions of natural systems.

Current state of both the essential environmental functions and the functions that support life and human activities varied from medium to low with three of the six geographical areas in the selected territory showing low values.

Weaknesses for the essential environmental functions include the seismic susceptibility of land, the close proximity to a subduction zone of plate tectonics, sedimentation processes of rivers and agricultural land, changes in river and stream beds due to, among other factors, deforestation, as well as changes in the volume of local rivers and tributaries and the decrease in land moisture.

Strengths found were the great diversity of the natural systems; agrological potential of land; abundance of natural ecosystems, animal and vegetable species; and existing parts of natural areas and environmental corridors selected by El Salvador's governmental authorities as protected areas.

Past and current intensity and pattern of human intervention on natural systems was noted to have reduced forest coverage, contaminated fluvial systems, eroded and contaminated land, destroyed the natural habitat, and decreased the abundance of species, as well as disturbed life cycle. The resulting increased vulnerability to climate variability, global climate change, and to environmental disturbances of natural or socio-natural origin, explained the medium to low values in the processes and fulfillment of the essential environmental functions.

With regards to the functions that support life and human activities, the mayor weaknesses were the degree of water availability in quality and quantity for consumption and use by families and for agricultural and livestock activities, and the lack of forests to mitigate the incidence of floods.

Resilience

Structural coupling is the second-order explanatory variable of vulnerability in terms of resilience. As structural coupling increases, the greater the coping range of human systems with respect to the incidence of natural dynamics.

Structural coupling is determined by both environmental influence and determination and the capacity of environmental management. The level of environmental influence was found to be medium to high mainly because of the pattern of river flooding.

The major weaknesses were the contamination of the aquifers during floods and the high levels of water saturation in land due to the type of soil and low drainage capacity. These are noted to affect crops, result in the isolation of various human settlements, cause human health problems, and limit the possibility of transporting goods due to bad local road conditions.

As regards the capacity of environmental management, it was found to be at a medium to low level. This, due primarily to the high levels of land contamination; to high level of exploitation of terrestrial, aquatic, and marine species; and to insufficient and ineffective flood prevention and mitigation works. An important note was that the sources of water and soil contamination and the excessive capture of marine species are from external agents to the territory. In addition, the management of the hydroelectric dams is under the responsibility of agents at the national level.

The Baseline Local Climate

For the characterization of local climate, observations from meteorological stations with information on the variables precipitation and temperature were considered. The best records correspond to the 70's decade, since the information available afterwards is scarce and refers only to the precipitation variable. Many of the meteorological stations had short record series and usually showed discontinuities.

Data used is from meteorological stations within or close to the selected territory. These were categorized according to the number of observations and records, as follows: (1) Category “P” was given to stations having records on precipitation only; (2) category “CO3” was assigned to stations with three daily observations and records of other parameters such as temperature (“common climatology”); and (3) category “CP3” was given to stations with three daily observations and more complete records, which include parameters such as humidity and wind (“principal climatology”).

The territory’s climate is influenced primarily by the adjacent waters of the Pacific Ocean and by the meteorological systems associated with the ITCZ and Easterly waves. Local weather and climate are frequently influenced directly by migratory tropical hurricane systems Also, as mentioned previously, the selected territory is the area of greatest vulnerability in the country and the most affected by frequent extreme droughts and floods.

In terms of precipitation, the months May through October define the rainy season and show daily averages greater than 5mm (approx. 0.20in); the rest of the months are considered dry. However, during April and November, the transition months, a significant amount of precipitation occurs with a total monthly average of 50mm (approx. 1.97in). The following graph shows the monthly mean precipitation from 1961 to 1965 from the meteorological station La Carrera (classified under Category CP3).

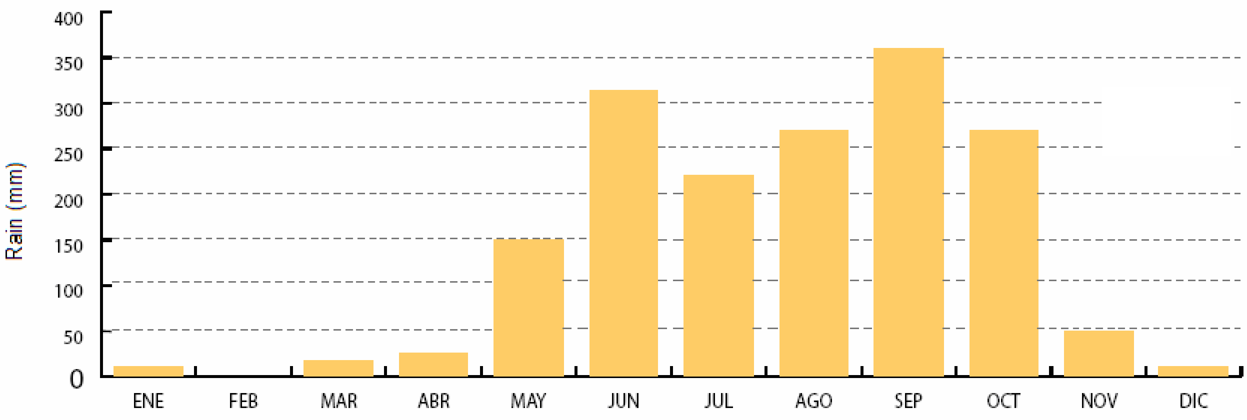

Figure 3.1.9: Mean monthly precipitation for 1961-1985, La Carrera station

As regards extreme temperatures within the selected territory, the highest temperatures occur during the day around two in the afternoon, while the lowest temperatures occur around five in the morning. Land-sea breezes regulate local climate and in the morning produce an onshore-breeze that contributes to the humidity, rain generation, and freshening of the environment in the selected territory. The graph below, also from the La Carrera meteorological station, shows the behavior of the maximum and minimum mean temperatures during the year.

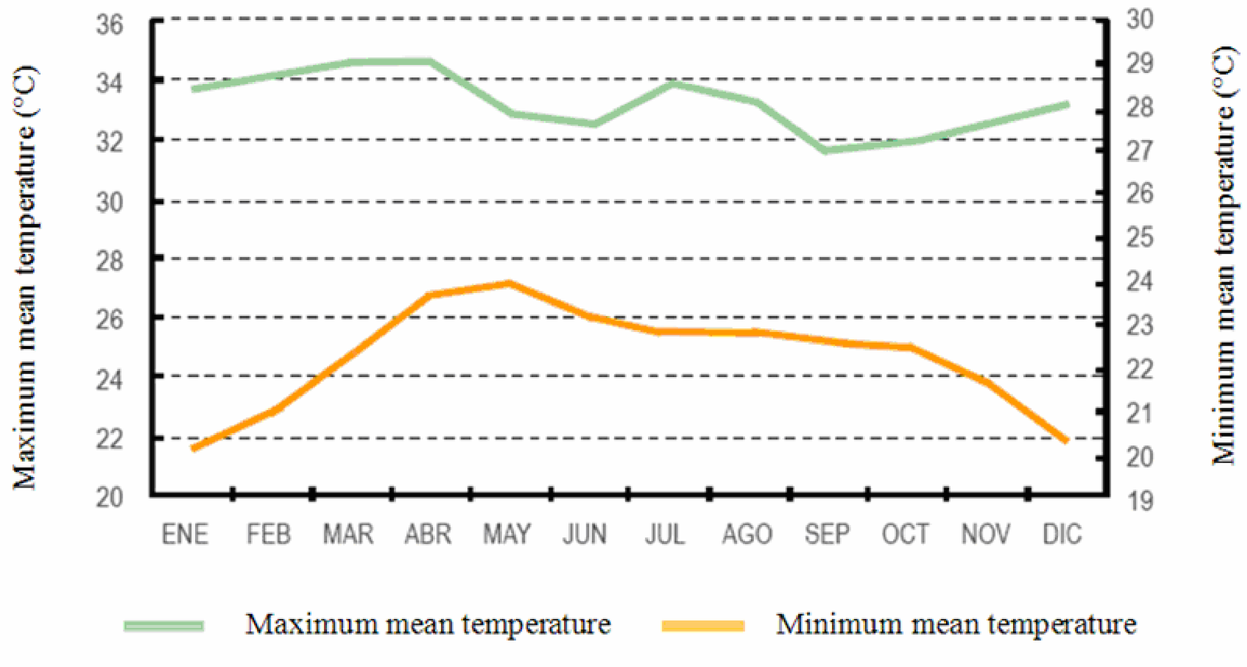

Figure 3.1.10: Behavior of monthly extreme mean temperatures

The Economic Environment

The study of the economic environment focused on the family-scale economy and analyzed the survival strategies chosen by rural population: subsistence, commercial agriculture, integrated commercial agriculture, double-purpose cattle raising systems, and traditional fishing. The analysis of the economic environment was based on the three dimensions identified as explaining the local economic cycle: production, commercialization, and distribution & consumption. Shown at the end of this section are the variables and associated indicators for this environment.

The Productive Dimension

This dimension refers mainly to the type and diversity of productive activities adopted by families in the selected territory and is addressed by looking at the organization of production and the technological level.

As regards the organization of production, both banks of the Lempa River show a process of diversifying their economic activities. This is manifested in the various initiatives of the agriculture/livestock sector, such as agriculture, cattle-raising, and traditional fishing. Those activities not related to the agriculture/livestock sector include agribusiness, tourism, ecotourism, transportation, commerce, and other services.

The drive for diversification of productive activity is noted to be important due to the (i) trend for small-scale cultivation areas, which is a result of socioeconomic conditions of people within the selected territory, and (ii) because it enhances the level of productivity of the agriculture/livestock sector. Because of diversification, the organization of the family-scale production is noted to be the major strength for the productive dimension.

With regard to the technological level, both banks of the Lempa River show lack of innovation and technical assistance in support of activities related to the agricultural and livestock sectors. The low level of implementation of appropriate technologies is the major weakness for the economic dimension and is evident in the sensitivity that the agricultural and livestock species show in response to droughts and floods. It is noted that local species, vegetables, grasses, and fish, among others, do not cope well with precipitation and temperature variations.

An appropriate technological response to climate threats does not exist in the selected territory. There is a lack of technical assistance from public entities and of policies to encourage technological innovation and experimentation. Vulnerability of the family-scale economy to climate variability is considered a topic of great importance to the selected territory.

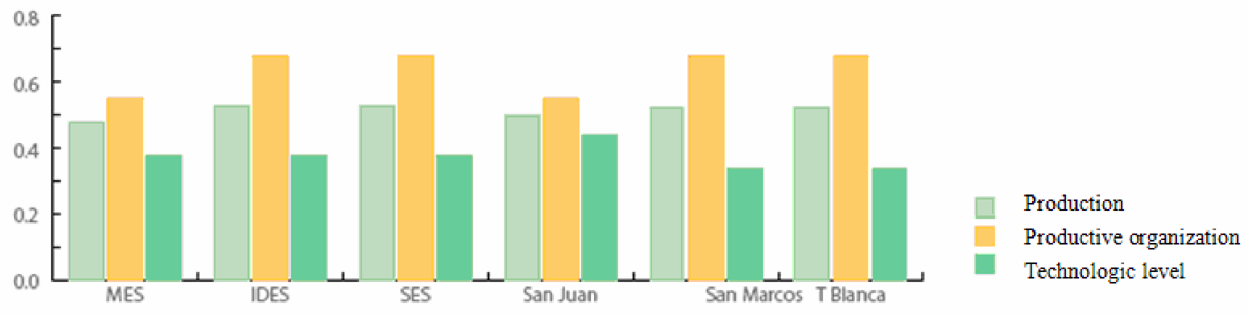

Figure 3.1.11: Explanatory variables for the productive dimension of the Economic Environment

The Distribution and Consumption Dimension

A fundamental component of this dimension is the family buying capacity, which is determined by the level and source of income, the structure of land tenure and other assets, and the quality and scope of educational services, public health, basic services, and credit. This dimension was therefore approached by looking at the level of access to resources for economic activity with respect to the following variables: source of family income, land tenure, and access to credit by local families.

The low level of access to credit in all of the territory was the greatest weakness for this dimension. Due to lack of guarantees, the national financial system determines that the majority of local people not be eligible for credit. The family buying capacity is low and families have access only to the basic food basket.

With respect to land tenure, at least 60% of the families own land, yet this has not been sufficient in order to stimulate the economy through agriculture/livestock activities, or to improve the income and buying capacity of families.

As for family income, the biggest strength has been the acquired capacity of households to be less dependent on income generated from agricultural and livestock activities. This is due to the increased risks to the small producer in the agricultural and livestock sector as a result of national policies implemented for the economic sector in the past two decades. Privatization, deregulation, and reduction of public function processes in the last 20 years have caused deprived rural areas to suffer a subsequent lack of public investment in social and economic infrastructure and services.

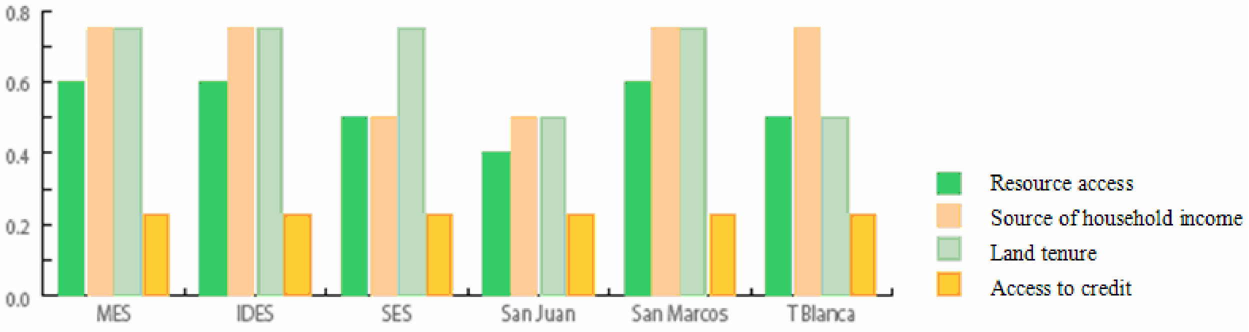

Figure 3.1.12 : Explanatory variables of the consumption and distribution dimension

The Commercial Dimension

The emphasis for this dimension is the commercialization of production, which is approached through the following variables: level of connectivity between communities and parcels in support of economic activity, level of market diversification for production, and the degree of market-oriented local production.

In general, the deficiency in access roadways and transport by sea and land, as well as the lack of access to new markets were noted to be barriers to the circulation and commercialization of goods and services. During the rainy season, many of the roads become inaccessible to road traffic making the transfer of products from land plots to markets difficult or impossible. In addition, land and sea transport is not pertinently available for most of the territory and its cost not affordable to local people.

As regards the access to new markets, one of the barriers mentioned is the risk transferred to small producers by the market-dominant intermediaries who, for example, return the items which are not sold defer payments for up to six months. Nevertheless, in both banks of the Lempa River there is a strong movement towards the search, penetration, and opening of new markets for agriculture/livestock production, agroindustrial production, and tourist services.

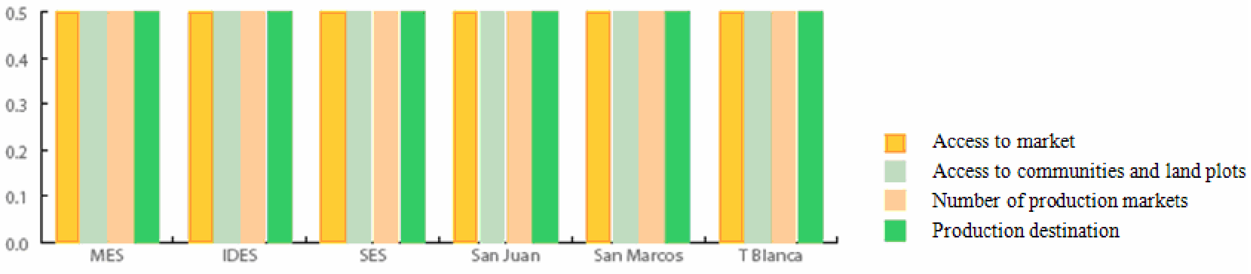

Figure 3.1.13: Explanatory variables of the Economic Environment's commercial dimension

Integrated analysis of the economic environment's dimensions

Local economic potential exists due to the considerable number of families who own land plots and who have strived for productive and social organization. By diversifying livelihoods and agricultural and livestock species, the risks associated with climate vulnerability have decreased in the selected territory. However, the lack of financial capital, physical infrastructure and equipment remain barriers to the stimulation of local economy. In addition, the state of poverty of local people in both banks of the Lempa River limit human capacities needed for the development and adoption of appropriate technologies, research and penetration of markets, and emergence of innovative undertakings.

The following graph summarizes the strengths and weaknesses of the three dimensions in the Economic Environment:

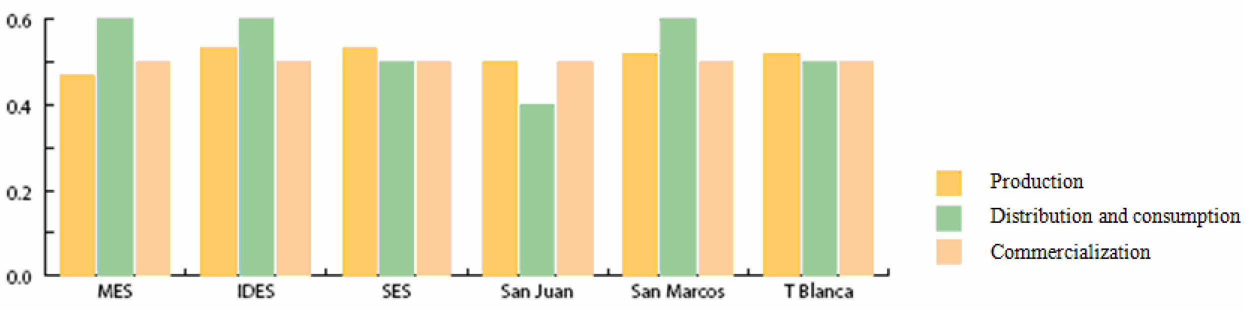

Figure 3.1.14: Level of strengths and weaknesses by Economic Environment

Contribution of the economic environment to local vulnerability

In general, medium values were obtained for both resilience and adaptive capacity of the family-scale economy. Higher resilience values are explained as local families' attempts to increase their income from non livestock and agricultural activities, as well as the high yields of basic grains. Adaptive capacity was noted to be similar for the various geographical areas, but in some cases affected by the low level of resource potential and the lack of innovation and experimentation. Resilience tends to be higher than adaptive capacity mainly because of efforts developed by existing organizations to overcome problems arising from local biophysical conditions.

Tables below show the relationship between the explanatory variables of resilience and adaptive capacity with the explanatory variables for the economic environment dimensions. The following are the indicators for the economic environment:

Indicators
1 No. of local agricultural activities
2 Basic grain planted area
3 Diversity of livelihoods associated with local survival strategies
4 Relative efficiency in the agriculture/livestock productive activities
5 % people with access to technical assistance for production
6 % producers with innovative methods and technology
7 % producers utilizing irrigation in production activities
8 Technological response in the agriculture/livestock sector to local temperature
9 Technological response in the agriculture/livestock sector to local precipitation
10 % income from activities others than agriculture/livestock activities
11 % people who own the land for the agriculture/livestock activities
12 % people who have access to credit for economic activities
13 Access to local human settlements and parcels
14 No. of markets available and accessible for what is locally produced
15 % of market-oriented production

Economic Environment			
Dimensions	**2nd Order Variables**		**Indicators**
10. Production	10.1 Production organization	1.1.1 Diversification of survival strategies in the agriculture/livestock sector	1
		1.1.2 Productive capacity of basic grains	2
		1.1.3 Diversity of livelihoods incorporated in survival strategies	3
		1.1.4 Local production efficiency in the agriculture/livestock sector	4
	10.2 Technological level	1.2.1 Technical assistance	5
		1.2.2 Experimentation and innovation	6
		1.2.3 Irrigation use	7
		1.2.4 Technological response to local temperature	8
		1.2.5 Technological response to local precipitation	9
11. Distribution & consumption	11.1 Access to resources	2.1.1 Origin of family income	10
		2.1.2 Land tenure	11
		2.1.3 Access to credit	12
12. Commercialization	12.1 Access to market	3.1.1 Level of connectivity between communities and parcels with economic activity	13
		3.1.2 Level of market diversification for production	14
		3.1.3 Degree of market-oriented production	15

Vulnerability (Relationship with Economic Variables)		
Dimensions	**2nd Order Variables**	**Economic Variables**
13. Resilience	13.1 Organization Type	1.1.1, 2.1.1
	13.2 Control Mechanisms	1.1.4
	13.3 Structural coupling	1.2.4, 1.2.5
14. Adaptive Capacity	14.1 Resource Potential	1.1.2, 2.1.2, 2.1.3, 3.1.1, 3.1.2
	14.2 Innovation and Experimentation	1.2.1-1.2.3
	14.3 Organization Complexity	1.1.3, 3.1.3

3.2. Current local climate threats and impacts

Calculation of the current climate vulnerability index (CVI)

Climate vulnerability in the territory was analyzed by addressing it as a function of three explanatory variables: climate exposure, resilience, and adaptive capacity.

Climate exposure was addressed from a climate threat point of view. To calculate climate threat, a Climate Threat Index, or CTI, was constructed based on five meteorological indicators associated with temperature and precipitation extremes. The latter includes extreme wet and dry climate events.

Annual records of maximum and minimum temperature and precipitation for the baseline period 1961-1990 were used to develop the indicators and were acquired from the San Miguel-UES meteorological station (Latitude: 13° 26.4' N, Length: 88° 07.6' W). The following criteria were used to select the meteorological station: (a) level of representativeness for the selected territory, as per the Principal Component Analysis; (b) 30 years or more of availability for records of daily precipitation for the period 1961-1990; (c) availability of precipitation records updated up to the year 2005, and (d) 30 years or more of availability for records of maximum and minimum temperature.

The behavioral pattern of the indicators and remaining data were estimated using the Statistical Downscaling Model or SDSM (see Appendix II). All records below the first quantile were considered to be extreme dry events while all records above the fifth quantile were considered extreme wet events.

The first step in estimating the value for the CTI was to define and calculate a range for each of the five selected indicators for the period 1961-1990, as shown in the table below. The probability that the event occurs is given in parenthesis, e.g. 1(23) is the recurrence of an extreme dry year each year (continuous) with a probability of 23%.

The small size of the selected territory allowed the calculation of a single CTI value, since there is no micro-regional or zonal information on the indicators and all the geographical areas including the human communities considered under the study, are located within the two coastal plains covered by the selected territory, where local climate is very similar.

Box 3.2-1 Ranges associated with the behavioral pattern of the meteorological indicators for the baseline climatology (1961-1990)

Symbol	Meteorological Indicator		Behavioral Range (1961-1990)				
			A	B	C	D	E
Rsx	1	Recurrence of an extreme dry year (years)		1(23)	2(6)	4(6)	
Rlx	2	Recurrence of an extreme wet year (years)		7(10)	4(3)	1(3)	
DC40mm	3	Maximum number of days with consecutive rain ≥ 40 mm (days)		4(1)	3(2)	2(7)	
RPS11d	4	Recurrence of periods with consecutive dry days ≥ 11 days during July and August (years)		1(26)	2(6)	4(6)	
Atx	5	Increase in maximum annual temperature during an extreme dry year (°C)	<0.4	(0.4-0.5)	(0.6-0.7)	(0.8-0.9)	>0.9

As for indicators (1) and (5) of the CTI, the occurrence of an extreme dry year (mean annual precipitation below normal levels) does not necessarily imply an increase of annual mean maximum temperatures. When an extreme dry year is determined by a decrease of the seasonal mean precipitation below the normal rainy season´s levels (with the highest temperatures of the year); the annual mean maximum temperatures increase. Whereas if an extreme dry year is determined by a decrease of the seasonal mean precipitation below the normal dry season´s levels (with the lowest temperatures of the year due to prevailing anti-cyclonic conditions); the annual mean maximum temperatures do not necessarily increase.

After defining the behavioral range for each indicator, the level of threat associated with each one was defined. This was done by identifying the impacts on the productive, hydrologic and hydraulic processes. Specific criteria allowed the categorization of the impacts and the subsequent quantification of the levels of threat.

The current value for the CTI was calculated as a simple average of the values calculated from two sub-indices: levels of climate threat on productive activities (IAC-p) and levels of climate threat on the hydrologic and hydraulic processes (IAC-h) in the selected territory. According to the value calculated for the CTI, the level of climate threat in the selected territory is moderate.

Note that the CTI only reflects the level of local climate threat derived from extreme climate events associated with the precipitation and temperature variables. It does not reflect the climate threat related to other climate event or process.

Identification of current climate local impacts

As regards productive activities, the greatest exposure is determined by the recurrence of an extreme dry year, the maximum number of consecutive days with rain ≥ 40mm, and the recurrence of periods with consecutive dry days ≥ 11 days during July and August. Variations in temperature are also noted to constitute a threat to production, especially when combined with the midsummer drought[‡] during the rainy season.

With a recurrence of an extreme dry year droughts and the adverse affects of flooding are heightened thereby triggering the decrease in yields from agricultural and livestock activities. The recurrence of periods with consecutive dry days ≥ 11 days during July and August has an increasing adverse affect as the midsummer drought intensifies, which affects the harvest from the May sowing and creates problems for activities associated with the August sowing period. The increase in annual maximum temperature during an extreme dry year increases evapotranspiration and therefore water demand for crops, especially during the dry season.

The hydrologic processes are affected mainly by the recurrence of extreme wet or dry years. As water balance depends on the rain volume rather than the number of rainy days, the decrease in rainy days during the extreme dry years has a greater impact than the number of consecutive days with rain ≥ 40mm and the recurrence of periods with consecutive dry days ≥ 11 days during July and August.

Increases in temperature also have negative effects on water balance. As a result of the increase in evapotranspiration, there is a loss of vegetative land cover in the selected territory which exacerbates the negative impacts associated with local water availability.

4. Future Socioeconomic, Environmental and Climate Scenarios

See Appendix I for a description of the methodology and technical criteria implemented to develop local socioeconomic scenarios. Appendix II shows the methodology used to develop future climate scenarios.

[‡] The annual cycle of precipitation over the southern part of Mexico and Central America exhibits a bimodal distribution with maxima during June and September and a relative minimum during July and August, known as the midsummer drought.

4.1. Future local socio-economic and environmental scenario

Future local socio-cultural environment

The projection of the 23 indicators of the socio-cultural environment by 2015 showed a strengthening of the three dimensions of the socio-cultural environment with respect to the baseline.

The greatest projected growth in both banks of the Lempa River was for the cultural dimension, this as a result of the level of increase for the following indicators: *high to very high* endogenous processes of local development; *very high* harmony with the local environment; *very high* cultural, historical, and territorial identity. The projected growth for the normative dimension had levels between *high* and *very high*, while the psychosocial showed a *high* level of projected growth.

The rate of improvement for the level of projected growth for the normative dimension was greater than the rates for the other dimensions in both banks. This was due to the high rates of improvement for the following three of the five indicators of the normative dimension: *high* level of security and functionality in the western bank of the territory, *very high* functionality and *high* security for the eastern bank of the territory, and *medium* level of quality of life in both banks.

Contribution of the socio-cultural environment to the projected future local vulnerability

There was a higher projected level of growth for resilience and adaptive capacity in both banks of the selected territory. This was due mainly to the efforts and commitments projected for local actors in the search of opportunities for local endogenous development. Comparative current pattern between resilience and adaptive capacity in both banks does not change.

The high levels of projected growth in the case of resilience are due to the *high* levels associated with the variable *control mechanisms* in the western bank and to the *very high* levels associated with the variable *structural coupling* in the eastern bank.

As regards the projected improvement rate, it is greater for the adaptive capacity than for resilience. In both banks, the rate of improvement for adaptive capacity was due, consecutively, to the contribution of the following variables: experimentation-innovation, complexity of organization, and resource potential.

Future local natural environment

The baseline values for each of the 31 indicators of the natural environment were projected to 2015 using as a guide the action lines derived from the local expression of the socioeconomic and environmental dynamics. In general, the results showed an increase in climate vulnerability due to the decrease in natural resource potential and a substantial improvement in local capacities to properly manage the local environment.

The essential environmental functions in both banks showed an increase in the processes of deterioration with regards to the agrologic potential of land and the erosion processes in the middle and high parts of the river basins. No significant changes are expected with respect to the sensitivity to the effects of seismic and geological behavior.

Since precipitation projections by 2015 indicate a rain decrease during the rainy season and an increase in temperatures, it is expected that future stream flow levels and the level of land moisture will continue to decline.

With respect to the life and human activity supportive functions, a decline in the level of water availability for consumption and family use is expected as a future scenario, especially for the western bank of the selected territory. This arises from the gradual decline in phreatic levels and base flows that, for the most part, the middle and high parts of the territory are already experiencing. Water in these parts is largely distributed for consumption by use of tanks for the extraction of subterranean water or by natural spring water.

The eastern bank is not expected to be significantly affected because the coastal plain is seen as equivalent to a high yielding aquifer. Even with a decline in phreatic levels the availability of the resource would still be maintained.

In the case of rock and sand resources, the eastern bank would be the most affected due to the increase in exploitation in fragile areas which would demand efforts for environmental conservation. With respect to the effectiveness or incidence of forests in flood mitigation, it is projected that current conditions in the eastern bank, which are the result of efforts and projects to extend and conserve forest cover in shore and transition areas, will be maintained. The contribution of forests to adaptive capacity is expected to decline in the western bank since forest cover is under great pressure and protection regulations are scarce, non-existent or ineffectively implemented.

The incidence level of flooding is expected to remain the same in the future for both banks, within current prevailing conditions. With respect to the Lempa River, these would be the mitigation of extreme events through improvements in the operation of the hydroelectric dam and the ongoing deterioration and deficiency of the protection and drainage infrastructure. In the case of secondary rivers, there would be recurrent flooding and flood-related damages, such as those that already happen annually in the western bank and the coastal fringe of the eastern bank.

Soil salinity conditions by 2015 would be similar to current conditions, without considering an eventual sea level rise. As regards ground permeability and drainages, current impacts would increase by 2015 in the western bank due mainly to the accretion of silt and the advanced state of deterioration of drainages.

A decrease with respect to current conditions in water availability from aquifers, and therefore a decrease in the local adaptive capacity, is expected for both banks of the Lempa River. This is seen as being directly linked to the high rate of water contamination and the gradual processes of environmental deterioration of the river basins.

With respect to the values projected for the indicators related to the capacity of environmental management, the level of conflict between current and potential land use is maintained in both banks of the selected territory. Although, for the western bank, a drop in the level of conflict is projected due to the short term adoption of land planning municipal ordinances, which are expected to decrease the level of territorial vulnerability in a future scenario.

Deforestation processes are projected to increase by 2015 for both banks of the selected territory due to lack of controls and pressure to obtain firewood and lumber for the national market of the construction sector. Both banks would also see a decrease in the capacity of protection against floods due to the scarcity of infrastructure works for protection and drainage.

Contribution of the natural environment to the projected future local vulnerability

The results show a significant contribution of the natural environment to local future vulnerability. Adaptive capacity and resilience are expected to decrease in both banks. In the western bank, the essential environmental functions would show the greatest rate of change with respect to current conditions, which would in turn decrease the contribution from the resource potential variable and would affect negatively future adaptive capacity.

The structural coupling variable of the selected territory would not show major changes with respect to current conditions. This is mainly due to the existing short and medium-term initiatives and local projects which would affect positively in preventing a higher deterioration of the environment.

A significant reduction in resource potential is projected in both banks of the selected territory. The resource potential variable shows the greatest rates of change with respect to current values and the highest contribution to local vulnerability. Structural coupling presents an evident decrease in future values with respect to current values and therefore a decrease in its contribution to future local resilience.

Future local economic environment

The baseline values for each of the 15 indicators of the economic environment, grouped under the three dimensions that characterize it, were projected to 2015. To assign the future values of the indicators, an analysis was conducted by means of discussion workshops with community leaders and the territory's technical groups, which allowed examining and visualizing possible trends and future settings of the local economic activity.

Productive activity would show a general trend to improve in the different micro-regions and zones of the selected territory. The major strengths would be found in the productive diversification of both agriculture/livestock activities and the livelihoods of families. An improvement in productive efficiency is also evident in the eastern bank due to better use of resources.

The area planted with basic grains would tend to decrease due to the loss of profitability of such grains and because of the increase in the planting of other species. An analysis done by local people shows that this would not affect the family food security as there would be an area of cultivation that would cover the minimum family food needs.

In general, it is expected that diversification of the productive-basis will be strengthened in both banks of the selected territory for both the agriculture/livestock and non agriculture-and-livestock activities. There would also be an improvement in the level of agricultural productivity.

The coverage of technical assistance and training would not show significant variations due to the limitations of local organizations to assist a greater proportion of the producers and the lack or inexistence of government institutions in the selected territory. The greatest technological strengths would appear in the use of species and varieties with greater coping range or resistance to climate change, in the extension of irrigated agricultural area coverage, and for the eastern bank, in the adoption of permaculture practices and systems.

Future projections indicate that the levels of involvement from the part of the local organizations with respect to productive activities would be in terms of coverage rather than in technical improvement through systems of irrigation and diversification. The latter would demand additional efforts to the existing ones. As a result of local knowledge of climate variability and change, species and varieties capable of coping with climate variations would be adopted by means of rescuing native materials.

Despite the autonomous interventions currently being carried out in the selected territory, the greatest strength would continue to be productive organization, while the main weakness would continue to be the lack of technological level due to the low proportion of coverage in the provision of technical assistance.

With respect to distribution and consumption, and from the point of view of access to the necessary resources for production and the wellbeing of rural local population, family income would continue to be mainly from agriculture/livestock-related activities. This would imply a reduction in the processes of continuous descapitalization. However, because national macro-policies would not be generating opportunities for local development, there would be a decrease in the real income of families, which would reduce their purchasing power, and there could be greater impoverishment of local population.

Access to credit will continue to be limited due to excess requirements and securities from part of the financial entities. A major strength is the fact that the majority of families who own land will continue to have ownership, and will therefore have direct access to land and its resources. The land market would stabilize due to a steep decrease in the selling of land.

As regards the distribution of national wealth, local population does not see substantial future changes in public investment in the selected territory. There is no expectation for significant improvement in the provision of health, education, communication, credit, technical assistance, training, waste collection, energy and potable water services; nor in the availability of an economic or social infrastructure.

There would be an important improvement to market access due to the development of the access roads to the communities and land plots. The latter would be a result of investments and support of community investments from part of the municipalities.

The search and opening of new markets through mechanisms that link production with local, national, and regional markets, is predicted to accompany the processes for productive diversification of commodities and economic activities. It is expected that by 2015 there will be an increase in the proportion of market-oriented production.

Contribution of the economic environment to the projected future local vulnerability

In general, future resilience in the selected territory shows a trend to increase due to the improvement in structural coupling and the type of organization. The adaptive capacity of the family-scale economy will continue to have *medium* values, lower than those for resilience.

Projections for the eastern bank show positive and significant modifications with regard to resilience as a result of efforts to promote diversification in the productive activities of the agriculture/livestock sector. The western bank would maintain current levels of resilience since the type of organization, control mechanisms, and structural coupling are not expected to change in the future.

For the eastern bank, the control mechanisms will continue to be relevant given that the technological innovations will be strengthened in order to increase yields. As far as structural coupling in the eastern bank, seen as a technological response to local climate conditions, there will be an increase in the promotion of species or varieties capable of coping with or resistant to climate events and with an emphasis in the recovery and utilization of the local species.

Impact work from the local social organizations at the municipal, sectoral, national and international levels are expected to be stronger in the future. Regarding the adaptive capacity, the variable *resource potential* will continue to have as its strength land ownership, while its weakness will continue to be the low coverage of financial services.

The variable *innovation and experimentation* is projected to be a restriction to local development in both banks of the selected territory due to the difficulties in increasing its coverage; yet, the commitment from part of the local organizations to promote new innovative technologies would be maintained. As regards the variable *organization complexity*, the projections indicate that efforts from part of the various geographical areas to increase diversity in the different economic sectors will intensify and as such will reduce the proportion of self-consumption-oriented production.

4.2. Future Local Climate Scenarios

Recent Observed Climate trends

According to the 1998 study *Baseline Climate Scenarios for the Republic of El Salvador*[§], a notable increase in the magnitude of the mean annual temperature was identified during the baseline period 1961-1990 and particularly during the 80s. The estimated values for the linear tendencies indicated a warming process of approximately 0.04 °C (0.072 °F) per year, which is equivalent to an increase of the annual mean temperature of approximately 1.2 °C (2.16 °F) during the baseline period.

[§] Centella, A., et Al., 1998[a]

Another 1998 study, *Climate Change Scenarios for Impact Assessment in El Salvador*[**], indicates that the mean annual temperature would be increasing from 0.8 °C (1.44 °F) to 1.1 °C (1.98 °F) by 2020, and from 2.5 °C (4.5 °F) to 3.7 °C (6.66 °F) by 2100. The precipitation values are considered to be more uncertain since the projections ranged from -11.3% to 3.5% by 2020 to -36.6% to 11.1% by 2100.

The following table summarizes the global, regional, and national climate change scenarios by 2020 and 2085. Global values are from the 2001 Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the regional values are from the 2006 study, *Climate Change Scenarios for Costa Rica*[††], and local values are from the second study for El Salvador mentioned above.

Box 4.2-1: Climate Change Scenarios by 2020 and 2085

Climate variables by level		Projected climate change (potential threats for the selected territory)
Global	Hurricanes or tropical storms	Intensification of hurricane-associated winds
	Sea level rise	+3-14 cm (+1.2-5.5 in) at a global level
		+5-32 cm (+2.0-12.6 in) in 2050
Regional	Mean annual Temperature	+0.3°C (0.54°F) in 2010; +1.2°C (2.16°F) in 2050; +1.8-2.2°C (3.24-3.96°F) in 2075 (B2-A2); 2.3-3.3°C (4.14-5.94°F) in 2100
	Mean seasonal Pcp	- Pcp in 2050 due to abnormal increase in temperature in the Pacific Ocean (May-July)
		- Pcp in 2050 (Aug-Oct) with a greater increase than in the first quarter of the rainy season
National	Annual mean T	+0.8-1.1°C (1.44-1.98°F) by 2020; 2.5-3.7°C (4.5-6.66°F) by 2100
	Mean annual Pcp	-11.3-(+3.5)% in 2020; -36.6-(+11.1) % by 2100
	Midsummer drought pattern	- Pcp in July and August by 2050
	Changes in the pattern of Pcp during the year	- Monthly levels of Pcp in September by 2050

Future Local Climate Change Scenarios

The development of the local climate change scenarios, including methodology, results and conclusions, is presented in Appendix II.

Baseline and future mean minimum temperatures

In average by 2020, under scenario A2, the annual mean minimum temperature would increase 0.2 °C (0.36 °F), and by 2085 it would increase an additional 0.2 °C. Under scenario B2, the annual mean minimum temperature would increase 0.2 °C and would remain as such until 2085. The following table shows changes in the annual mean minimum temperature for the baseline 1961-1990 (climate representative of 1975).

Box 4.2-2: Baseline and future annual mean minimum temperatures, San Miguel station

Month	A2 Scenario		B2 Scenario	
	2020 minus 1975 (°C)	2085 minus 1975 (°C)	2020 minus 1975 (°C)	2085 minus 1975 (°C)
January	0.2	0.5	0.2	0.3
February	0.4	0.8	0.4	0.6

[**] Centella, A., et Al, 1998[b]

[††] IMN-MINAE-CRRH, 2006, “Climate Change Scenarios for Costa Rica”.

Box 4.2-2: Baseline and future annual mean minimum temperatures, San Miguel station

Month	A2 Scenario		B2 Scenario	
	2020 minus 1975 (°C)	2085 minus 1975 (°C)	2020 minus 1975 (°C)	2085 minus 1975 (°C)
March	0.5	0.9	0.5	0.8
April	0.2	0.7	0.4	0.5
May	0.2	0.2	0.2	0.2
June	0.4	0.1	0.4	0.2
July	0.3	0.0	0.2	-0.1
August	0.0	-0.2	-0.1	-0.3
September	0.1	0.1	0.2	0.1
October	0.3	0.3	0.4	0.0
November	0.2	0.5	0.0	-0.2
December	0.2	0.5	0.1	0.2
Annual	0.2	0.4	0.2	0.2

Baseline and future mean maximum temperatures

There is a greater increase in annual mean maximum temperatures than annual mean minimum temperatures. The annual mean maximum temperature increases from 0.3 °C (0.54 °F) by 2020 to 0.5 °C (0.9 °F) by 2085, under scenario A2. The table below presents the values for the baseline and future mean maximum temperatures.

Box 4.2-3: Baseline and future annual mean maximum temperatures, San Miguel station

Month	A2 Scenario		B2 Scenario	
	2020 minus 1975 (°C)	2085 minus 1975 (°C)	2020 minus 1975 (°C)	2085 minus 1975 (°C)
January	0.3	0.3	0.3	0.3
February	0.4	0.4	0.5	0.3
March	0.4	0.5	0.5	0.4
April	0.6	0.5	0.4	0.6
May	0.6	0.9	0.7	0.7
June	0.4	0.8	0.5	0.5
July	-0.5	0.0	-0.6	-0.2
August	0.0	0.8	0.0	0.5

Box 4.2-3: Baseline and future annual mean maximum temperatures, San Miguel station

Month	A2 Scenario		B2 Scenario	
	2020 minus 1975 (°C)	2085 minus 1975 (°C)	2020 minus 1975 (°C)	2085 minus 1975 (°C)
September	0.7	1.3	0.5	1.2
October	0.1	0.4	0.2	0.3
November	0.2	0.3	0.2	0.3
December	0.2	0.2	0.1	0.2
Annual	0.3	0.5	0.3	0.4

The result of future climate scenarios for extreme temperatures (maximum and minimum) is considered better defined and more homogenous that for rain; the increase in air temperature would be gradual in the entire region and would be as important in the sea as on the ground. The local scenario by 2085 indicates that the extreme minimum temperatures would increase 0.4°C (0.72 °F) more, while the extreme maximum temperatures would increase up to 0.5 °C (0.9 °F) more.

Increases in temperature in the Caribbean Sea, tropical Atlantic Ocean, and in the north-eastern Pacific Ocean close to the Central-American coasts, could provoke towards the end of the century a much more favorable condition for the development of tropical storms or hurricanes.

Decreases in temperatures during the midsummer drought months (July and August) could be explained from greater insolation due to the absence or decrease in clouds, which would tend to increase thermal contrasts between the sea-land surfaces and thereby favor a greater persistence and intensity of the sea-land breezes and produce a greater cooling of the environment. Nights would also tend to be less hot as the cloudless skies would favor night chills.

Baseline and future precipitation from rain

The following table shows changes between the baseline period 1961-1990 (1975) scenarios and the future 2020 and 2085 scenarios. In general, projections show that precipitation from rain will decrease during the rainy season from May to October.

Box 4.2-4: Baseline and future precipitation from rain scenarios, San Miguel station

Month	A2 Scenario		B2 Scenario	
	2020 minus 1975 (%)	2085 minus 1975 (%)	2020 minus 1975 (%)	2085 minus 1975 (%)
January	-2.12	-1.06	-0.98	-0.65
February	0.04	0.84	-3.12	0.87
March	-0.53	2.16	0.51	2.64
April	1.09	1.63	1.20	0.60
May	1.58	-4.51	-3.63	-4.24
June	0.13	-5.56	2.95	-5.61

Box 4.2-4: Baseline and future precipitation from rain scenarios, San Miguel station

Month	A2 Scenario		B2 Scenario	
	2020 minus 1975 (%)	2085 minus 1975 (%)	2020 minus 1975 (%)	2085 minus 1975 (%)
July	0.41	-6.03	-3.21	-6.07
August	0.69	-9.21	-1.33	-4.59
September	-2.40	-2.32	0.96	-2.16
October	0.51	0.67	-1.20	-5.27
November	-0.93	-0.50	0.03	0.43
December	2.15	0.86	1.00	1.15
Annual	-0.07	-3.95	-0.51	-3.95

The increase of rain during the month of April, seen in both the A2 and B2 scenarios and in all time horizons, could be a false signal of an early start for the rainy season. This could cause a delay of the May rains, which would be more evident under scenario B2.

The next table summarizes the projected changes for the variables annual mean minimum temperature, annual mean maximum temperature, and precipitation, by 2020 and 2085. Also included is the behavioral pattern of extreme dry and wet events, expressed using the five indicators that are part of the projected CTI.

Box 4.2-5: Local climate change projections by 2020 and 2085

Projected climate variables	Projected local climate change (local climate threats)
▪ Mean minimum T	▪ +0.2 °C (B2 and A2) by 2020; +0.4 °C by 2085 (B2-A2)
▪ Mean maximum T	▪ +0.3 °C by 2020 (B2 and A2); +0.4 °C to +0.5 °C by 2085 (B2-A2)
▪ Monthly pattern of Pcp	▪ +1.09% and 1.58% in April and May by 2020 (A2)
	▪ May: -3.63% Pcp by 2020 (B2), -4.51% and -4.24% by 2085 (A2 and B2). Could be related to a delay in the start of the rainy season
	▪ + Pcp in April by 2020 and 2085 (A2 and B2): could be a signal of a false start of the rainy season
	▪ - Pcp in September by 2020 and 2085 (A2 and B2), when normally there exists the maximum peak of rain
	▪ - Levels of Pcp from May to October (B2) by 2020 and 2085, with an increase in June (2020), and by 2085 (A2) with an increase in October
	▪ Annual Pcp accumulated does not change significantly: from -0.07 to -0.51% by 2020 (A2-B2), and -3.95% by 2085 (A2 and B2)
▪ Midsummer drought period	▪ - Pcp during July and August in 2085 (A2 and B2) and in 2020 (B2): could be linked with an intensification of the midsummer drought
▪ Absolute max T	▪ +0.4 °C in May; 44.4 °C in May by 2020
Future climate threat index (CTI):	**Projections of the CTI by 2020:**
▪ Recurrence of an extreme dry year	▪ From 1-2 years (20-3%)
▪ Recurrence of an extreme wet year	▪ Recurrence of 4 years (10%)

Box 4.2-5: Local climate change projections by 2020 and 2085

Projected climate variables	Projected local climate change (local climate threats)
▪ Maximum number of consecutive days with rain ≥ 40 mm	▪ Recurrence of 3-2 years (2-7%)
▪ Recurrence of extreme dry periods ≥ 11 days during July and August	▪ Recurrences of 1, 2, and 4 years (26 and 6%)
▪ Increase in maximum annual T during an extreme dry year	▪ +(0.2-0.4)°C (the annual mean maximum temperature by 2020 would be 35.3°C)

4.3. Future local climate change-related threats and impacts

Calculation of the climate threat index (CTI) by 2020

The results of the local climate scenarios by 2020 generated parameters and criteria which served as a framework and basis for the future projection of the five CTI indicators to the same year. The SDSM was used for this purpose (see Appendix II).

The indicators were projected over the baseline climatologic records for the period 2006-2035 and with a methodology that utilizes the results of the A2 scenario. In order to represent the behavior of the CTI indicators by 2020, three categories (A, B, and C) were defined and associated with the three climatologies that were generated using the daily observed predictor data derived from the NCEP[‡‡] reanalysis for the period 1961-2001, and from the daily predictor data of the Hadley Center model, version 3, or HadCM3, for the period 1961-2099.

Data of both the NCEP reanalysis model and the SDSM under A2 and B2 scenarios, with current forcing satisfactory reproduce current observed mean minimum, absolute minimum and mean maximum temperatures. Other parameters as for the absolute maximum temperature, daily temperature ≥ 38° and monthly mean rainfall, these are overestimated. As for daily rainfall ≥ 40 mm, it is underestimated, although in all cases the monthly distribution pattern is well reproduced.

The future changes in the four indicators related with precipitation, Rsx, RIx, DC40mm, and RPS11d (see Box 3.2-1), were therefore estimated based on the scenarios generated by the HadCM3 during the period 1961-1990. These scenarios were compared with the future scenarios by 2020 (climatology 2006-2035) in order to define the magnitude of change between both periods. For each indicator, the change in magnitudes were applied directly to the observed baseline climatology or inferred from expert judgment to then be applied.

The HadCM3 model was not used to recalculate the baseline climatology for the indicator associated with temperature (Atx). For this indicator, a future scenario for the climatology 2006-2035 was calculated and directly compared with the observed scenario for 1961-1990.

The following table illustrates the categories associated with each behavioral range for the observed baseline climatology (1961-1990), the recalculated baseline climatology, and the climatology for 2006-2035. These ranges are used to calculate the value of the five indicators of the CTI.

[‡‡] USA Nacional Center of Environmental Prediction.

Box 4.3-1 Behavioral ranges of the CTI indicators associated with the three climatologies

Symbol	CTI Indicators	Behavioral ranges associated with the climatologies			
		A	B	C	Type of climatology
Rsx	Recurrence of an extreme dry year (years)	1(13)	3(13)	6(3)	Scenario A2 for 1961-1990
		1(23)	2(6)	4(6)	Observed climatology 1961-1990
		1(10)	3(10)	10(3)	Scenario A2 for 2006-2035
Rlx	Recurrence of an extreme wet year (years)	10(6)	3(3)	1(16)	Scenario A2 for 1961-1990
		7(10)	4(3)	1(3)	Observed climatology 1961-1990
		11(3)	5(10)	1(10)	Scenario A2 for 2006-2035
DC40mm	Maximum number of days with consecutive rain ≥ 40 mm (days)	4(1)	3(1)	2(2)	Scenario A2 for 1961-1990
		4(1)	3(2)	2(7)	Observed climatology 1961-1990
		4(0)	3(1)	2(2)	Scenario A2 for 2006-2035
RPS11d	Recurrence of periods with consecutive dry days ≥ 11 days during July and August (years)	1(26)	2(6)	4(6)	Scenario A2 for 1961-1990
		1(26)	2(6)	4(6)	Observed climatology 1961-1990
		1(26)	2(6)	4(6)	Scenario A2 for 2006-2035
Atx	Increase in maximum annual temperature during an extreme dry year (°C)	<0.4	(0.4-0.9)	>0.9	Observed climatology 1961-1990
		<0.2	(0.2-0.4)	>0.4	Scenario A2 for 2006-2035

Concluding from the above table, the probability that an extreme dry year recurs annually is reduced from 23 to 20% in the 2020 climatology. This was derived by comparing the A2 scenarios for both the 1961-1990 and 2006-2035 periods, which shows a reduction of 3% in both the A and B categories. No changes are observed in category C for the probabilities of recurrence between 6 and 10 years.

A comparison between extreme dry and wet years reveals that, for an annual recurrence by 2020, the probability of their occurrence decreases in greater magnitude for the rainy years than for the dry. For a recurrence between 3 and 5 years (category B), the probability of recurrence of rainy years increases by 7% and decreases by 3% for the dry years.

The probability of having four consecutive days with rain ≥ 40mm (category A) is practically a null value. No changes are observed for the categories B and C by 2020.

Since the A2 model scenarios tend to calculate or estimate central tendency values, such as mean or median, it is very rare that days with rain less than 1mm or days without rain (rain “0”) appear. The accumulated rain during the months of July (+1%) and August (+2%) by 2020 and in the A2 scenario are not statistically significant with respect to the baseline period 1961-1990. Therefore, for 2006-2035, the recurrence and probabilities for the periods of dry consecutive days for 1961-1990 are kept.

For the period 2006-2035, the extreme increases in annual maximum temperature in the higher than normal range oscillate between 0.2 and 0.4 °C over the 35.3 °C average. According to the baseline climatology, this occurs for the most part during extreme dry years, generally followed by years with rain in the normal range.

Behavioral ranges for the indicators of the CTI by 2020

Future values of the climate indices were estimated for the period 2006-2035 by applying the magnitude of projected change between the climatology of scenario A2 (1961-1990) and the climatology of scenario A2 (2006-2035) to the observed climatology for the period 1961-1990. Future values are shown in the table that follows.

Box 4.3-2 Behavioral ranges of the CTI indicators by 2020

Symbol	CTI Indicators	Behavioral ranges for 2006-2035 (Scenario A2)		
		A	B	C
Rsx	Recurrence of an extreme dry year (years)	1(20)	2(3)	
Rlx	Recurrence of an extreme wet year (years)		4(10)	1(10)
DC40mm	Maximum number of days with consecutive rain ≥ 40 mm (days)	4(0)	3(2)	2(7)
RPS11d	Recurrence of periods with consecutive dry days ≥ 11 days during July and August (years)	1(26)	2(6)	4(6)
Atx	Increase in maximum annual temperature during an extreme dry year (°C)	<0.2	(0.2-0.4)	>0.4

<u>Recurrence of an extreme dry year</u>
The change of -3% between the A2 scenarios for 1961-1990 and 2006-2035 are applied to the observed climatology 1961-1990. For category B, the recurrences of 3 years of the A2 scenarios can be considered like 2 years and the -3% change between the A2 scenarios can be applied to the observed climatology. Category C is not considered in the analysis since the years of recurrence for the different climatologies vary from 4, 6, and 10 years.

<u>Recurrence of an extreme dry year</u>
Category A is not considered since the years of recurrence vary from 7, 10, and 11 years. For category B the +7% change between the scenario A2 climatologies 1961-1990 and 2006-2035 were applied to the observed climatology with recurrence of 4 years. The probability of recurrence of a year becomes null for the scenario 2020.

<u>Maximum number of days with consecutive rain ≥ 40 mm</u>
The probability of occurrence for a recurrence of 4 years in category A becomes null after applying the change in magnitude. Since categories B and C do not show any changes, the recurrences and probabilities by 2020 result the same as for the observed climatology 1961-1990.

<u>Recurrence of periods with consecutive dry days ≥ 11 days during July and August</u>
No changes are estimated for categories A, B, and C since the recurrences and probabilities of occurrence for the period 1961-1990 are the same as for the climatology 2006-2035.

<u>Increase in maximum annual temperature during an extreme dry year</u>
The temperature range of oscillation decreases by 2020 with respect to the baseline climatology (1961-1990). The range is applied above the mean maximum temperature of 35.3°C, corresponding to the period 2006-2035, and which is 0.2 °C greater than the average of 35.1 °C for the observed period (1961-1990). At a monthly level, these results could be understood as a possible sign that the months April, May, and September, could become less rainy by 2020 (2006-2035).

Estimation of local climate change impacts by 2020

Based on the behavioral ranges for each of the CTI indicators by 2020, the levels of future threat were defined by projecting the identified impacts over the productive, hydrologic, hydraulic and environmental processes in the selected territory. Although, CTI values were projected by 2020, the obtained values were used to year 2015, in order to assure consistency with the time horizon adopted for the socioeconomic and environmental scenarios.

The same methodology used to calculate the CTI for the baseline was used to calculate the future CTI value; that is, the simple average of the future values calculated for the two sub-indices: CTI-p and CTI-h (levels of climate threat over productive processes and levels of climate threat over hydrologic and hydraulic processes, respectively).

In terms of climate exposure, the future CTI reveals that the selected territory will continue to be affected at a moderate to high level. With respect to productive processes, the greatest exposure will be determined by the maximum number of consecutive days when the rain ≥ 40mm and the recurrence of periods with dry consecutive days ≥ 11 days during July and August. Changes in temperature would be a threat to agricultural production given that current species would experience a reduced coping range with climate variability. The problem would heighten from the combination of a temperature rise and the recurrence of dry consecutive days during the rainy season.

The hydrologic and environmental processes would be affected mainly by the recurrence of extreme dry and wet years. As a consequence, there would be an increase in evapotranspiration, and therefore, the availability of water could not be sufficient for the needs of crops and animals. The table that follows shows the impacts associated with climate change over the local human and natural systems.

Box 4.3-3 Impacts associated with the CTI projected by 2020

Human or natural system \ Impact & threat	Type of impact	Level of threat
Rural economy and quality of life	▪ Damage and loss to rural housing ▪ Human health problems, e.g. malaria, diarrhea ▪ Food insecurity and child malnutrition ▪ Lack of plants and animals important to food security and the local survival strategies ▪ Lack of potable water form local aquifers ▪ Emigration of youth population due to loss of local livelihoods ▪ Contamination of water wells and bodies due to flooding ▪ Isolation of the rural population due to flooded land ▪ Lack of inputs associated with local economy-supportive environmental functions ▪ Degradation of agricultural land due to the combination of flooding and droughts ▪ Reduction of agricultural yields in May and August ▪ Loss of domestic and livestock animals ▪ Shortage of family income during the agricultural productive cycle ▪ Abandonment of agricultural, aquaculture, and fishing activities by the rural population	Medium to high
Economic Infrastructure	▪ Deterioration or destruction of facilities and equipment, e.g. mills, irrigation equipment ▪ Sedimentation and collapse of local drainage systems ▪ Collapse of existing local dams (points of rupture) ▪ Deterioration and collapse of roads, paths, lanes, bridges, sewer systems and local docks	Medium to high

Box 4.3-3 Impacts associated with the CTI projected by 2020

Human or natural system \ Impact & threat	Type of impact	Level of threat
Natural marine-coast and terrestrial systems	▪ Forest fragmentation and appearance of plagues and fires ▪ Deterioration of mangrove swamps due to flooding events ▪ Abnormalities in the development and behavior of native animal and plant species due to the reduction in their climate coping ranges ▪ Loss and disturbances to habitats and abnormalities in the behavior of migratory species ▪ Increase in soil sedimentation and erosion in lower lands of the coastal fringe due to dragging materials and deposits during floods ▪ Salinization of aquifers due to the combined effect from floods and tides in the coastal fringe ▪ Disturbances of the environmental functions of the natural systems ▪ Decrease in soil moisture, levels of productivity, agricultural potential, availability of vegetable and animal species, infiltration capacity and storage of ground water, and increase in evaporation	Medium to high

5. Integrated Assessment of Current and Future Climate Vulnerability

To calculate the climate vulnerability index (CVI), the values derived for the climate threat (E), resilience (R) and adaptive capacity (A) sub-indices, were integrated into the following expression:

$$CVI = E\,[2 - (R + A)] / 2 \quad \text{with } CVI_{\max} = 1 \text{ and } CVI_{\min} = 0$$

The CVI integrates, therefore, vulnerability associated with the socio-cultural, economic, and natural processes in the selected territory, including local climate threats.

The current climate vulnerability index (CVI) for the baseline period

The table below shows the values calculated for the CVI and the three sub-indices for the baseline year, desegregated by geographical area. Note that as estimated values get closer to one (1.00) vulnerability increases, while as the values get closer to zero (0.00) it decreases.

Box 5-1 Current climate vulnerability index values in the selected territory

Geographical area / Explanatory variable	Western Bank			Eastern Bank		
	MES	IDES	SES	San Juan	San Marcos	Tierra Blanca
Resilience Sub-index (R)	0.586	0.592	0.530	0.465	0.509	0.544
Adaptive Capacity Sub-index (A)	0.514	0.544	0.556	0.554	0.591	0.578
Climate Threat Sub-index (CTI)	0.475	0.475	0.475	0.475	0.475	0.475
Climate Vulnerability Index (CVI)	0.214	0.205	0.217	0.223	0.214	0.208

It is concluded that for the baseline year and for the various zones and micro-regions of the selected territory, there is a low level of climate vulnerability. Current values for the CVI and the resilience and adaptive capacity sub-indices show a similar behavior in the different zones and micro-regions. In addition, the western bank shows values slightly higher for the variable *resilience*; the eastern bank exceeds the values for the variable *adaptive capacity* when compared with the western bank.

In general, the variation in the levels of vulnerability in the geographical areas is explained by the distinct contributions from each of the three environments to the values of the *adaptive capacity and resilience* sub-indices. Since the CTI value is the same for all the territory, it does not contribute to the differences in the levels of vulnerability.

With respect to the *adaptive capacity* variable, the socio-cultural environment shows the highest level of contribution to this variable. It can be concluded that the low levels obtained for the current CVI are the result of the endogenous efforts and strengths that were constructed locally and reflected in the socio-cultural environment.

The natural environment had the lowest contribution to the *adaptive capacity* variable. This as a result of the historical patterns of occupation and transformation in the selected territory, which have continually pressured and deteriorated the local natural systems and which have produced a structural decoupling between natural and human systems. The latter ultimately leading to the decrease in potential of the available natural resources.

The following table shows the level of contribution of each of the environments to the *adaptive capacity* levels in face of local climate threats, by geographical areas.

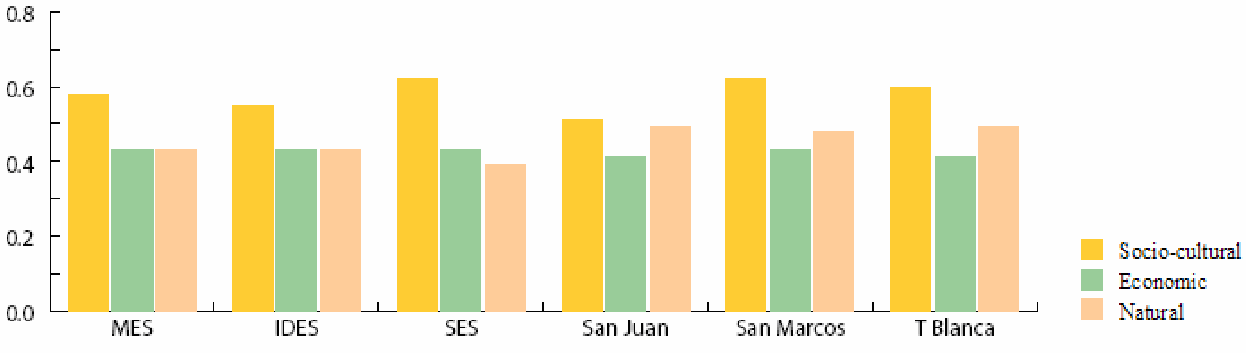

Figure 5.1: Contribution of the three environments to the adaptive capacity of the territory

With respect to the *resilience* variable, the natural environment contributed the least to this variable. This is due, in part, to the high prevalence of environmental processes over the selected territory, and particularly from flooding, droughts, low ground permeability and drainage, and the high levels of salinization of soil and water.

The greatest contribution to the *resilience* variable was from the economic environment. This as a result of the complexity of organization of production, in terms of efforts such as diversification of economic activities, diversity of commodities in agricultural and livestock industry production, efficiency in productive processes, and the adoption of species and varieties more adapted to local climate conditions.

The socio-cultural environment also significantly contributes to the *resilience* variable, mainly because of the work that local counterpart organizations, among others, do for the consolidation and extension of the alliances with other development actors and agents at the regional and international levels. The previous due to initiatives related to existing local strategic planning promoted by local organizations, namely: strengthening of local capacities and opportunities for sustainable development, improvement of local floods-related early warning systems, rescue and promotion of indigenous and local knowledge related to more climate resilient agricultural systems, technologies and practices. The following figure illustrates the contribution of each of the environments to the *resilience* variable:

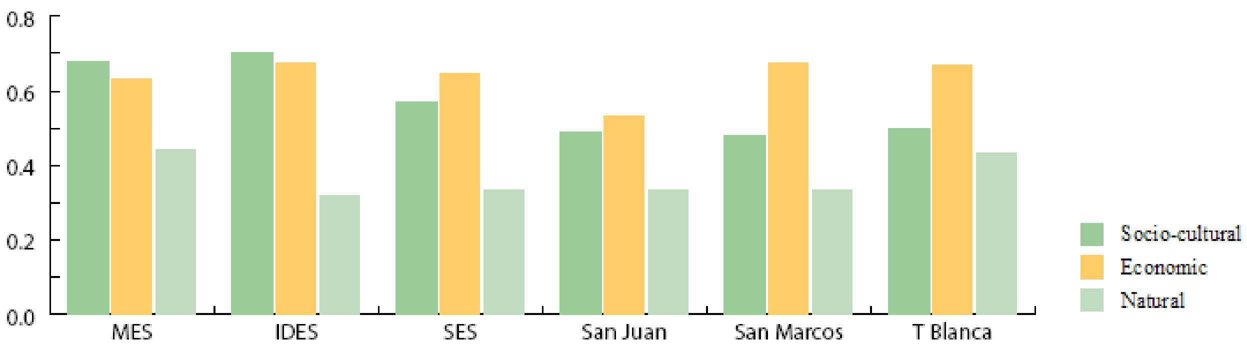

Figure 5.2: Contribution of the environments to resilience in the territory by geographic area

Comparative analysis of the current and future climate vulnerability index

The future climate vulnerability index, or future CVI, was calculated by 2015 using the values of the sub-indices *climate threat, resilience, and adaptive capacity* that were projected to the same year. According to the results, which are given in the table that follows, for all the zones and micro-regions of the selected territory, future climate vulnerability will tend to increase with respect to the baseline vulnerability. This is due to the following main factors: i) an increased value for the future *climate threat* sub-index; and ii) the increased values of the *resilience and adaptive capacity* sub-indices do not counteract the weight of the climate threat sub-index within the future CVI.

Box 5-2 Current and future value of vulnerability and of its explanatory variables in the selected territory

Geographical Area / Explanatory Variable	Western Bank						Eastern Bank					
	MES		IDES		SES		San Juan		San Marcos		Tierra Blanca	
	Current	Future	Current	Future	Current	Future	Current	Future	Current	Future	Current	Future
Resilience	0.586	0.619	0.592	0.611	0.530	0.622	0.465	0.546	0.509	0.626	0.544	0.633
Adaptive Capacity	0.514	0.559	0.544	0.579	0.556	0.588	0.554	0.562	0.591	0.584	0.578	0.570
Climate Threat	0.475	0.543	0.475	0.543	0.475	0.543	0.475	0.543	0.475	0.543	0.475	0.543
Climate Vulnerability	0.214	0.223	0.205	0.220	0.217	0.214	0.233	0.242	0.214	0.215	0.208	0.216

It is noted that in both banks of the Lempa River, both the *adaptive capacity* and *resilience*, show an increase in their values due to the projected strengthening of some of the local processes.

The future CVI shows similar values in all of the micro-regions of the western bank and in the zones of the eastern bank. Variations in the future CVI would be determined by the characteristics projected for the micro-regions and zones of the future CVI itself and not from the future CTI. The latter remains the same in all of the selected territory.

With respect to the variable *adaptive capacity*, only the socio-cultural environment would improve its future value by 2015 with respect to the baseline, and would remain the environment with the highest contribution to it; the remaining environments would decrease its future values.

The natural environment is considered the most critical. The deepening deterioration, scarce land planning, and the lack of municipal land management, affect the fulfillment of the future essential environmental functions and those which support human and life activities.

With respect to *resilience*, the natural environment would show the lowest values among the three environments by 2015, just as in current or baseline conditions. Its future values would decrease with respect to the baseline. This could indicate that the natural environment is contributing to the future vulnerability of the territory probably due to the low local capacity of control and influence in the environmental deterioration processes.

The economic environment would show a significant contribution to the *resilience* variable as a result of the existing strengths in the organization of production. However, the socio-cultural environment would continue to have the highest contribution to the *resilience* variable due to the initiatives included in the strategic planning of the local organizations which seek to strengthen and create capacities and opportunities of local development.

In general, it is concluded that although the levels of climate vulnerability would increase by 2015, they would remain in the low range category. It is noted, that the projected socioeconomic and environmental scenario includes the processes and measures of autonomous adaptation, which would explain the relatively high projected values for the *resilience and adaptive capacity* sub-indices. If the local actors did not assume the efforts that are proposed and incorporated in their local development plans, the contribution of the three environments to the aforementioned variables would decrease significantly and consequently the future CVI would be much higher.

Also noted is the fact that the CTI only incorporates the extreme climate events associated with temperature and precipitation from rain. This means that the whole range of threats that future climate change would have on the local human and natural systems is not reflected. For example, sea level rise could represent a significant threat for the marine-coast zone of the territory.

The fact that the future socioeconomic and environmental scenario represents the projected baseline with autonomous adaptation by 2015 is important to note. The execution of the adaptation measures from the adaptation strategy to climate change in the selected territory is an additional effort to those already projected for local sustainable development.

6. Adaptation Strategy and Measures to Climate Change

Future strengths and weaknesses identified through the future projection of the indicators by environment allowed for the identification of the most critical and primary problems according to the perception of the local actors. The main objectives and problems by environment served as guideline for the definition of the purpose and specific objectives of the adaptation strategy developed for the selected territory. The most urgent of these problems were the basis for the identification of the action lines, which group the set of specific measures of adaptation.

Purpose and Objectives

Purpose

To strengthen the organization and capacities of the local rural population, in order to incorporate in the socioeconomic activities the adaptation to climate change, within the framework of sustainable management in the selected territory.

Specific Objectives

I. Increase the coping range to climate change of local rural survival strategies by means of economic diversification and the adoption of appropriate productive systems, technologies and practices.

II. Strengthen local capacities to incorporate climate change in land management by improving local knowledge on land planning and the development of land management criteria and plans.

III. Reinforce local organization and capacities to advocate policies and public priorities at the national and municipal levels that incorporate adaptation to climate change, by the appropriate strengthening, dissemination and implementing of the legal framework.

Scope

Time Horizon

The year 2015 was the time horizon chosen to define the objective and measures of the adaptation strategy in order to complement with the deadline for reaching the Millennium Development Goals or MDG. Both the socioeconomic and climate scenarios were projected to 2015.

Type of Action Lines

The adaptation strategy includes adoption and advocacy measures. Adoption measures are those options that could be implemented directly by rural families and local organizations working and established within the selected territory. Advocacy measures are those that should be incorporated in public policies, in either the municipal or the central governmental entities, as part of their legal mandate and institutional responsibilities. Local actors would make efforts to influence policy and decision-making processes in order to incorporate in these adaptation to climate change.

The values of the indicator system under baseline conditions should be modified, as part of the adaptation strategy, in order to increase climate resilience and adaptive capacity, and thus to reduce vulnerability to current and future climate related impacts.

List of Acronyms and Abbreviations

MARN	Ministry of the Environment and Natural Resources
CVI	Climate Vulnerability Index
CTI	Climate Threat Index
CBL	Coordinadora del Bajo Lempa
GBL	Grupo Bajo Lempa
m.a.s.l.	Meters above sea level
ZCIT	Inter-tropical Convergence Zone
SAT	Early Warning Systems
Pcp	Precipitation
SDSM	Statistical Downscaling Model
HadCM3	Hadley Center model, version 3
NCEP	National Center for Environmental Prediction
MDG	Millennium Development Goals
GCM	General Circulation Models
hPA	Hectopascals
SNET	National Service for Territorial Studies
IHMS/HBV	HBV Rainfall-Runoff Hydrological Model

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