Background

El Salvador, with the ratification of the United Nations Framework Convention on Climate[1] Change and the Kyoto Protocol[2], not only assumed the commitments derived from said international legal instruments, but also evidenced its political will to add itself to the world efforts against global climatic change.

The First National Communication of El Salvador was the result of two years of combined efforts among several institutions, national experts, and specialized entities of the international scientific community, under the coordination of the Ministry of the Environment and Natural Resources (MARN).

The document was prepared based on the outcomes from the studies carried out by the Climate Change Enabling Activities GEF-Project [3], developed between September 1997 and December 1999, financed by the GEF[4]. These studies were executed by national experts with specialized advisory and training.

The purpose of the GEF Project was to contribute to the effective management of climate change within the framework of environmental, social and economic domestic policies, mainly favoring the participation of the various members of society; the project encompassed three components: a) The preparation of the First National Communication, b) the Strengthening of domestic capabilities and c) Public awareness on climate change.

These studies were developed based on the methodologies validated by organizations specialized on climatic change[5]; which sustained both national needs and priorities, as well as the outcomes of global and regional studies on climate change. Likewise, the results were consulted, concerted and validated by relevant sectors and stakeholders.

The First National Communication was endorsed by the political level of the government through the MARN, which represented the government before the Convention and also evidences the clear commitment of the country to accompany the international community in the search of solutions to global environmental problems, particularly to the safeguarding of the balance of our global climate system.

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[1] December, 1995.
[2] November, 1998, fifth country in signing said instrument.
[3] Project UNDP/GEF/ELS/97/G32.
[4] Financial Mechanism of the UNFCCC.
[5] UNFCCC, US-CSP, CC:TRAIN, NCSP (UNDP/GEF), UNEP Collaborating Centre on Energy and Environment, etc.

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Executive Summary

The environmental degradation of El Salvador has been closely linked to the effect of greenhouse gas production, mainly due to the accelerated pace of three processes: the growing urbanization, changes in the use of soil and the rise of contaminating industries. It is important to analyze the evolution of these processes when assessing the potential options to reduce greenhouse gas emissions.

Key social economic indicators of El Salvador such as the illiteracy rate surpassing 20%, the population living in poverty of 47%; with 18% living under extreme poverty and the GDP per capita (in 1990 US$ dollars) of US$1,200; are a clear demonstration of the Government's priorities and are the groundwork for a significant and equitable economic growth.

Energy consumption reflects the same situation, regarding structure and levels: firewood represents almost 50% of the total consumption of energy, food cooking with firewood represents almost 60% in the urban areas and more than 85% in the rural areas, with a consequent growing deforestation; this clearly emphasizes the need to start with an immediate fuel replacement process, fostering the penetration of cleaner, cheaper and better quality sources at the local level for the user. The consequence of a development in this direction cannot have another effect but an increase in total and per capita emissions.

In order to provide a fair accountability of El Salvador within the climate change problem, it is important to highlight that in 1995, CO_2 emissions in El Salvador represented approximately 3.2% of the US emissions in 1990.

Notwithstanding the above, El Salvador carried out a preliminary analysis of the potential mitigation options in the energy sector, and developed future scenarios that allowed to infer or measure the potential evolution of the social economic system and the identification of options for the rational use of energy, that without sacrificing prioritary growth and equity objectives of the nation, could result in a positive contribution to the global problem.

Net Annual Emission of Greenhouse Gases in El Salvador
Base Year: 1994

	Gases				
	CO_2	CH_4	N_2O	CO	NO_x
Annual Net Emission (Gg)	8,644.94	148.50	13.21	512.66	34.02
Sectors					
1. Energy	4,224.18	18.09	0.52	437.48	31.03
2. Industrial Processes	490.12				
3. Agriculture		88.14	12.69	70.65	2.86
4. Changes in the Use of Soil and Forestry	3,930.64	0.52	$3.6x10^{-3}$	4.53	0.13
5. Wastes		41.75			

Source: National GHG Inventory: base year 1994.

Regarding vulnerability, there seems to be a clear increasing trend in temperature throughout the year without important changes in the structure of the annual variation pattern in accordance with the climate model projections applied to El Salvador. An important characteristic reflected in the rainfall patterns, is the trend to intensify dog days. This fact, which is evident in all the projections for future emission scenarios, could have effects on the food production and water usage sectors.

Due to the profound effects of El Niño-Southern Oscillation (ENSO) of the last decades, droughts have been studied attentively in El Salvador. According to the outcomes of a quick assessment on the potential impacts of climate change on the coasts of El Salvador, a drop in cattle production could be expected due to the prevalence of the droughts, which would result in losses amounting to US$3.1 million dollars in the year 2025 for the maize production.

Likewise, the most negative effect would be the potential rising of the sea level along the coasts of El Salvador, due to the loss of farming production areas, human settlements and productive and tourist infrastructure.

According to the global climate scenarios and the estimations for the Salvadoran coast line[6], in the next 100 years, there could be a potential loss of 10% of the total[7] area (149.1 km^2) under a scenario from a 13 cm. rise to one of 27.6% (400.7 km^2), under a scenario of 1.1 m in the rise of sea level.

The Salvadoran population will grow in 50% by the year 2020 with regards to 1995, and will double by the year 2100, according to socio-economic scenarios, leading to a proportional increase in food demand.

The changes in crop productivity due to climate change, affect the social context. These effects are evidenced in health, nutrition, education and poverty levels. To the extent that the basic grain production decreases, there will be a marked drop in employment and an increase in prices, which results in higher poverty levels and the non fulfillment of basic needs. The negative dietary changes also strongly affect the population's mortality, morbidity and life expectancy levels.

The Government of El Salvador through the Ministry of the Environment and Natural Resources, aware of the need to promote early actions to contribute to the Convention's objective, is fostering the necessary institutional arrangements to ensure the continuity and effectiveness of the actions regarding climate change. To this effect, the Government is making efforts to create the required national capabilities to define and execute climate change mitigation and adaptation strategies, programs and projects.

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[6] The evaluation study of the potential rise in sea level along the coasts of El Salvador does not include the intervention of the variables related to the tectonic plaques.

[7] The total coastal area under study is 1,397.3 km^2.

I. Introduction

The responsibilities assumed by El Salvador before the international community with the ratification of the United Nations Framework Convention on Climate Change and with the First National Communication, evidences the country's political will and the efforts carried out to contribute to the climate change solution.

The purpose of the First National Communication of El Salvador, is to report the country's position with regards to its relative contribution to climate change and also regarding the national potential impacts derived from the problem.

Likewise, the document includes the institutional efforts carried out to insure the continuity and effectiveness of the mitigation and adaptation to climate change measures, as well as those headed towards the effective and early enforcement of the Convention and the Kyoto Protocol.

The document was drafted based on the outcomes of the studies carried out during the execution of the Climate Change Enabling Activities GEF-Project, coordinate by the Ministry of the Environment and Natural Resources. These studies were carried out by local experts linked to national institutions, with the technical advisory and training provided by international experts.

The National Communication includes the most relevant outcomes of various studies on climate change. The 1994 national circumstances, as well as the socio-economic scenarios for the various time horizons, were the foundations to develop climate change impact sectoral evaluations, and for the analysis of mitigation options and scenarios for the energy sector.

The outcomes of the GHG[8] inventory, show the significant participation of the Energy Sector in the country's total emissions. Both the relevance of said sector, and the fund limitations of the GEF-Project, led to determine that the analysis of mitigation options would be limited only to the Energy Sector, delaying the studies for the remaining sector, to a later date.

The studies on current climatology and climate scenarios for the various time horizons, have generated very interesting results on the potential temperature and rainfall variations, constituting a fundamental input to develop vulnerability assessments and the potential impacts of the variability and global climate change on natural ecosystems and key socio-economic sectors.

[8] Base year 1994.

II. National Circumstances: 1994.

Human activities affect the emission of greenhouse gases, to the extent that they cause changes in the use of soil, contamination of water bodies, emission of gases due to the increase in vehicles and the proliferation of industrial activities with the consequent increase in waste generation, etc.

It was estimated that in 1987 the emission of Carbon Dioxide (CO_2) in El Salvador, due to the burning of fossil fuels and cement production amounted to 600,000 metric tons. The total emission of greenhouse gasses reached a total of 1.3 million MT[9] in the same year, including the production of CO_2 from other sectors and remaining gasses from other sectors such as the methane and chloro-fluorocarbons.

1. El Salvador: Geography and Ecology.

El Salvador is located in Central America, within the hot or torrid zone, to the north of the equator and to the west of the Greenwich meridian. It is located between parallels 13^{o} 09' and 14^{o} 27' north latitude and meridians 87^{o} 41' and 90^{o} 08' west longitude from the Greenwich meridian, between the tropic of Cancer and Capricorn in the tropical belt.

El Salvador has an area of 20,740 km^2, with important geographical and ecological variations. To the south and along the coastline it has the coastal plains separated by two mountain ranges. The recent volcanic chain is located in a parallel west-east strip and the central pit, generating disperse valleys, mountainous areas and brooks. The old volcanic range is located to the north and together with the Lempa river separates the territory in two areas.

Approximately 86% of the national territory is ranked as subtropical humid forests, 8% as sub-tropical very humid forests and 4% as tropical humid forest land[10]. Annual average rainfall fluctuates between 1,525.8 mm and 2,127.2 mm, with an average of 1,823.6 mm. Annual average temperatures range between 24.2^{o}C and 25.9^{o}C, with an average of 24.8^{o}C[11].

In the 30 years between 1960-1991, El Salvador experienced very little variation in solar energy, thanks to its geographical position. In the latitude where it is located, the global variation of winds and the mountains, contribute to consolidate its climate. Besides, its location within the Central American Pacific versant located the country in the dry tropic zone. Ninety percent of the total rainfall falls during the rainy season and the remaining 10% during the dry season. As a whole, these geographic ecological and climate aspects of the country, which are closely interconnected, become one sole body and influence national life.

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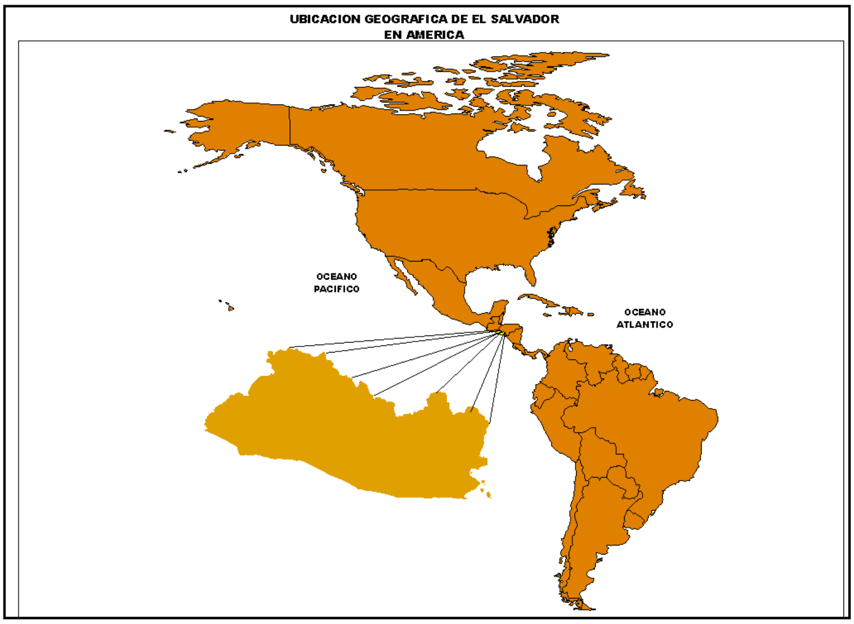
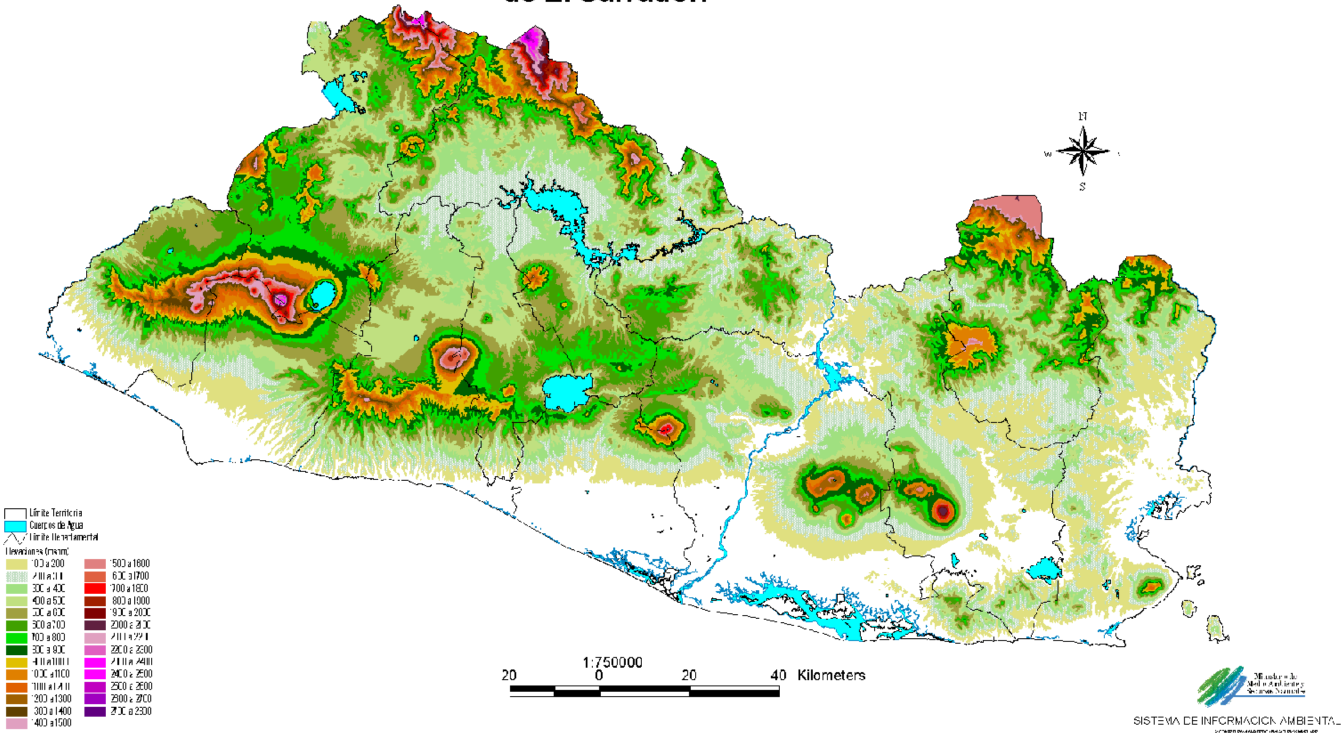
[9] Leger Sivard, Ruth et al, 1991.
[10] Holdridge,1975.
[11] Centella, et al, 1998b.



Mapa de Rangos de Elevaciones de El Salvador.



2. Demographic Features.

El Salvador is one of the countries with the highest population density per square kilometer. According to the last Population Census, in 1992, the population density was 243 inhabitants per square kilometer. In San Salvador, the capital and most important city of the country, the population concentration for that same year was estimated in approximately 5,372 inhabitants per square kilometer.

2.1. Demographic Growth Rates.

It is important to note that the reduction of global population growth rates does not mean that natural growth rates have dropped. The lower global growth rates during the 70's, 80's and 90's are explained in terms of the high international migration of Salvadorans, estimated in more than 62,000 annual migrants. Natural growth rates continue being high[12].

2.2. Migrations.

2.2.1. Internal Migrations.

In the early 80's, the armed conflict generated the first massive displacements of rural populations, who sought refuge in the department capitals or urban areas within their municipalities. At the end of 1981, the total number of displaced persons was 164,297, and by 1994 there were more than 427,892 persons. Approximately 20% of the displaced persons were located in 14 municipalities of the department of San Salvador.

2.2.2. International Migrations.

An important number of people migrated to foreign countries, especially to the United States of America, due to the political situation of the time. Of the total number of Salvadorans who migrated (2,325,000 personas by 1992), 75.3% (1,750,000) migrated to the United States of America and 20.4% (475,000) to Mexico and Guatemala.

2.3. Population Distribution.

Due to the greater internal migrations in the last two decades, the population of El Salvador changed from being predominantly rural, to a relative balance between the urban and rural populations. This has meant a growth in the traditional urban centers. By 1992, approximately 30% of the population was concentrated in the city of San Salvador and surrounding municipalities, between 1971 and 1992, the population density in San Salvador had doubled itself.

3. Economy.

3.1. Agriculture.

The agricultural sector lost importance as the generator of production, exports and food during the 90's. As a whole, the farming sector reduced its share in the GDP from 16.5% of the total in 1992, to only 13.8% in 1994.

Between 1992 and 1994 food crops and export products reduced their volume significantly. It is important to highlight that despite the reduction in the volume of basic grains, the area dedicated to harvest the same has doubled between 1960 and 1990.

[12] CELADE, 1987.

3.2. Industry.

The share of industrial sector in the total GDP dropped from 22.7% to21.1% between 1992 and 1994, but still contributes more to the GDP than the agricultural sector. The industrial development has a low technological level and contributes significantly to environmental contamination.

Five industrial branches concentrate more than 75% of the sector's production: textiles, food, chemical products, paper/cardboard and metal products. It is important to mention that although the mineral non metallic product production has a low relative importance in the GDP (1%), it has a considerable impact on the quality of air.

It is worthwhile highlighting that free zones and bonded areas were created in the 70's, with the consequent establishment of the "maquileras" or foreign apparel manufacturing plants. Between the years 1992 and 1994, the value of the maquila industry production doubled and represented almost 40% of total exports.

3.3. Macroeconomy.

The stability of the great micro economic balances, such as the general price index and the balance of payment balances, as well as public finances represent another relevant aspect of the economic behavior. For instance, the balance of the balance of payment shows positive figures since the beginning of the decade, translated into an increase in international net reserves and the reduction of the public deficit as compared to the 80's.

Chart 2.1
Main Economic Indicators (1994)

Actual GDP Growth (%)	6.0
Commercial Balance	- 1,324 (Million US$)
Apparel exports	430.4 (Million US$)
Family remittances	1,001.6 (Million de US$)
Fiscal deficit/GDP (%)	0.7

Source: Quarterly Magazine. April-June 1996. Central Reserve Bank

4. Social Aspects.

Three variables of the social context relate to greenhouse gas emissions: education, health and poverty. The low educational levels inhibit the processes that lead to reduce net emissions, health issues related to the quality of air, water, and poverty levels determine the unsustainable use of natural resources.

4.1. Education.

According to official data, the general illiteracy rate for 1994 was 26.8%. in the urban area, being 16.1% of the total, while in the rural area it was of 40.6%. Only 27.7% of the population studied beyond the six first years of school. This percentage reached 40.9% in the urban area, but only 10.9% in the rural area. The total population with university degrees was 5.4% of which approximately 95% live in the urban area.

4.2. Health

The child mortality rate between 1990-1993 was of 41 deaths per every 1,000 live births, while the mortality of children under 5 years of age was calculated in 5.1 per every 1,000 live births. The main causes for consultation were acute respiratory infections (51.9%) and stomach infections (31.4%).

4.3. Poverty.

The low salary levels in El Salvador results in unsatisfied basic needs, reflected in high poverty percentages. The minimum salary by the end of 1994, only covered one part of the basic basket of goods, and it was estimated that 1.59 minimum salaries were needed to buy the full basket and 3.54 minimum salaries to cover the cost of the expanded basic basket (food, education, housing and other).

5. Energy Profile.

5.1. Own Primary Energy Resources.

The main internal energy sources of the country are: hydraulic, geothermal and biomass (firewood and vegetable wastes). These three forms of primary energy are renewable sources.

Chart 2.2
Consumption of Primary Energy, 1994

Forms of Energy	Tcal	%
Hydraulic	1,607.9	5.5
Geothermal	2,080.3	7.0
Oil	8,447.1	28.6
Mineral Carbon	0.3	0.0
Firewood	15,677.6	53.1
Vegetal wastes	1,722.3	5.8
Total	29,535.5	100.0

Source: National Energy Balance 1994. CEL

Chart 2.3
Gross Electricity Generation 1994

Source	GWh	%
Hydroelectric	1,472.3	45.9
Geothermal	406.7	12.7
Thermal	1,331.9	41.4
Total	3,210.9	100.0

Source: National Energy Balance 1994. CEL

5.2. Imported Primary Energy Resources.

El Salvador imports oil, mainly from Mexico and Venezuela. The country has one refinery, therefore its imports are a combination of crude oil and oil byproducts.

5.3. Consumption of Secondary Energy.

Chart 2.4
Secondary Energy Consumption

Product	Tcal	%
Firewood	15,440.6	53.0
Vegetal wastes	1,063.5	3.6
Oil byproducts	10,204.2	35.0
Mineral Carbon	3.9	0.0
Electricity	2,320.3	8.0
Firewood coal	116.2	0.4
Total	29,148.7	100.0

Source: National Energy Balance, 1994. CEL

Chart 2.5
Energy Consumption by Sectors

Sectors	Tcal	%
Residential and Commercial	15,838.5	54.3
Industrial	6,120.9	21.0
Transportation	6,535.2	22.4
Others	624.1	2.3
Total	29,148.7	100.0

Source: National Energy Balance 1994. CEL

Despite having an adequate hydraulic and geothermal potential, in 1994, the unfavorable hydrological conditions forced to satisfy the increase in electric energy demand with mainly the thermal plants. Throughout 1993, the thermal electric plants contributed in 32.6% of the gross electric energy generation, and in 41.4% in 1994.

6. Environment.

Environmental degradation has been closely linked to greenhouse gas emissions, as they relate to the deterioration of natural resources. The land use change, the creation of contaminating industries and the growing urbanization constitute three elements that should be taken into account when evaluating the relationship between environmental degradation and the greenhouse gas emissions.

The proliferation of temporary crops and the reduction of the area dedicated to agricultural products for exportation are the two main environmental degradation causes in the sector.

An important reduction in the area of primary natural forests happened simultaneously with the extension of annual crops. In accordance with the First and Third National Farming Census between 1950 and 1971, the natural forest area decreased in 18%. By 1994, it was estimated that the area of primary natural forests was not larger than 50,000 hectares, equivalent to approximately 2.5% of the national territory[13].

On the other hand, the coffee cultivated area experienced a relative growth before 1990, but since then has shown a marked dropping trend, mainly due to the expansion of urban zones in detriment of coffee cultivated areas. This has important implications for the environment, since the shade coffee cultivation provides many similar environmental benefits to those of a natural forest. Cotton on the other hand, became economically environmentally non viable, due to the intensive use of fertilizers and pesticides in the 60's and the 70's..

[13] SEMA: Environmental Agenda, 1992. FUSADES: The Green Book, 1997.

Since the emergency of the industry in 1950, the environmental variable has not been included. There are no programs to treat the effluence of industrial activities. This includes both agro industry and the manufacturing industry that mainly stayed in the city of San Salvador. Of 145 industries in the metropolitan area of San Salvador, only 9 of them treated their effluents in 1994. On the other hand, the majority of sugar and coffee processing plants deposit their effluents in the rivers without any treatment. The two sectors that emit the greatest volume of suspended particles were the cement and tile production. Tile production causes emissions because it uses firewood as fuel.

There is a strong trend towards urbanization in the country, causing two problems worthwhile mentioning with regards to climate change: waste management and the increase in the number of vehicles, and therefore traffic jams.

It is estimated that approximately 64% of the garbage generated in San Salvador is not collected, but rather thrown into ditches where it is burnt without any control. Domestic waste waters are unloaded into the river network that circulates the city, also without treatment. The concentration of colliforms in this network highly surpasses the tolerance limits for human beings.

On the other hand, the number of vehicles in the country tripled in the last two decades, mainly concentrating in the metropolitan area of San Salvador, thus generating carbon dioxide emissions as well as other greenhouse gases, as a result of the traffic jams.

Up to 1994, El Salvador did not have a specific law to regulate the use of natural resources, and the preservation of the environment,[14] Likewise, there was no governmental entity responsible for the environmental policies and the enforcement of a legal framework.

[14] Currently the Legislative Assembly approved the Environmental Law, which entered into force on May 4, 1998.

III. Greenhouse Gas National Inventory.

1. Greenhouse Gases and Climate Change.

The atmosphere is essential for the life on earth. For more than 3 billion years, the earth's atmosphere has been changed and molded by the interaction with living organisms. Nevertheless, it was not until the industrial revolution that human beings had a significant effect on these processes.

Greenhouse gases (GHG) in the low atmosphere (troposphere) such as steam, carbon dioxide, methane and nitrous oxide allow the sun rays to pass (short waves) and retain part of the radiation emitted by the earth (long waves or infrared) re-sending them again in several directions, but particularly to the land surface. Greenhouse gasses retain part of the heat of the atmosphere, impeding it to go back to space. This heat retention process is known as the "greenhouse effect" and thanks to this, the earth's global average temperature stays in approximately 15^{o}C, the absence of the same would cause a temperature of -18^{o}C, making life impossible.

In the year 1750 with the onset of the Industrial Revolution and particularly since the XX Century, greenhouse gas emissions from human activities have increased causing an increment of 30% of CO_2 concentrations in the atmosphere. The following activities have contributed the most to this phenomena: fossil fuel consumption, industrialization growth, agriculture, deforestation and land use change.

The climate system, which is comprised by the atmosphere, biosphere, geo-sphere, hydrosphere and crio-sphere; has maintained a balance between incoming and outgoing solar energy, by means of a series of interactive processes. The increase in greenhouse gas concentrations in the atmosphere has also increased the atmosphere's capability to retain the radiation from the earth, slowing down the rhythm of energy emitted towards the space, causing an accumulation of energy. This variation is known as positive radiative forcing.

In order to reestablish the energy balance, the climate system responds by means of adjustments, such as the warming of the earth's surface, variations in rainfall regimes, changes in atmospheric circulation, the increase in the sea average level, and other changes to the climate system components and their interaction mechanisms. These variations in the climate parameters are called climate change, which inevitably impact the natural ecosystems and social and economic sectors in terms of their vulnerability.

2. Methodological Considerations.

All the countries that ratified the FCCC committed themselves to achieve the Convention's ultimate goal and all related legal instruments such as: stabilize GHG concentrations in the atmosphere to a level that impedes any dangerous anthropogenic disturbance to the climate system.

Number 1 (a) of Art. 4 of the Convention, which describes the commitments, states that all the Parties involved should prepare, periodically update, publish and send to the Conference[15], national inventories of antropogenic emissions by sources and drainages of all greenhouse gases, not regulated by the Montreal Protocol, using comparable methods approved by the Conference of the Parties, in accordance with Article 12 and keeping in mind common but differentiated responsibilities, the specificity of national and regional priorities, objectives and circumstances for development.

Inventories are a tool that allow to quantify how human activities and some natural processes contribute to the emission and sequestration of GHG, as well as to develop mitigation programs and projects.

The inventory should be prepared following the FCCC three volumes of methodological directives[16]. Depending on the methodology, activities and processes these have been divided into five sectors: energy, industrial processes, land use change, forestry, agriculture and waste.

Among the relevant features of the standards and procedures used to build an inventory, we can mention the standardization and applicability that will guarantee and facilitate the consistent and systematic assessment and rating of GHG emissions among the various countries.

The inventory of El Salvador includes the balance of the emissions of three gases[17]: Carbon dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O); also including Carbon Monoxide and (CO) and Nitrogenous Oxides (NO_x) as indirect contributors to the greenhouse effect.

Given that GHG emissions are closely linked to a nation's whereabouts and development, it is important to establish the base year against which reported emissions are quantified. El Salvador used 1994 as the base year to build the inventory, considering the political and socio-economic problems that El Salvador faced throughout the 80's until the signing of the Peace Accords in 1992, and also based on the Convention[18] guidelines.

3. Institutional Arrangements.

The Ministry of the Environment and Natural Resources (MARN) through the coordination with the GEF-project[19] and within the framework of a technical cooperation agreement with the Central American University José Simeón Cañas (UCA), hired said University to prepare the Inventory. The Energy Sciences Department of the UCA co-ordinated, trained and advised the multi-disciplinary team in charge of the various sectors under study. A private enterprise participated in the energy sector.

Within the National Communication preparation process, the technical co-ordinator of the inventory was invited to participate in several regional workshops on inventories and mitigation analysis, in order to improve national capacities and expected future enhancements and updating to the national inventory[20].

[15] Annual meetings of all FCCC countries, to discuss and negotiate the setting forth and effective and early enforcement of the commitments undertaken by the Convention, Kyoto Protocol and all other related legal instruments.

[16] Please refer to the complete document of the National Inventory for Greenhouse Gases for the 1994 reference year.

[17] By virtue of the D10/ CP2 (Decision No. 10 of the Second Conference of the Parties to the Convention on Climatic Change).

[18] Decision 10, Second Conference of the Parties.

[19] Support the Creation of Capabilities to Prepare the First National Communication.

[20] Central American Regional Workshop on Greenhouse Gas Inventories and Mitigation Analysis, Antigua, Guatemala (February 1999). UNFCCC Workshop on Emission Factors and Activity Data and National Feedback on the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, La Habana, Cuba (September 1998). CC:TRAIN Latin American and the Caribbean Regional Workshop on Preparing a Climate Change Mitigation Analysis, La Habana, Cuba (March, 1998).

On the other hand, CFI Kaiser International Inc. was hired by US-CSP, to provide advisory to the Inventory technical coordinator, to review the methodology and improve the quality of the document.

During the process to prepare the inventory, two sector consultations were carried out, to gather the observations and agree on methodologies.

4. Limitations in the Preparation of the Inventory.

The limitations found in the preparation of the inventory, that could continue to represent an obstacle for future updating of said document are:

a. The lack of a national effective data system.

   There are no institutional arrangements nor procedures to generate, manage and analyze the information required to systematically prepare and update the inventory.

b. Data institutional deficiencies.

   Certain information required to prepare the inventory was lacking since the agencies involved do not keep records or collect relevant data with regards to the inventory. The municipalities for instance, lack relevant information on solid waste generation and management.

   With regards to land use change and forestry, the lack or outdated data is very notorious. The entity in charge of preparing the forestry inventory has not prepared an inventory and the only map of tree vegetation was made in 1981, based on satellite pictures and air pictures taken from 1974-76.

   The data that said sectors use is very aggregated, even the data contained in the GIS has not been validated against field work, it is secondary and imprecise. This situation contrasts with the detailed levels required by the FCCC methodology for the inventory.

c. State Institutional Reform:

   As a result of the privatization of some State utilities, the latter does not generate this information. Such is the case of the energy balance prepared by CEL, the OLADE national counterpart. This agency does not record since its privatization in 1997.

d. Methodological Problems:

   Since the quality, detail level and amount of information demanded by the "methodology" responds to a "from and to" approach of developed countries, the institutional reality of our country does not allow to respond to said requirements appropriately, especially in the Land Use Change and Forestry Sector.

e. Level of uncertainty:

   Although the FCCC methodology aims at reducing uncertainty to the lowest levels possible, it is not feasible to reliably quantify the level of uncertainty in El Salvador due to the quality of available information and the almost exclusive use of emission factors by default. The procedure requires to asses the level of uncertainty of emission factors from different sources as well as the data from the socio-economic activities included in the Inventory, but this information is not available.

The national inventory should be subjected to a thorough technical review in the near future. This review should be participative, open and transparent and carried out by a team of accredited experts in order to:

a. Analyze the national institutional framework involved in the data generation and management for the preparation of the inventory, and develop a proposal for a simple, functional and effective information system.

b. Verify the availability of documents to expedite self verification procedures or independent technical reviews, to recalculate data.

c. Examine data and methodologies by source and drainage categories.

d. Analyze the quality of inventory outcomes and quality control procedures. Identify areas that need to be improved and ways to overcome methodological and data presentation problems.

5. Total Emissions.

Chart 3.1 summarizes each one of the sources considered in the National Inventory of GHG in El Salvador for the 1994 base year which are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and nitrogen oxide (NO_x). Based on the FCCC methodology, calculations and inventory analysis were based on the three main GHG: carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N_2O).

Chart 3.1: Summary of GHG Emissions for 1994 (Gg)

	CO_2 Uptake	CO_2 Emissions	CH_4	N_2O	CO	NO_x
Total National Emissions /Uptake	9,363.64	-718.70	148.50	13.21	512.66	34.02
1. Energy[21]	4,224.18		18.09	0.52	437.48	31.03
2. Industrial Processes	490.12					
3. Agriculture			88.14	12.69	70.65	2.86
4. Land Use Change and Forestry	4,649.34	-718.70	0.52	$3.6x10^{-3}$	4.53	0.13
5. Waste			41.75			

It is necessary to clarify the difference between net and gross emissions, since net emissions result from subtracting GHG uptake by drainage from man managed ecosystems provoked by various sources. Gross emissions refer solely to effective GHG emissions derived from human activities, without including the gases absorbed by the ecosystems.

A total emission of 1.6 ton of CO_2 per inhabitant[22] ($1.6x10^{-3}$ $GgCO_2$ per inhabitant) was estimated based on the information in the National Inventory and the population of El Salvador in 1994 .

CH_4 and N_2O emissions could reach a relative contribution to global warming in the near future that would be higher than the one shown in the base year. This phenomenon becomes more important when the nation attempts to identify and prioritize GHG mitigation measures and policies.

The Global Warming Potential (GWP) relates to the amount of CO_2 emissions necessary to create an effect equal to global warming that would provoke the emission of the mass unit of another gas during a specified period. The conversion operation is carried out using the GWP in accordance with the values indicated in Chart 3.2, which represents the relative radiative power of various gases with respect to CO_2, as defined by the FCCC for the three main gases in terms of the time horizon.

[21] The "Reference Approach" Chart 3.6 was used to quantify the amount of CO_2 for this sector.
[22] Consistent with IEA, 1996: Key World Energy Statistics (Energy Sector, 1996: 0.75 $tonCO_2$/inhab) and with WB 1999-2000: Annual Report (Energy Sector, 1995: 0.77 ton CO_2/inhab), keeping in mind that during the base year the Energy Sector had a 47% share in the total domestic CO_2 emissions.

Chart 3.2 GWP of the three main GHGs		
Gas	GWP In 20 years	GWP In 100 years
CO_2	1	1
CH_4	56	21
N_2O	280	310

Chart 3.3 shows the relative importance of the three main gases at the end of a 20 year time horizon: CO_2 represents 42% of the net emissions of El Salvador, followed by CH_4 representing 40%, and N_2O, representing 18% of all emissions.

Chart 3.3 Emissions of the Main GHGs					
Gas	1994 Gross Emissions (Gg)	1994 Uptake (Gg)	1994 Net Emissions (Gg)	Net Emissions in 20 years	Net Emissions in 100 years
CO_2	9,363.64	-718.70	8,644.94	8,644.94	8,644.94
CH_4	148.50		148.50	8,316.00	3,118.50
N_2O	13.21		13.21	3,699.81	4,095.10
Total				20,660.75	15,858.54

The outcomes in Chart 3.4 come from the consolidation of the three main gases, previously converted in CO_2 equivalent terms. This conversion allows to assess the relative participation of gases and emitting sources.

El Salvador's net antropogenic emissions amount to 20,660.75 Gg_{equiv}-CO_2, which represents 3.6 ton_{equiv}-CO_2/inhab (3.6x10^{-3} Gg_{equiv}-CO_2 per inhabitant).

Chart 3.4 Summary of GHG Emissions and Uptake for 1994 (Gg_{equiv}-CO_2 in 20 years)						
	CO_2 Emissions	CO_2 Uptake	CH_4	N_2O	Total	%
Total Domestic Emissions / Uptake	9,363.64	-718.70	8,316.00	3,699.81	20,660.75	100
1. Energy[23]	4,224.18			145.60	4,369.78	22
2. Industrial Processes	490.12		1,013.04		1,503.16	7
3. Agriculture			4,935.84	3,553.20	8,489.04	41
4. Land Use Change and Forestry	4,649.34	-718.70	29.12	1.008	3,960.77	19
5. Waste			2,338.00		2,338.00	11

[23] The "Reference Approach" was used to quantify the CO_2 (Chart 3.6).

6. Carbon Dioxide Emissions (CO_2).

The CO_2 as a GHG, allows the entrance of solar energy to the earth's surface, delaying at the same time the flow of heat to the exterior part of the atmosphere, thus playing a very important role in the planet's temperature regulation.

The presence of this gas in the atmosphere is key to complete the so called carbon cycle found in nature as carbonates, contained in calcareous rocks, but above all in the CO_2 contained in the atmosphere and dissolved in water. Green plants sequester CO_2 from water or air photosynthesis and transform it into organic compounds that induce plant growth and serve as food for consumers and decomposers.

Respiration, fermentation, the processing of minerals and fossil fuel and biomass combustion are just some of the mechanisms that return CO_2 to the atmosphere to complete the cycle.

These carbon sequestration and returning mechanisms have allowed to establish a balanced and self regulated system that has achieved the compensation of CO_2 concentrations in the atmosphere during several periods.

In the last four decades, as a result of the unbalance between sequestration and emission CO_2 concentrations have progresses significantly. One of the direct effects of this increase in concentrations is increase in global average temperature.

It has been estimated that El Salvador had a net emission of CO_2 of 8,644.94 Gg. In 1994. The sources that contributed to carbon return to the atmosphere were: the Energy Sector with 4,224.18 Gg (49%), the Industrial Processes Sector with 490.12 Gg (6%) and the Land Use Change and Forestry Sector with 3,930.64 Gg (45%).

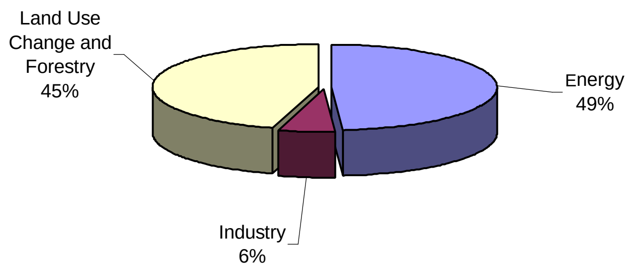


Fig. 3.1: Proportion of Net Total Emissions of CO_2

6.1. CO_2 Emissions of the Energy Sector.

The CO_2 produced by the Energy Sector was quantified in 4,224.18 Gg, by means of the "Reference Approach" (Top-Down); which consists in estimating emissions from the amount of carbon contained in imported fossil fuels and consumed in the country during the base year.

The broken down calculation of the "Reference Approach" method is shown on Chart 3.6. Note that the calculation does not consider the contribution of firewood and farming wastes, since they were included in the land use change and forestry sector, as per the FCCC methodology.

This method does not identify the consumption of fuels at a sector level. It is important to quantify emissions by sub-sectors, given the importance of the same to establish GHG mitigation policies. This method is called "Analysis per Source Category" (Bottom-Up). Chart 3.6 summarizes the outcomes found in both approaches.

The emissions reported by the Reference Approach are higher than those reported by the Analysis per Source Categories, nevertheless, the difference is not higher than 6%, which is an acceptable value, considering the uncertainties related to the source data and emission factors. The emissions calculated based on this last method are: 4,024.53 Gg, considering the following sub-sectors: Energy Industry, Manufacturing Industry, Transportation, Residential and Commercial (Chart 3.5).

The Energy Industry Sub-sector quantifies the emissions produced during the transformation of crude oil into its derivatives and thermoelectric generation. The estimate of emissions was 1,303.98 Gg.

The CO_2 emissions in the Manufacturing sub-sector amount to 656.40 Gg, associated with the consumption of hydrocarbons used to generate steam or any other used by these various industries.

The Transportation Sub-sector includes land, train and civil aviation emissions. The amount of CO_2 emitted is 1,815.56 Gg. The CO_2emissions of the Commercial and Residential Sub-sector are estimated in 248.59 Gg due to the consumption of hydrocarbons in commercial and domestic activities.

Chart 3.5
CO_2 Emissions of the Energy Sector by Sub-sector
Source Category Approach (Gg)

Energy Industry	1,303.98	32%
Manufacturing Industry	656.40	16%
Transportation	1,815.56	46%
Commercial and Residential	248.59	6%
Total	4,024.53	100%

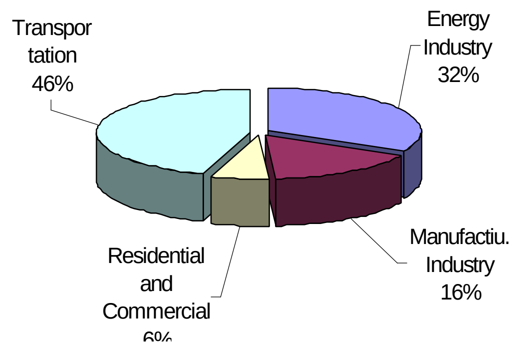


Fig. 3.2: Percentage of CO_2 Emissions in the Energy Sector by Sub-sector

Chart 3.6
Comparison of the Two Approaches Used to Estimate Total CO_2 Emissions in the Energy Sector (Gg)

Types of Fuel			Reference Approach	Analysis per Source Category
Liquid Fossils	Primary Fuels	Crude Oil	2,567.59	
		Liquid natural gas		
	Secondary Fuels	Gasoline	217.64	770.65
		Jet Kerosene (bunkers)	-101.04	0.37
		Kerosene		51.29
		Diesel	1,248.57	1,996.34
		Residual Fuel	125.61	948.64
		LPG	181.91	214.45
		Ethane		
		Nafta		
		Asphalt	-0.35	
		Lubricants	-17.48	
		Petroleum Coke		
		Refinery Gas		41.05
		Other oils		
Total Liquid Fossils			4,222.45	4,022.79
Solid Fossils	Primary Fuels	Anthracite		
		Coke Carbon		
		Other bituminous carbon	0.12	0.13
		Sub bituminous carbon		
		Lignite		
		Oil shale		
		Turf		
	Secondary Fuels	BkB		
		Coke	1.61	1.61
Total Solid Fossils			1.73	1.73
Gas Fossils		Natural gas (dry)		
Total			4,224.18	4,024.53
Biomass Total			7,906.91	7,852.20
		Solid biomass	7,906.91	7,852.20
		Liquid biomass		
		Gas biomass		

6.2. CO_2 Emissions in the Industrial Processes Sector.

This sector quantifies CO_2 emissions considered as a byproduct of certain industrial processes. For the case of El Salvador, the only applicable process is the production of cement and live quicklime from calcium carbonate. The emission of CO_2 generated by the use of limestone as a soil neutralizing agent is also included. The estimated emissions are 490.12 Gg. The amount of CO_2 resulting from cement production was estimated in 455.97 Gg, and from lime production 23.70 Gg and farming lime usage 10.45 Gg.

Chart 3.7
CO_2 Emissions of the Industrial Processing Sector by Sub-sector(Gg CO_2)

Cement production	455.97	93%
Lime Production	23.70	5%
Limestone	10.45	2%
Total	490.12	100%

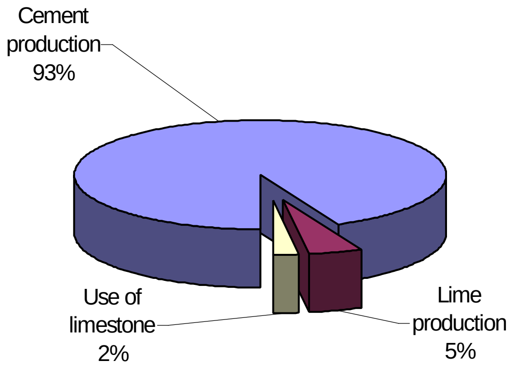


Fig. 3.3: CO_2 Emissions Percentage in the Industrial Processing Sector by Sub-sector

6.3. CO_2 Emissions in the Land Use Change and Forestry Sector.

The net CO_2 emissions caused by this sector were estimated in 3,930.64 Gg, which include the sequestration of CO_2 achieved by the vegetation in farming lands abandoned during the armed conflict of the 80's. CO_2 sequestration was estimated in 718.7 Gg, corresponding to an area of 98,000 hectares of recovered forests as a result of 20 years of abandonment.

Total emissions in this sector amounted to 4,649.34 Gg, with the contribution of the following activities: the change suffered in forest coverage due to the intensive use of firewood with 4,068.10 Gg, the burning of grasslands and farming waste after harvesting with 534.60 Gg and biomass decay with 46.64 Gg.

Chart 3.8 CO_2 Emissions of the Change in the Use of Soil and Forestry Sector (Gg)		
Change of forests and firewood consumption	4,068.10	87%
Burning of grasslands and farming waste	534.60	12%
Biomass decay	46.64	1%
Total Gross Emissions	4,649.34	100%
Aptake	718.70	
Total Net Emissions	3,930.64	

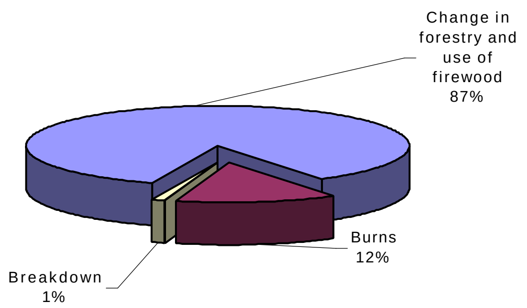


Fig.3.4: Percentage of CO_2 Gross Emissions in the Land Use Change and Forestry Sector per Sub-sector

7. Methane Emissions (CH_4).

Atmospheric methane is considered the second most important gas for the greenhouse effect. As indicated in Chart 3.2, even small amounts of CH_4 emitted could have a significant effect on global warming, since it uptakes infrared radiation more efficiently than CO_2.

In 1994, CH_4 emissions were estimated in 148.50 Gg, being the main generators Agriculture with 88.14 Gg (60%), Waste 41.75 Gg (28%), Energy with 18.09 Gg (12%) and Land Use Change and Forestry with 0.52 Gg (negligible).

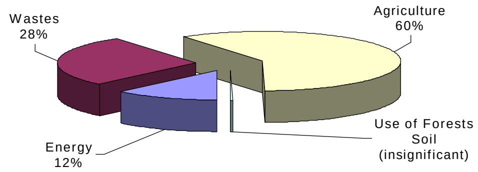


Fig.3.5: CH_4 Emissions Sectorial Share

7.1. Methane Emissions in the Agricultural Sector.

CH_4 emissions in this sector were calculated in 88.14 Gg. The main generating sources were associated with enteric fermentation (digestive processes) domestic cattle wastes with 83.24 Gg, rice production by flooding with 1.63 Gg and burning and farming wastes with 3.27 Gg.

Chart 3.9 CH_4 Emissions in the Farming Sector (Gg)		
Enteric Fermentation	83.24	94%
Rice cultivation	1.63	2%
Burning and farming waste	3.27	4%
Total	88.14	100%

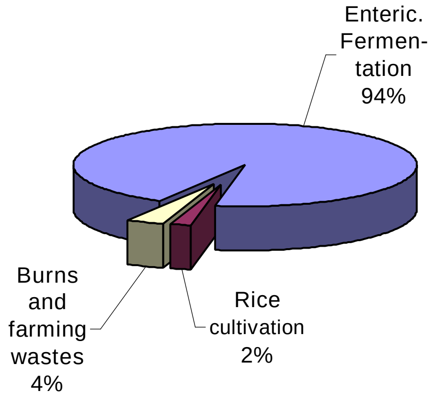


Fig. 3.6: CH_4 Emissions Share in the Agricultural Sector per Sub Sector

7.2. CH_4 Emissions in the Waste Sector.

CH_4 emissions included in this sector are a result of anaerobic digestion of organic matter, and were calculated to sum 41.75 Gg, distributed as follows: those generated in the municipal solid waste dump sites 25.64 Gg, those from domestic waste water treatment 2.78 Gg and those from industrial waste waters 13.33 Gg.

Chart 3.10 CH_4 Emissions in the Wastes Sector (Gg)		
Municipal Solid Waste	25.64	61%
Domestic Treatment drainage	2.78	7%
Industrial waste treatment	13.33	32%
Total	41.75	100%

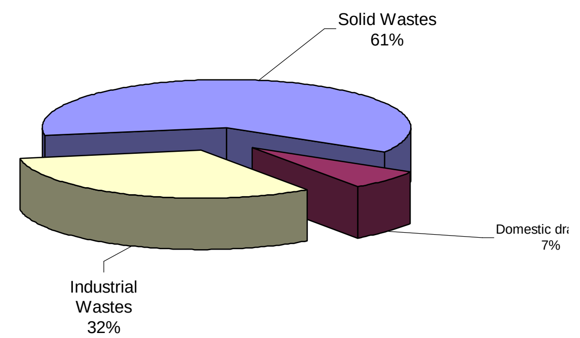


Fig.3.7: CH_4 Emissions in the Waste Sector per Sub Sector

7.3. CH_4 Emissions in the Energy Sector.

Methane, nitrous oxide, carbon monoxide, nitrogen oxide and volatile organic compounds emissions other than methane are basically due to the incomplete combustion associated with the type of fuel used, operational conditions, control and maintenance technologies and the life period of the equipment used.

Total emissions for this sector amount to 18.09 Gg, mainly contributed by the Residential and Commercial sub-sectors with 17.28 Gg, the industry with 0.46 Gg, transportation with 0.30 Gg and the energy industry with 0.05 Gg (negligible).

Chart 3.11 CH_4 Emissions in the Energy Sector (Gg)		
Residential and Commercial	17.28	95%
Transportation	0.30	2%
Energy Industry	0.05	negligible
Manufacturing Industry	0.46	3%
Total	18.09	100%

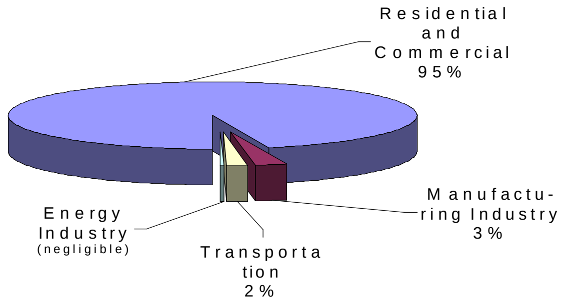


Fig.3.8: CH_4 Emissions in the Energy Sector per Sub-Sector

7.4. CH_4 Emissions in the Land Use Change and Forestry Sector.

The methane emission in this sector is fundamentally due to the amount of carbon released during the in situ biomass burning, mainly of grasslands and farming waste. CH_4 emitted is estimated in 0.52 Gg.

8. Nitrous Oxide Emissions (N_2O).

Nitrogen is one of the main plant nutrients necessary for a vigorous plant growth. This element is aggregated to the soil through fertilizers such as Ammonia Nitrate (NH_4NO_3) as an atropogenic contribution. Nitrogen is sequestered by the plants at a rate which depends on the species and soil category. For instance, a forest area can sequestrate 15 kg/hectares/year, while the lands with farming or grassland location can sequester 40 kg/hectares/year or more.

The main source of N_2O in El Salvador comes from the fertilizer unused by the plant, which is dragged towards the underground water by the rain (lixiviation), or towards the surface water bodies in the process called dentrification (reduction of low anaerobic status nitrates). Likewise, there is a release of N_2O during the burning of farming residues, which occurs in accordance with the following reaction:

$$NH_4NO_3 \xrightarrow{calor} N_2O + 2H_2O$$

Poor farming practices, such as the way fertilizers are applied, and the maintenance of high amounts of immobile biomass also cause N_2O emissions. By 1994, N_2O emissions were estimated in 13.214 Gg, and the agricultural sector was the main contributor with 12.69 Gg (96%), the Energy sector with 0.52 Gg (4%) and the Land Use Change and Forestry sector with 0.004 Gg (negligible).

8.1. N_2O Emissions in the Agricultural Sector.

N_2O emissions in the Agricultural Sector amount to 12.69 Gg, computed in the following activities: burning of grassland and farming waste, 0.078 Gg (1%); crop cultivation, 2.74 Gg (22%); Pasturing 3.49 Gg (27%); Atmospheric Disposal 0.41 Gg (3%); Lixiviation, 5.71 Gg (45%) and Human Waste 0.26 Gg (2%).

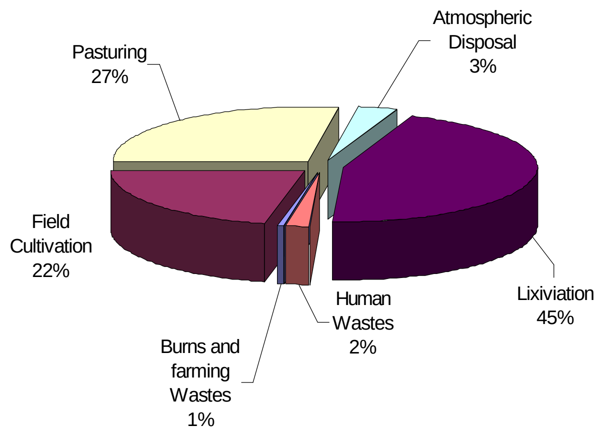


Fig. 3.9: N_2O Emissions in the Agricultural Sector per Sub-sector

8.2. N_2O Emissions in the Energy Sector.

N_2O emissions like methane emissions in the energy sector, are associated with combustion systems. The emissions in this sector amount to 0.52 Gg.

8.3. N_2O Emissions in the Land Use Change and Forestry Sector.

N_2O emissions in this sector are mainly due to the burning of forests. It was estimated that in 1994 a total of 0.004 Gg were released.

IV. Measures to Enforce the Convention.

Following are the values of some key social and economic indicators of El Salvador: the illiteracy rate which exceeds 20%; and the fact that 47% of the population lives under the poverty levels, and 18% under extreme poverty; the GDP per capita (in 1990 US$) is approximately US$ 1,200. This reflects national priorities that should be based on the need for an important and fair economic growth.

The structure and levels of energy consumption reflects the same situation: firewood represents almost 50% of the total energy consumption; 60% of this fuel is used for cooking in the urban areas and 85% in the rural areas. This strongly contributes to the growing deforestation and evidences the need to immediately start the process of fuel replacement, promoting the penetration of cleaner and better quality sources, at a lower cost for the user. The consequence of the aforementioned will be an increase in total and per capita emissions.

In order to make a fair comparison and to determine the situation and liability of El Salvador, we have highlighted the indicators of other countries and their relative comparison to local values.

Chart 4.1.

Emissions per Inhabitant (Ton CO_2/hab)

Countries	1990
USA	24.06
Canada	17.44
Australia	16.91
Russia	16.11
Germany	12.76
Average Countries Annex I[1]	13.34
El Salvador[2]	0.77 (1995)

In 1995, CO_2 emissions in El Salvador represented approximately 3.2% of the US emissions in 1990, and a much lower percentage than the ones in 1995 and those of today. It is evident that the efforts that El Salvador could make, and which are identified throughout this survey, could be significantly important within the local level, but, still marginal regarding their contribution to the global problem.

[1] Set of developed countries and countries transitioning towards a market economy which have ratified the FCCC, which are listed in Annex I of the Convention.
[2] WB, 1999-2000: Annual Report (emissions from the Energy Sector).

Notwithstanding the above, it is necessary to seek the resources to better understand the behavior of the energy system and develop future scenarios that will allow to interfere or measure the potential evolution of the social and economic system, and identify options for the rational use of energy, provided that the prioritary objectives of a fair economic and social growth are not sacrificed, and that the country can positively contribute to the global problem.

1. Analysis of the Mitigation Options in the Energy Sector

1.1. Methodological Considerations

A comparison between two evolution scenarios of the Salvadoran system was made following the guidelines defined by the FMAM/MB for the development of climatic change mitigation studies. One of them is the Reference Scenario, which is associated with the foreseeable evolution of the system, according to the current dynamic, without explicit policies or actions to reduce GHG emissions. And also the Mitigation Scenario which assumes the election of a set of climatic change mitigation actions and options to assess whether it is convenient or not to apply them.

The diagnostic study was the starting point, and it allowed to understand the relations between economy – energy and energy – environment, as well as the dynamics of the economic activities and the energy system, object of this study and also, their impact on the accumulation of the GHG in the atmosphere.

After the diagnostic study, it is necessary to identify the available mitigation options in the sectors being analyzed. The Mitigation Scenario assumes the pre-selection of the most interesting options to mitigate the climatic change effects.

The evaluation of the mitigation options included in the Mitigation Scenario should be based on the costs and benefits they represent as compared to the expected situation and the Reference Scenario. The scope of the study, does not include the assessment of the mechanisms to enforce a mitigation policy, and therefore, the Mitigation cost curves have not been calculated, since it is not possible to include the indirect costs associated to mitigation options.

The operation of the energy system was analyzed in both Scenarios, by controlling the consistency of the energy flows, from the reserves to consumption, using the LEAP model.

An environmental database was additionally generated for this study, coherent with the previously adopted emission coefficient base when developing the GHG national Inventory in 1994

1. 2. Energy-Environmental Diagnostic Study.

1.2.1. Domestic Energy Consumption.

The domestic energy requirements are essentially satisfied by oil products, electric energy, plant residues and firewood, oil, hydro energy, geothermal energy and biomass which are the main sources of energy supply in El Salvador, as seen from the perspective of primary energy.

Figure 4.1 shows the initial moderate growth period during the seventies, followed by a sharp contraction and stagnation throughout the period from 1981 to 1992, due to the armed conflict. After the signing of the Peace Accords, the growth trend in consumption continued, at an annual average rate of 12%, which is higher than in the seventies (4.6%).

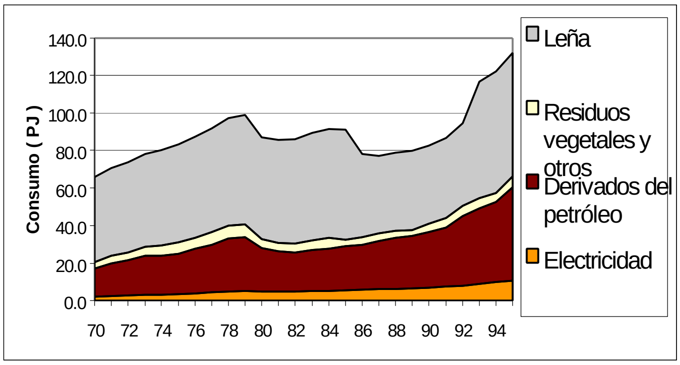


Figure 4.1: Total energy consumption evolution from 1970 to 1995[3]

The historical behavior of energy intensity has been quite erratic, mainly due to the high domestic consumption of firewood and to the fact that an important part of the same is "non commercial energy" used by the residential sector; it is difficult to estimate consumption, since there are no reliable statistics and also due to the uncertainty associated to estimation methods. The opposite is true if we only take into account the consumption of commercial energy that is, a clear growing trend throughout the period under consideration, which is stressed even more during the last five years.

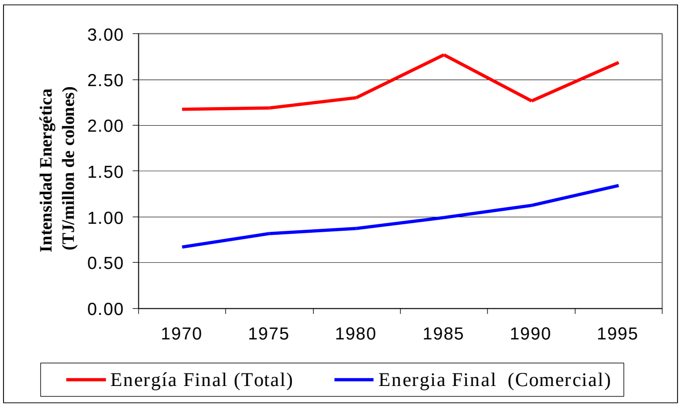


Figure 4.2: Energy intensity in El Salvador, from 1970 to 1995.
(1990 TJ/million colones in 1990)

The per capita consumption has increased in 27% from 1970 to 1995. A sharp increase is observed between 1990 and 1995. If only commercial energy is considered, the growth rate is even greater during this same period.

1.2.2. Energy Supply.

Domestic energy supply was covered with renewable domestic sources in more than 55% from 1970 to 1995. Nevertheless, there has been a drop in the participation of renewable sources and a significant increase in the participation of crude oil and its derivates.

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[3] CEL: National Energy Balance, Series 1980-1996.

Biomass resources are the main domestic energy source; these are comprised of firewood and plant residues; the firewood consumed in El Salvador comes from the various types of vegetation found in the country, and their energy use competes with other uses such as wood production and environmental protection.

Oil requirements are currently satisfied by the importation of crude oil or its derivates, and this will not change in the future. In the nineties, the direct import of oil derivates increased, particularly the import of diesel oil, which is consumed by the transportation sector and thermoelectric generation.

1.2.3. The Energy Policy and the Process of Sector Transformation

Energy policy design and formulation in El Salvador is not characterized by an integrated conception, but rather by its fractioning at the sub sector levels. An important change in the domestic policy occurred after 1989, moving from a high state intervention model to a privatized and less regulated model. The new model implied the non intervention of the State in productive activities and the reduction and modernization of the state apparatus, as well as the liberalization of the internal market and the reduction of tariff barriers.

1.2.4. Environmental Diagnostics Study.

In accordance with the 1994 GHG National Inventory, the emission of 4,024.53 Gg of carbon dioxide (CO_2), 18.09 Gg of methane (CH_4) and 0.52 Gg of nitrous oxide (N_2O) are attributed to the energy sector activities. The amount of CO_2 reported in this study is in the non biogenic category, coming exclusively from the burning of fossil fuels. Likewise, the calculation of emissions corresponds to the "Analysis by source categories" method, which allows to quantify emissions by sub sectors, in opposition to the "reference approach[4].

Chart 4.2
CO_2 emissions by Sub Sectors (Year 1994)

Sub Sector	Gg	%
Transportation	1,815.56	45.11
Energy Industry	1,303.98	32.40
Manufacturing Industry	656.40	16.31
Residential y Commercial	248.59	6.18
TOTAL	4,024.53	100.00

The environmental problem caused by the Transportation Sector is not only reflected in its contribution to GHG emissions but also in the emission of other highly harmful gasses to human life.

CO_2 emissions associated to the burning of hydrocarbons in the energy industry are concentrated in the thermo electric industry. CO_2 emissions in the Residential and Commercial sectors are mainly due to the burning of LPG and kerosene. It is expected that the emissions of CO_2 will increase given the efforts to replace firewood with LPG, together with the urban growth.

[4] The difference between both methods, as well as the emissions resulting from both methods, are explained in the GHG National Inventory.

1.2.5. Social and Economic Context.

The Mitigation study has only considered the projections up to the year 2025, with intermediate ones for the years 2005, 2010 and 2020. Social and Economic scenario projections are based on the identification and analysis of demographic, social, economic, territorial and institutional indicators.

It was agreed to use the Trend[5] Scenario in the GHG Mitigation Energy Study. As its name indicates, it assumes that the trend displayed in the last few years will continue or at least vary very slightly.

Chart 4.3 Projected Demographic Indicators					
Demographic Indicators	Unit	2005	2010	2020	2025
Population	Millions	6.996	7.687	8.992	9.726
Population Growth Rate	Annual %	1.59	1.38	1.21	1.27
Percentage of Urban Population	UP/TP %	66.8	71.9	81.3	87.2[6]

Source: Umaña, 1998. Corrections: Aguilar, 1999.

Social Indicators take into account : literacy, schooling, housing type, housing utilities, child mortality, poverty level, among other. The trend of these indicators are shown below:

Chart 4.4 Projected Social Indicators					
Social Indicators	Unit	2005	2010	2020	2025
Literacy	%	81.4	82.7	85.2	86.5
Schooling	%	75.7	77.7	81.9	84.0
Child Mortality <1 year	%	31.5	29.4	25.5	23.7
GDP social expenditures	%	5.0	5.6	6.8	7.6
Population under poverty	%	45.0	43.8	41.5	40.4
Population under extreme poverty	%	17.3	16.8	15.9	15.5

Source: Umaña, 1998.

The scenario has kept the historical average rate of 3.5% in the last 15 years (1984-1998), to project growth from 1999 to 2025.

Chart 4.5 Projected Economic Indicators					
Indicator	Unit Measure	Years Considered			
		2005	2010	2020	2025
GDP in 1990 dollars	Million US$	9,505	11,524	16,900	20,533
GDP Growth Rate	%	3.9	3.9	3.9	3.9
GDP per capita	US$ 1990	1,359	1,499	1,907	2,111
Primary GDP	% GDP	12.0	11.1	9.5	8.7
Industry GDP	% GDP	21.5	21.7	22.0	22.1
Services GDP	% GDP	66.5	67.2	68.5	69.2

[5] Umaña, 1998.

[6] The data corresponding to the urban population percentage in the year 2025, result from projecting the 1995 values (General Directorate of Statistics and Census) and differ form the data in the Social Economic Study (Umaña, 1998). Interpolation has been used to calculate intermediate values, using the growth rate of the estimated population in the Umaña study. It is important to highlight that no significant changes are expected in the outcomes of the energy study resulting from said percentage differences

1.3. Reference Energy.

1.3.1. General Guidelines

It has been foreseen that the energy demand of social and economic sectors will include:

a. The penetration of new energy sources, such as natural gas and solar energy.
b. The change in the historical trend share of the various sources in different uses.
c. The improvement of specific energy consumption and its final use.
d. The continuation of the same structure of transportation means and modes.

Regarding energy supply, it has been foreseen that the refinery will enhance its processing capacity of crude oil in 32% between 1995 and the year 2020.

The inclusion of new hydro electric plants has not been foreseen but, an increase in geothermal development is expected, as well as a greater growth in plants that use oil and coal derivates.

1.3.2. Total Energy Demand

The outcomes of this scenario indicate that:

a. El Salvador is heading towards a growing depedency on fossil fuels. Its share has increased from 41.5% in 1995 to 61.2% in 2020.
b. The transportation sector has experienced the greatest increase in energy demand. The demand increase during the analyzed period has been estimated in 185%.
c. The energy demand growth in the residential sector was estimated in 18.8%. Said increase obeys to the introduction of the LPG, whose energy transformation efficiency is much higher than firewood.
d. Firewood as an energy source has dropped in 14.5% during the analyzed period.

Chart 4.6
Annual Energy Demand by Sectors (PJ)

Sectors	1995[7]		2005		2010		2020	
Residential	53.22	44.8%	56.68	37.8%	58.81	35.1%	63.23	28.5%
Transportation	31.22	26.2%	48.10	32.1%	56.49	33.7%	88.99	40.2%
Industrial	27.17	22.9%	35.45	23.6%	41.03	24.4%	53.58	24.3%
Other sectors	7.25	6.1%	9.72	6.5%	11.38	6.8%	15.58	7.0%
Total	118.85	100.0%	149.95	100.0%	167.71	100.0%	221.69	100.0%

1.3.3. Electric Energy Supply and its Emissions

The following electric energy demand forecast resulted from the hypothesis and outcomes of the social economic trend scenario

[7] These data result from the simmulation with the LEAP model; data defficiencies have been corrected in the series of CEL Energy Balances 1980-1996, especially in firewood consumption.

Chart 4.7 Electric Energy Forecasted Demand				
YEAR	FORECASTED ENERGY (GWh)			GROWTH (%)
	DEMAND	LOSSES	TOTAL	
1995	3,130.0	220.0	3,350.0	
2005	4,490.0	261.3	4,751.3	3.6
2010	5,430.0	316.0	5,746.0	3.9
2020	7,980.0	452.4	8,432.4	3.9

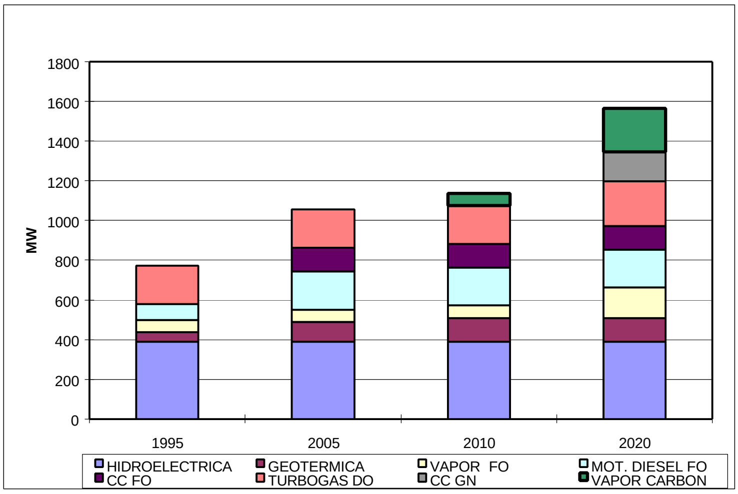

Figure 4.3: Evolution of the Installed capacity of the Reference Scenario Generating Park.

1.3.4. Thermal Electric Generation Emissions

Given the conditions of the new regulatory framework in the electric energy sector, it has been considered that thermal energy will be the main source of supply, for the reference Scenario, through foreign investment.

Chart 4.9 summarizes the evolution of the generating park, evidencing the strong penetration of generators that intensively use oil derivates. The penetration of natural gas was defased up to the end of the period.

The hydro electrical source maintains the installed capacity until the end of the study, but varies every year under consideration, in accordance with the assumed hydrological conditions. The geothermal resource increases in accordance with the stabilization plans of the Ahuachapán and Berlín geothermal fields.

Chart4.8 Evolution of the Installed Capacity by Resource (MW)				
RESOURCE	1995	2005	2010	2020
Hydroelectric	388	388	388	388
Geothermal	50	100	120	120
Steam Fuel Oil	60	63	63	153
Diesel Fuel Oil Engines	80	192	192	192
CC Fuel Oil	0	120	120	120
Turbogas Diesel	194	194	194	224
CC Natural Gas	0	0	0	150
Steam Coal	0	0	60	220
Sub – Total	772	1,057	1,137	1,567
Self production				
Diesel	45	45	45	45
Sugar Processing Plant	44.8	55	60	70
Sub – Total	89.8	100	105	115
TOTAL	861.8	1,157	1,242	1,682

Chart 4.9 Electric Energy Supply per Resource Type (GWh)				
Resource	1995	2005	2010	2020
Hydro electrical	1,463.8	1,528.4	1,542.0	1,562.4
Geothermal	409.8	844.7	1,018.9	1,024.2
Steam Fuel Oil	275.0	305.0	374.5	884.0
Diesel Fuel Oil Engines	205.1	1,274.0	1,366.4	1,468.9
Combined Cycle Fuel Oil	0.0	567.2	565.1	699.6
Turbogas Diesel Oil	915.1	86.6	315.9	235.3
Combined Cycle Natural Gas	0.0	0.0	0.0	799.7
Coal Steam	0.0	0.0	399.7	1563.8
Subtotal	3,268.8	4,605.9	5,582.5	8,237.7
Self production				
Diesel	17.3	27.6	31.5	39.4
Sugar Mill	97.9	120.4	131.3	153.2
Subtotal	115.2	147.9	162.8	192.6
Total	3,384.1	4,753.8	5,745.3	8,430.3

Chart 4.10 Consolidates the evolution of the GHG emissions attributed to thermoelectric generation. It is estimated that the Non Biogenic CO_2 emissions will have increased in 213% by the year 2020.

Chart 4.10 GGE Emissions in Thermal Electric Generation (Gg)								
	1995		2005		2010		2020	
GHG	TP	SP	TP	SP	TP	SP	TP	SP
Non Biogenic CO_2	1,368.1	17.4	1,957.8	27.7	2707.1	31.4	4,279.3	39.5
Biogenic CO_2		319.9		340.7		327.9		309.7
CO	1.6	0.4	5.6	0.5	6.2	0.4	7.0	0.4
CH_4	0.2		0.4		0.4		0.5	
NO_X	7.8	0.3	27.0	0.3	30.9	0.3	38.2	0.3

CT: Thermal Plants and AP: Self production

1.3.5. Refinery Sub Sector.

In El Salvador, refineries are not complex and therefore do not present a high retrofit of heavy to light and/or intermediate oil derivates.

The capacity resulting from these changes could range between 24,000 and 28,000 Bbl/day, depending on the amount of crude processed. Refineries have rarely operated to their full capacity, but rather at 70% average capacity.

According to the information provided by the Company, there are no expansion plans to include new processes and/or high investments in the mid term. Therefore, it was estimated that the refinery would not significantly increase its processing capacity and that by the year 2020, it would have a capacity of 7 million Bbl/year. Likewise, it has been estimated that the derivates produced in this refinery will be maintained with the following production structure throughout the period: 33.4% fuel-oil, 28.5% diesel-oil, 23.3% gas, 6.6% kerosene Jet Fuel, 3.9% non energetic, 2.6% LPG and 1.7% refinery gas.

Chart 4.11 Total GHG Emissions due to Oil Refinery. Reference Scenario					
	1995	2005	2010	2020	Unit
Methane (CH_4)	27.70	31.98	33.55	36.70	Mg

1.3.6. Total Emissions.

Chart 4.12 consolidates the GHG projected emissions of the energy system for the period from 1995-2020.

Chart 4.12 Total GHG Emissions (Gg)				
GHG	1995	2005	2010	2020
Non Biogenic CO_2	4,364.2	6,617.1	8,333.3	13,130.0
Biogenic CO_2	9,416.1	9,476.8	9,381.8	8,452.8
CO	482.7	547.2	566.0	638.5
CH_4	33.2	32.7	31.8	27.7
NO_X	37.4	66.5	73.5	91.3
N_2O	0.2	0.2	0.2	0.2

Chart 4.13 indicates the contributions to the total CO_2 emissions of each one of the sectors demanding energy and thermoelectric generation. Likewise, it shows the highest oil consumption and the drop in firewood consumption, reflected in the increase of Non Biogenic emission in 201%, and the drop of the biogenic ones in 10%.

Chart 4.13 Evolution of the CO_2 Emissions by Sector (Gg) Reference Energy Scenario								
	1995		2005		2010		2020	
DEMAND	Non Biog.	Biogénic	Non Biog.	Biogénic	Non Biog.	Biogénic	Non Biog.	Biogénic
Residential	297.7	7,143.97	523.74	6,836.64	692.03	6,541.83	1,182.77	5,414.44
Transportation	1,816.45		2,867.63		3,403.80		5,427.98	
Industry	793.83	1,839.55	1,141.40	2,175.49	1,380.85	2,382.36	2,029.67	2,591.54
Remaining Sectors	70.79	112.74	98.86	123.95	117.96	129.63	167.53	167.53
TRANSFORMATION								
Thermoelectric Plants	1,368.13		1,957.76		2,707.05		4,279.29	
Self production	17.35	319.85	27.68	340.70	31.63	327.95	39.54	309.73
	4,364.24	9,416.10	6,617.08	9,476.78	8,333.32	9,381.78	13,130.0	8,452.75

1.4. Energy Mitigation Scenario.

1.4.1. General Guidelines

This scenario assumes that the policies and actions that will modify the current consumption trend will be put into practice and that the GHG emission mitigation technologies will be introduced. These mitigation measures take into account the processes that we expect to promote in the near future given their economic, social or environmental reasonableness.

1.4.2. Sectorial Guidelines

a. Residential Sector:

The mitigation measures in this sector are mainly focused on facilitating the penetration of sources with the least specific emissions, such as natural gas and solar energy. Likewise, additional enhancements are expected in the specific consumption and efficient use of energy, compared to the ones in the reference scenario.

In the urban area, these measures tend to accelerate the penetration of natural gas and LPG as the replacement of firewood, kerosene and electricity. The penetration of solar energy has been estimated in the higher income urban population levels, especially for water heating. It has been estimated that electric energy will be exclusively used in the residential sector and that kerosene will drop to insignificant levels for lighting purposes.

Regarding the yields of these sources, it has been estimated that firewood will achieve a substantial enhancement in efficiency, reaching 15% by the year 2020; other sources will have relatively low yield increases; in the case of the LPG it will increase from 60% in 1995 to 65% in the 2020. Electricity efficiency will improve from the current 60% to a 68% in the year 2020.

b. Transportation Sector:

The reference scenario in this sector, as indicated by the international car industry and local affiliates, assumes an improvement in car energy yields. This Mitigation Scenario, not only assumes that this specific consumption drop trend will sharpen, implying that the penetration of vehicles capable of reducing the consumption of oil sub products will take place, but also assumes an important change in transportation policies, that affect the participation of transportation modes and means.

With regards to total energy consumption it is worthwhile stressing the expected diversification of sources during the period under analysis. The penetration of electric energy LPG and CNG, as well as diesel and gas throughout the reference year, represented 93% of the final energy consumption, but it is expected to drop to 78%. The increase in energy consumption of this sector throughout the period under analysis will be 140% with respect to the reference year, at an annual average rate of 3.6%

c. Industrial Sector:

This sector has followed the general guidelines of the mitigation scenario. Equipment renewal and energy conservation programs were developed throughout the period under analysis, thus enhancing the efficiency in the use of energy.

The industrial sector's energy consumption would increase in 80% during the period under analysis at an annual average rate of 2.4%, which indicates that despite this increase, the sector will lose relevance compared to the transportation sector. With regards to the participation of sources, a change in the consumption structure may be observed, which reflects the penetration of NG, whose participation in the final energy consumption would be 8.7%, and the increase in fuel oil would reach 39 % participation. The remaining sources will decline their participation.

d. Other Sectors:

This sector has the smallest final energy consumption share, and is the least relevant regarding emissions. The only specific guideline for this sector is solar energy penetration in the Commerce and Services Sub Sector, since it is expected that it will be used to heat water. Solar energy participation has been estimated in 2.0% of the energy consumed in the Commerce and Service Sub Sector by the year 2020. Efficiency enhancements have been included in all sources.

1.4.3. Analysis of the Energy Demand.

Findings show that domestic energy consumption will grow at an annual average rate of 1.7%, stressed during the first decade and losing stress during the last decade, when all the measures adopted become effective . (Figure 4.4)

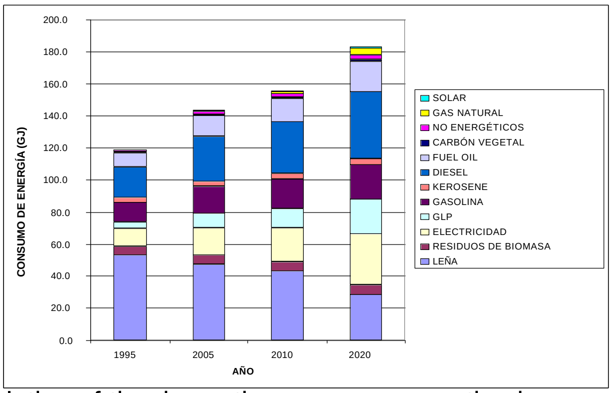

Figure 4.4: Evolution of the domestic energy consumption by sources, during the period 1995-2020

The participation of the sector in the final energy demand shows a significant shift in structure, where the transportation sector consumption represents 41% of the total consumption, displacing the residential sector, which was the main energy consumer in the reference year.

Chart 4.14 GHG Emissions from the Final Energy Demand (Gg)				
GHG	Years			
	1995	2005	2010	2020
Non Biogenic CO_2	2,978.8	4,508.5	5,324.9	7,401.6
Biogenic CO_2	9,096.3	8,262.9	7,609.1	5,361.8
CO	477.5	497.2	483.8	418.2
CH_4	32.1	27.5	24.3	14.1
NO_X	29.1	37.8	39.8	44.5
N_2O	0.2	0.2	0.2	0.1

1.4.4. Energy Supply and its Emissions .

With regards to the supply related activities, special attention was placed on electricity generation, since the highest fuel consumption is concentrated in this area of the energy sector (87.7%).

Certain measures aimed at slowing down the supply with thermal resources exclusively, as well as the introduction of incentives to make other sources more attractive for the private sector, have been taken into account in the mitigation scenario, given the conditions of the new regulatory framework. It is estimated that by the year 2005, NG will have reached a significant penetration, since the construction of the gas duct crossing Guatemala and El Salvador would be operating. The following supply guidelines will be followed during the remaining years:

a) The hydroelectric resource will increase in 80 MW by the year 2010, with the installed capacity in San Marcos Lempa.
b) The geothermal resource will increase in accordance with the stabilization plants of the geothermal plants of Ahuachapán and Berlín and the development of the geothermal plant in San Vicente.
c) The external sector is balanced, the same as the reference scenario, since there is a sound balance between exports and imports.
d) The steam to fuel oil plants do not display any change up to the year 2005. From the year 2010, the NG plant is retrofitted and in the year 2020 the capacity is increased with a 100 MW machine, using the same technology.
e) Fuel oil combined cycles appear with 120 MW in the year 2000, and are retrofitted to NG in the year to 2005 for the remaining part of the period. The fuel oil plant factor will be 30.4%, which will significantly increase its participation when all units are changed to NG.
f) This scenario considers that the photo voltage alternative starts participating from the year 2005 for self producers, slightly increasing throughout the period.
g) Internal combustion engines using fuel oil for generation allow to use the full capacity of the ones currently existing in the Nejapa Plant which will be increased in 112 MW in the year 2000, with no mayor expansions from thereon.
h) Regarding diesel turbines, their retrofitting to NG starts in the year 2005, increasing their capacity with a 60 MW turbine by the year 2010, enhancing the installed capacity from 194 MW to 254 MW at the end of the period.
i) In this scenario, NG develops significantly not only in the retrofitting of the previously mentioned combined cycle, but also in its progressive increments under the shape of combined cycles.
j) Coal is displaced by the strong penetration of NG, and is absent throughout the periods.

Chart 4.15
Evolution of Generating Park, Installed Capacity by Resource(MW).
Mitigation Energy Scenario.

Resource	1995	2005	2010	2020
Hydroelectric	388	388	468	468
Geothermal	50	120	120	190
GN Steam	0	0	63	163
Fuel Oil Steam	60	63	0	0
Diesel Engines Fuel Oil	80	192	192	192
NG Turbo Gas.	0	194	254	254
Diesel Oil Turbo Gas	194	0	0	0
NG Combined Cycle	0	120	120	460
Sub-Total	772	1077	1217	1727
Self Production				

Diesel	45	45	45	45
Sugar Processing Plant	44.8	55	60	70
Solar Photo Voltage	0	0.2	0.63	1.5
Sub-Total	89.8	100.2	105.63	116.5
Total	861.8	1177.2	1322.63	1843.5

The supply of the generation park will mainly depend on fossil fuels throughout the period. It is expected that fossil fuels will supply 80% of the total supply in the year 2020, nevertheless, 63.7% will be supplied with NG in that same year. Despite its growth expansion, hydraulic and geothermal energy will only supply 20% of the total domestic supply.

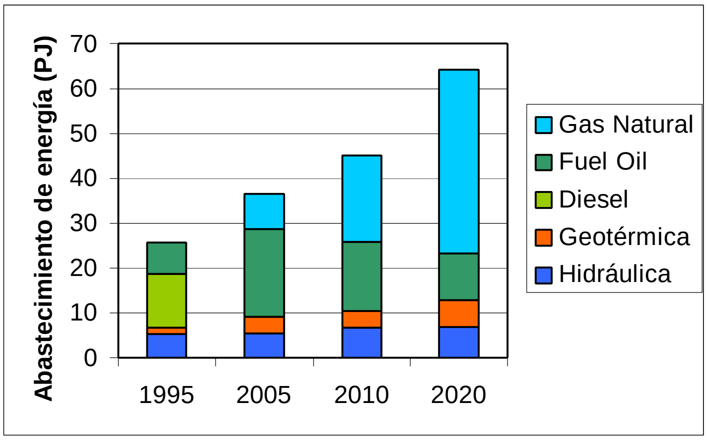

Figure 4.5: Evolution of energy supply by resource.

The evolution of the energy supply of the sector shows an increase in fuel oil consumption during the first decade, and its replacement with NG causes CO_2 emissions to grow during the first decade, declining throughout the period.

Chart 4.16 Thermal Electric Plants Total GHG Emissions. Mitigation Scenario.					
GHG	Years				Unit
	1995	2005	2010	2020	
Non Biogenic CO_2	1,368.1	1,538.8	1,271.0	1,254.2	Gg
CO	1.6	5.0	5.1	4.1	Gg
CH_4	173.2	459.1	472.6	830.4	Mg
NO_X	7.8	23.7	23.6	19.6	Gg

1.4.5. Hydro-Carbon Sub Sector

The same assumptions have been kept with regards to oil refineries, since their share in consumption and their emissions are not relevant to the energy supply sector.

Chart 4.17 GHG Total Emissions. Oil Refinery. Mitigation Scenario					
	1995	2005	2010	2020	Unit
Methane (CH_4)	27.70	39.32	41.41	45.08	Mg

1.4.6. Total Emissions in the Mitigation Scenario.

Findings show a growing trend in GHG total emissions; nevertheless, the annual average growth of the same is 1.4%, lower than the final energy demand growth rate (1.7%) and primary supply (2%), which indicates a significant reduction in GHG emissions per every unit of energy consumed in El Salvador.

Chart 4.18
Total GHG Emissions (Gg). Mitigation Scenario.

GHG	Years			
	1995	2005	2010	2020
Non Biogenic CO_2	4,364.2	6,075.0	6,627.5	8,695.4
Biogenic CO_2	9,416.1	8,603.7	7,937.0	5,671.5
CO	482.7	507.0	494.5	429.4
CH_4	33.2	29.4	26.4	17.0
NO_X	37.4	62.1	64.1	64.8
N_2O	0.2	0.2	0.2	0.1

1.5. Energy Scenarios Compared Analysis.

The following differences can be appreciated by comparing the structure by source in both scenarios:

a. The mitigation scenario displays a higher share of electric energy, associated with a slightly higher demand of the same.
b. LPG displays an increase in both absolute terms and demand share, as compared to the reference scenario.
c. The demand of firewood in the mitigation scenario is considerably lower than in the reference scenario; it is estimated in 37% less by the year 2020 than the estimated amount in the reference scenario.
d. Gas, diesel and fuel oil also display a lower demand share in the mitigation scenario, as well as a reduction in absolute terms as compared to the reference scenario.
e. The penetration of NG and solar energy do not represent a significant difference as compared to the reference scenario

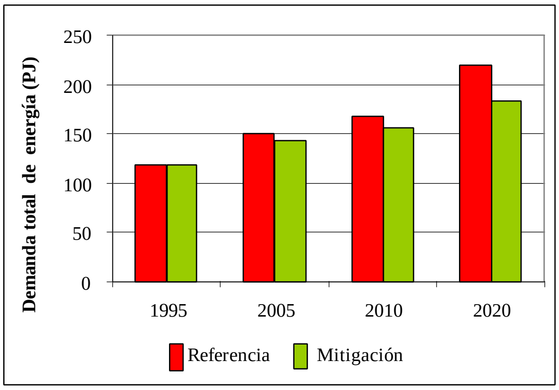

Fig 4.6: Comparison between the Reference and Mitigation Scenarios with regards to energy demand

The following aspects are worthwhile highlighting regarding sector consumption:

a. The Residential, Transportation and Industrial sectors show a significant reduction in consumption in the mitigation scenario as compared to the expected values in the reference scenario. The variation in the residential sector consumption is particularly noticeable, but is lower than the one for the reference year.

b. The residential sector is no longer the sector dominating consumption in either scenario, although this is more noticeable in the mitigation scenario, being replaced by the transportation scenario. This is explained by the replacement of firewood with energy products used with greater efficiency.

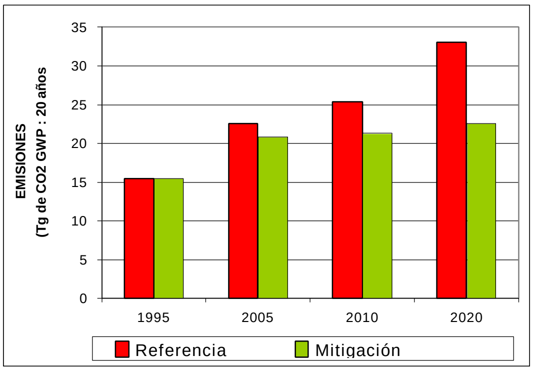

Figure 4.7: Comparing the Evolution of Total Emissions in both the Reference and Mitigation Scenarios.

1.5.1. Total Emissions.

Chart 4.19 shows the reduction in total emissions due to the mitigation measures, which is not so significant during the first decade, but improves as new energy sources penetrate and mitigation measures become more effective. Summarizing, a 32 % reduction is obtained with respect to the expected emissions in accordance with the reference scenario for that year.

Chart 4.19
Comparing Emissions in the various Scenarios in the year 2020

GHG	Reference	Mitigation	Difference	Percentage
Non Biogenic CO_2	13,126.8	8,695.4	-4,431.4	-33.8%
Biogenic CO_2	8,452.8	5,671.5	-2,781.3	-32.9%
CO	638.5	429.4	-209.0	-32.7%
CH_4	27.7	17.0	-10.7	-38.6%
Nox	91.3	64.8	-26.5	-29.0%
N_2O	$1.8x10^{-1}$	$9.6x10^{-2}$	$-8.2x10^{-2}$	-46.2%

1.5.2. Evolution of Energy and Environmental Indicators.

Chart 4.20 shows the positive effect of mitigation measures, that allow energy consumption and total emissions to grow at annual rates lower than the GDP and population. Energy intensity and energy per capita consumption drop with respect to the reference scenario, reflecting the improvement in the efficient use of energy.

Chart 4.20 Summary of Energy and Environmental Indicators					
Indicator	Year				Annual Average Rate
	1995	2005	2010	2020	
GDP (1990 Million colones)	49,156.0	71,220.0	86,649.0	128,262.0	3.9%
Population (Million inhabitants)	5.699	6.996	7.687	9.054	1.9%
Per capita GDP (Colones/inhab)	8,625.4	10,180.1	11,272.1	14,166.3	2.0%
Final Energy Consumption (PJ)					
Reference Scenario	118.8	149.9	167.7	219.3	2.5%
Mitigation Scenario	118.8	143.6	155.7	183.0	1.7%
CO_2 Emissions (Gg)					
Reference Scenario	4,364.2	6,617.1	8,333.3	12,992.9	4.5%
Mitigation Scenario	4,364.2	6,075.0	6,570.6	8,454.4	2.7%
Total GHG Emissions (CO_2 Cg; PCG 20 years)					
Reference Scenario	15,476.5	22,516.4	25,329.0	33,039.6	3.1%
Mitigation Scenario	15,476.5	20,821.8	21,386.1	22,507.4	1.5%
Energy Intensity (TJ/million colones)					
Reference Scenario	2.42	2.11	1.94	1.71	-1.4%
Mitigation Scenario	2.42	2.02	1.80	1.43	-2.1%
Per capita consumption (TJ/inhabitant)					
Reference Scenario	0.021	0.021	.022	.024	0.6%
Mitigation Scenario	0.021	0.021	0.020	0.020	-0.1%
CO_2 Per capita Emissions (Ton/inhab)					
Reference Scenario	0.77	0.95	1.08	1.44	2.5%
Mitigation Scenario	0.77	0.87	0.85	0.93	0.8%
Total per capita emissions (Ton/inhab)					
Reference Scenario	2.73	3.22	3.30	3.65	1.2%
Mitigation Scenario	2.73	2.98	2.78	2.49	-0.4%
Emissions/GDP (Gg/million colones)					
Reference Scenario	0.315	0.316	0.292	0.258	-0.8%
Mitigation Scenario	0.315	0.292	0.247	0.175	-2.3%
CO_2 Emissions per energy unit (Gg/PJ)					
Reference Scenario	36.7	44.1	49.7	59.2	1.9%
Mitigation Scenario	36.7	42.3	42.2	46.2	0.9%
Emissions per energy unit (Gg/PJ)					
Reference Scenario	130.2	150.2	151.0	150.6	0.6%
Mitigation Scenario	130.2	145.0	137.4	123.0	-0.2%

1.6. Electric Supply Sensitivity

The study carried out a sensitivity analysis, considering the importance of electrical supply and its growing demand, and also that the proposed thermal electric option to fulfill the demand proves to be one of the greatest contributors to GHG emissions:

a. The role of the SIEPAC project is to promote private investment and consolidate the region's electric market integration. This project is referred to as the external sector in this study.

b. The possibility of expanding the domestic hydroelectric park when the El Cimarrón project starts operating. This project assumes the governmental will to exploit natural resources, given the return on investment period needed by hydroelectric projects as the one proposed.

1.6.1. Sensitivity Analysis in Face of the Participation of the External Sector.

The sensitivity to electric energy supply stated in this analysis considers the participation of the regional external sector, as a policy to reduce emissions at the local scale. This reduction could be accounted for as regional or world wide scale reduction, to the extent that said electricity is generated with non GHG emitting plants.

As expected, if the participation of the External Sector grows to satisfy electric energy demand, the thermal electric resource diminishes its participation, thus reducing GHG emissions as shown on the Chart below.

Chart 4.21
Emissions from the Thermal Electric Plants (Gg)
External Sector Sensitivity

GHG	1995	2005	2010	2020
CO_2	1,368.13	1,432.94	1,155.58	1,016.38
CO	1.61	4.75	4.58	3.11
CH_4	0.17	0.46	0.47	0.82
NO_x	7.80	22.52	21.32	15.19

1.6.2. Sensitivity Analysis in face of the El Cimarrón Hydroelectric Plant.

El Cimarrón is one of CEL's projects to expand hydroelectric generation in the country. Despite the strong opposition of domestic environmental organizations and local populations, it is necessary to evaluate its contribution in the reduction of GHG when replacing thermal electric generation.

Chart 4.22
Thermal Electric Plant Emissions (Gg) Sensitivity of El Cimarrón Plant

GHG	1995	2005	2010	2020
CO_2	1,368.1	1,538.8	1,267.4	1,115.5
CO	1.6	5.0	5.1	3.5
CH_4	0.2	0.5	0.5	0.8
NO_x	7.8	23.7	23.5	16.9

1.6.3. Outcome Analysis.

In order to compare the sensitivity analysis in the energy mitigation scenario, the emissions from thermal electric generation in each scenario were converted to a common reference, using the GWP for a 20 year horizon.

Chart 4.23 Total GHG Emissions from Thermal Electric Plant (Gg) Global Warming Potential (20 years)				
Scenarios	1995	2005	2010	2020
Mitigation	2,560.22	5,161.08	4,877.46	4,278.24
External Sector	2,560.22	4,872.91	4,414.99	3,367.07
El Cimarrón	2,560.22	5,161.70	4,863.13	3,679.91

The sensitivity analysis that considers the External Sector as an additional option to reduce emissions, would reduce the 2005 emissions in 9.4%, under the assumption that the import of electricity would reduce domestic thermal generation in 5%.

The total GHG emission drop during the period from 2005–2020 under the mitigation scenario is 17%. If we take into account the external sector, the emission reduction is estimated in 30.9%, and with El Cimarrón hydroelectric plant, the reduction would be approximately 28.7%.

1.7. Final Considerations.

The findings of this study should be construed as indicators of the possibility to reduce GGE emissions in the country, provided that the proposed measures and actions of the mitigation energy scenario are enforced.

The combination of climatic change mitigation policies and economic and social development presents three types of distinct difficulties, from the methodological perspective:

a. The existence of conflictive decision criteria, whose relative importance is not independent from the level of satisfaction reached by each one of them.

b. A high level of uncertainty, both in the context in which the decision process evolves, and in the preference structure of the decision maker, which is modified based on the probability of influencing in the system's behavior and the obstacles faced.

c. The multiple economic and social agents involved in the execution of mitigation measures and affected by them, whose participation is not institutionalized within the decision process.

Consequently, the acknowledgment of the existence of other economic and social agents is mainly focused on the knowledge of the impact of mitigation measures on said agents and in accordance with their magnitude, to study the feasibility to develop said measures.

Seen from the perspective of state powers, it is important to select what should be promoted and through which mechanisms, in order to motivate a change in the behavior of the economic agents in charge of enforcing mitigation options.

2. Guidelines for the Mitigation Strategy of the Energy Sector.

2.1. The Challenges of the Energy Sector

Energy resources are scarce and limited in El Salvador, reason why the energy supply is mainly comprised of electricity, oil, plant residues and firewood. Natural gas and /or oil deposits have not been found in the country to date, therefore the country depends on the oil imports from Venezuela and Mexico fundamentally.

In this context, there is a restricted possibility to develop the energy sector; therefore, it is important to highlight the ongoing structural reform of the energy sector, which is irreversible and necessary to face competition and globalization in the new millennium.

The energy sector was characterized by the high State intervention; planning, regulation and operations were concentrated in few institutions. Until 1989 the drafting of energy policies, and the planning and development of standards were concentrated in CEL; nevertheless, the 90's were characterized by significant sector reforms, the introduction of competition, and the privatization of important energy assets, as well as the creation of new regulating institutions.

On the other hand, the large dependency on biomass for energy consumption resulted in deforestation and the degradation of soils. Firewood consumption is currently one of the most serious problems of the sub sector reaching levels beyond sustainability, since half of the population lives in the rural area (firewood is used to cook food and to make bricks), and on the other hand, the efforts towards finding alternative energy sources develop very slowly.

If we consider that the energy sector is the main source of CO_2 emissions worldwide, representing 48.9% of the country's annual net emissions, and that the GGE affect climate, it is necessary to analyze the viability of mitigation options that harmonize with the structural changes carried out during the past decade, within the globalization framework and the international actions to preserve the planet from a climatic change.

2.2. The Energy Scenario of the XXI Century.

The new century's desirable and optimistic scenario would be one with many actors authentically competing among themselves, and with an efficiently enforced regulation where the State protects and preserves the environment, with measures directed to reduce CO_2 emissions in the Energy Sector.

The purpose of introducing competition and private participation in the energy sector is, first to increase efficiency, and also to introduce new technologies and reduce the price of energy sources. Nevertheless, these objectives cannot be met if the required transformation allows the vertical and horizontal integration of private enterprises, converting the public monopoly into a private monopoly. This is the reason why it is important to regulate with efficiency, since the development of a competitive market could be in conflict with the objectives to provide access to the marginalized population, by means of the rational and efficient use of energy sources, the preservation of the environment and a sustainable development.

Based on the above, a desirable scenario should count with: clear rules, an effective regulation, equity of supply, transparent prices, rational use and competition.

It will be a challenge to thrust the above premises in the XXI century scenario and to remove the obstacles, but this has to be done in a short term, accompanied by regulations to disincentivize environmental deterioration.

It is true that an effective regulation and authentic competition in the energy sector will not guarantee the long term sustainability. This is why the State must carry out concrete actions geared towards a sustainable development based on mitigation measures aimed at reducing greenhouse gas emissions, stagnating deforestation and rationally using the scarce energy sources available.

2.3. Energy Development Measures to Mitigate Climatic Change.

To mitigate climatic change, means to carry out actions aimed at avoiding the increase or reducing GHG, improve air quality and protect the environment. In this sense, it is necessary to control gas emissions from the thermal electric industry and the transportation sector, since these can be carried out by eliminating the barriers and obstacles to mitigation options and developing strategies that foster electric generation projects with alternate sources (solar, eolian, biogas and geothermal) as well as hydroelectric, besides promoting the ordering of the transportation sector.

The energy development measures that are necessary to mitigate climatic change should remove the obstacles to facilitate the set of projects and reforms that the electric, oil and biomass sub sectors should carry out, considering the long term benefits of a clean development, and stressing the changes in the legal frameworks and the execution of projects that use renewable energy both in the rural and urban areas.

2.4. Mitigation Energy Strategies.

To foster a sustainable energy development, it is necessary that the general strategy respond to the solution of the energy sector problems, especially those related to the mitigation of the climatic change and sustainable development, ranking the most urgent for the short term and the development of other related actions for the longer term. In this sense, the long and short term issues interrelate, differentiating themselves only by the outcomes and action periods. Short term has been defined from 1 to 3 years for the purpose of this study, and the long term from 4 to 15 years.

In the short term, the strategies to solve the prioritary and pressing energy mitigation problems should be proposed. Likewise, the definition of the necessary changes in the laws to impulse the long term strategies, should be defined.

In the long term, mitigation energy strategies should promote the development of projects, actions and reforms that contribute to reduce GHG emissions, in order to insure a sustainable future energy sector in harmony with the country's economic, social and environmental development.

The action lines expressed in these strategies should be based on strategic areas, that as a whole represent the tools to face the challenges and to reach the objectives of a sustainable energy development.

Another important aspect is the inclusion of mitigation energy strategies in the government's economic policy to facilitate enforcement and coordinate domestic and international efforts in this field. The only way to reduce greenhouse gas emissions is to impulse concrete actions and eliminate legal, economic, cultural and social barriers.

Due to the diversity of structural problems that the energy sector faces, as well as the greater participation of the private sector, the high dependence on hydrocarbons and the limited regulation, makes it necessary to concentrate the short term general strategy on prioritary actions in the following areas:

a. The reform of the energy legal frameworks, to enhance them, create regulations and establish more effective regulations: the creation of a governing body in the energy sector, the entry into effect of the Environmental Regulations and Law, the drafting of a general Hydrocarbon Law and the Free Competition Law, etc.
b. Concrete actions to protect the watersheds, stop deforestation, promote sustainable agriculture (use another term to stress the impulse that should be given to agriculture) and develop preservation programs and programs to promote the efficient use of energy.

c. Carry out feasibility studies regarding the sustainable hydroelectric and geothermal use, and foster the execution of private works.
d. Actions to facilitate the access to energy sources to low income citizens, by promoting and facilitating the introduction and use of clean energy, and the development of rural electrification programs and projects.
e. The strengthening of energy cooperation international programs, particularly regional project development.
f. Actions aimed at the compliance with the commitments made in international agreements regarding sustainable development, climatic change and the protection of the environment.
g. Promote civil society participation in the solution of energy and environmental problems.
h. Actions to facilitate competition and decentralization, by incorporating private agents and municipalities in the development of sustainable energy projects.

The long term general strategy should target sustainable energy measures that link the execution of energy projects to mitigate climatic change with energy consumption options for the population, highlighting quality and the enforcement of clean technologies, the conservation and efficient use of energy, the integration of regional energy markets, the protection of the environment and the strict adherence to the domestic and international laws in force, as well as the development of energy production and consumption patterns, compatible with environmental preservation.

If we take the above into account, the long term strategy can be defined as follows: facilitate the concretion of mitigation options in the XXI Century energy scenario, both in the domestic and regional environment, by eliminating the barriers that preclude the competitiveness of these options in the energy market. In this sense, the short and long term general strategy should reach the enforcement of a sound legal framework in the immediate future, as well as sustainable projects and studies, greater competition in the sector and the significant promotion of regional projects.

The energy strategy guidelines proposed stress the following areas:

a. The strengthening of the regulations, legal reforms and the definition ofinstitutionality.
b. The sustainable use of hydroelectric and geothermal resources
c. Sound financial mechanisms for renewable energy projects
d. Access to energy at fair prices for the population
e. The recovery and sustainable use of watersheds.
f. The preservation, efficient use and diversification of energy sources
g. Regional integration and cooperation, as well as the compliance with international agreements
h. Decentralization and competition.

The proposals for a strategy general electric guidelines to mitigate climatic change could be viable in the short and long term if they are introduced into the government policy management areas, becoming operational actions with their own budget and the participation of the private sector and the population in general. In this way, the trend scenario of the energy scenario would be changed to one of mitigation with significant GHG reductions, contributing to the world effort to reduce the climatic change caused by high gas concentrations.

Likewise, the participation of the private sector within the flexible mechanisms established in the Kyoto Protocol, could make the flow of investments from industrialized countries possible, as well as the transfer to clean technologies and the strengthening of domestic capabilities. The funds from the sales of the CER could financially leverage national mitigation projects.

3. Institutional Arrangements

3.1. Introduction

El Salvador, through its government and particularly through the MARN, which is the entity accountable for coordinating the preparation and follow up of an environmental policy, would be committed to establish the mitigation and adaptation to climatic change strategies provided that these help to achieve national priorities and that they foster sustainable domestic development.

3.2. Institutional Arrangements Proposals.

The MARN is promoting the necessary institutional arrangements for the continuity and effectiveness of the actions to guarantee the application of the Convention. To this end, institutional mechanisms specialized in climatic change are being designed and activated to achieve:

a. The institutional strengthening and national capabilities to effectively define and enforce mitigation strategies and the adaptation to climatic change, to participate in international organizations and forums in this field.
b. An effective inter sector and inter institutional coordination, to facilitate the definition and application of national strategies, programs and projects on mitigation and adaptation.
c. A permanent liaison with national universities and research centers to develop research programs in coordination with the international scientific community
d. A liaison with local levels[8] for the exchange of information and the promotion of projects and mitigation and adaptation actions.

The basic institutional mechanisms to apply the convention could be the following, based on the recommendations of Subsidiary Organisms and the Conferences of the Parties to the Convention, and the experience of other countries, and on the context and programs of National Governments:

a. The creation of a Climatic Change Unit within the MARN, that would coordinate the institutionalization and development of a National Climatic Change Program
b. The consolidation of a National Commission for Climatic Change
c. The creation of a National Scientific Committee for Climatic Change

3.2.1. The Climate Change Unit

The creation of the Climatic Change Unit (CCU) within the MARN[9] aims at responding to the greatest environmental challenge of the XXI Century: climate change. Also, the high complexity of the task, as well as the broad scope of action, the time horizon and scope required to execute a National Climate Change Program, demand the institutionalization of said Program within the Government's range of responsibilities.

On the other hand, the CCU would undertake three focal points: the FCCC, the IPCC and the CDM; and would carry out the coordination and follow up of the national commitments in these areas.

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[8] Local governments, rural communities, human settlements, etc.

[9] The Climate Change Unit was created within the internal regulations of the MARN, currently under the legalization process and the incorporation into the year 2000 general budget of the nation.

The actions in this Program should be closely related to climatic change working areas. On the one hand, the vulnerability and adaptation to the climatic change area would be closely related to the areas in charge of natural eco systems, international treaties on de-certification, bio-diversity and the Montreal Protocol. On the other hand, the actions to update GHG inventories and the policies and measures to mitigate climatic change, would be related to the environmental management area.

The nature and scope of the CCU's work should be in harmony with the governments facilitating and governing role, with the following main responsibilities:

- Coordinate the design and execution of national mitigation and adaptation programs, through discussion and concertation spaces created for this purpose, such as: the National Commission for Climate Change and the National Scientific Committee for Climate Change.
- Promote, in coordination with the National Commission for Climatic Change, the identification and execution of policies and measures to mitigate climatic change, through actions that will contribute to overcome the barriers to enforce them.
- In coordination with the National Scientific Committee for Climate Change, develop vulnerability and impact studies, as well as adaptation to climatic change projects.
- Prepare and systematically update Climate Change National Communications and the National GHG Inventories, obtaining the technical and financial resources required to comply with this task.
- In coordination with the entities involved, develop sensitization and awareness programs in face of the problem and the effective management of climatic change.
- Promote the creation of national capabilities, facilitating the education and training of national experts on earth and atmosphere researches, and on the transfer of mitigation and adaptation technologies.
- Participate in the preparatory meetings, conferences and technical workshops organized by the Secretariat of the Convention, as well as in the IPCC[10] sessions, and other organizations involved in the negotiations of the Climate Change Agenda, as a Focal Point .
- Define the domestic eligilibility criteria for the endorsement of GHG emission reduction projects[11], based on environmental additionality, transparency and the contribution to a sustainable national development.
- Follow up and see to the official verification of the effective execution of GHG reduction projects, particularly on the achievement of additional environmental and social economic benefits, to provide this information whenever the Secretariat of the Convention or any other accredited organization so requires.

3.2.2. National Program for Climatic Change.

The National Program for Climate Change should establish the large action lines regarding mitigation and adaptation; and strengthen the effectiveness of these actions through public awareness and scientific and technological developments on climatic change.

This Program will be successful to the extent it assists in the achievement of national priorities, and promotes the participation of the various sectors and actors of society.

The National Program for Climate Change comprises two main components: a) Mitigation Component and b) Vulnerability and Adaptation, besides, two cross-cutting issues will be defined: Sensitization and Public Awareness, and Scientific and Technological Development.

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[10] Inter Governmental Panel of Climatic Change Experts, a scientific organization accredited by the Convention.

[11] Greenhouse Gas Emissions.

Mitigation:

Mitigation includes all the actions aimed at reducing GHG or increasing carbon drains. This component comprises the preparation and updating of emission inventories by source and drain as well as the development and transfer of mitigation technologies and the promotion of mitigation programs and measures.

Vulnerability and Adaptation:

These encompass the actions aimed at reducing or preventing the impacts of variability and global climate change, including the study of vulnerability and impact of the various naturaleco systems and social economic sectors; the follow up and analysis of weather information; and the promotion of adaptation projects; as well as the prevention of natural disasters. Besides, it also encompasses scientific development and the transfer of climatic change adaptation technologies.

4. Mitigation Projects.

4.1. Introduction.

According to the results of the National GHG inventory of El Salvador, in the reference year of 1994, the sectors with the highest participation in total domestic GHG are the energy sector (50.4%), and the Land Use Change and Forestry Sector (42%). Based on the above, the potential options to mitigate GHG should mainly concentrate on these sectors. Nevertheless, given the high GWP of other gases, there are other interesting options in the Wastes, Agriculture and Industrial Processes Sectors.

The potential of mitigation projects for the energy sector have been identified in the GHG mitigation options analysis for said sector[12], in which the options identified are those with the least barriers and obstacles for their execution, and therefore the most feasible, and also those options that are seen as potential projects.

Nevertheless, additional studies should be carried out in order to objectively analyze the feasibility of the various options identified, in order to determine the cost effectiveness of each one. This analysis would allow to establish the level of competitiveness of the different potential national projects by sector and within the international environment.

To this end, the MARN has proposed the GEF, a project to expand rural electrification by promoting the use of renewable energy. The purpose of the project will be to create market conditions that favor the competitiveness of domestic renewable energies as compared to hydrocarbon electric generation. To this effect, a feasibility study of the PDF-B Project would be prepared during the year 2000, with the following main products: a) Evaluate the market opportunities to commercially develop renewable energy projects; b) Evaluate the legal and political frameworks for rural electrification using renewable energy sources; c) Design the activities to eliminate financial and economic barriers to the renewable energy projects, and d) Design the institutional framework and development of a training program.

Likewise, a program to create national public and private capabilities has been presented to the WB to apply the FCCC. The purpose of this project is to strengthen the MARN in its role as facilitator and promoter of emission reduction projects, and at the same time, develop the technical skills necessary to develop the cycle of climatic change Mitigation projects that will generate additional environmental benefits.

[12] Please refer to the complete study: Análisis de las Opciones de Mitigación del Sector Energético de El Salvador, 1999.

4.2. Potential Mitigation Options for the Energy Sector.

4.2.1. Transportation Sub Sector.

- The ordering of traffic, by improving urban and inter urban road networks and the enhancement and effective enforcement of the Law.
- Mode replacement, by increasing mass public transportation means and de-incentivizing the growth in individual vehicles.
- Replacement among sources, promoting sources with less emissions, such as NG and LPG.
- The early introduction of technical enhancements into the vehicles.
- Introduction of technological innovations (electric vehicles: trolley and train).
- The promotion of bicycles in certain urban centers and in the rural and suburban areas.

4.2.2. The Residential Sub Sector

- The introduction of renewable and cleaner energy sources, replacing firewood and kerosene with LPG and solar energy.
- The promotion of energy efficiency and conservation measures, by introducing solar energy to heat water, efficient bulbs and new construction technologies.

4.2.3. The Industrial Sub Sector

- The development of preservation and energy efficiency programs
- Technical enhancements by renewing equipment
- The introduction of natural gas
- The introduction of technological innovations using renewable and cleaner energy sources

4.2.4. Electric Generation Sub Sector

- The increase in the hydroelectric and geothermal resources
- Electric generation using renewable energy: solar, small hydroelectric plants, biomass and eolian.
- The introduction of combined cycles in steam thermal plants
- The introduction of natural gas in diesel and fuel oil thermal plants
- The increase in efficiency of the thermal plants by means of technological innovations

4.3. Potential Mitigation Options of the Land Use Change and Forestry Sector

- The reforestation and sustainable management of the main watersheds in the country.
- The protection of forests to avoid deforestation
- The conservation and sustainable management of natural areas
- The promotion of agri forestry and the prevention of forest fires

4.4. Potential Mitigation Options of the Waste Sector.

Sequestration of methane from the treatment of municipal, industrial and agri-industrial (coffee processing plants) waste waters.

4.5. Potential Mitigation Options of the Agricultural Sector.

- Post harvest management to avoid the burning of farming wastes and the preservation of farming soils.
- The appropriate and rational use of fertilizers.

4.6. Potential Mitigation Options of the Industrial Processes Sector.

- The replacement of the unsustainable use of firewood in the production of bricks, roof tiles, salt and lime with cleaner and renewable energy sources, such as LPG or biomass.
- Technological innovations in the production of cement, lime, beverages, etc.

4.7. Ongoing Potential Projects.

There are currently several entrepreneurial initiatives aimed at developing specific mitigation projects that are at the eligibility analysis phase at this moment. The greatest short back found by these initiatives is the lack of definition of the rules and procedures that will govern project eligibility at the international level within the CDM framework.

Chart 4.24
Ongoing Mitigation Projects in El Salvador

Nature of the Project	Sector	Mitigation Measure	Current Status
Technological upgradings in the cement industry.	Industrial	Increase energy efficiency in cement production.	NA
Expansion in the use of geothermal energy in electric generation.	Energy	Increase the participation of geothermal energy in the energy market, 80 MW more.	Eligibility analysis
Construction of small hydroelectric plants to generate electricity.	Energy	Increase the participation of hydroelectric energy in the energy market.	Análisis de elegibilidad
Expansion in the use of hydroelectric energy to generate electricity.	Energy	Increase the participation of hydroelectric energy in the energy market.	Eligibility Analysis
Program to preserve and efficiently use energy through a seed fund.	Doméstic, Commercial and Services	Improvement in energy consumption efficiency.	Eligibility Analysis
Technical upgrading and change of fuel in two thermal electric generation plants.	Energy	Upgrading of energy efficiency and the shift to a cleaner fuel (natural gas).	Eligibility Analysis
Building houses with efficient illumination and solar energy.	Domestic	Upgrade of the energy efficiency and the introduction of solar energy for caloric uses.	Eligibility Analysis
Establishement of waste water treatment plants and electric generation at the municipal level.	Services	Sequestration of methane for the municipal electric generation.	Eligibility Analysis
Modernization and technical upgrading of the vehicle park.	Transportation	Improvement in the efficient use of fuel, by means of technical standards and emission controls.	Eligibility Analysis

Source: Aguilar, Y., Aguilar M., 2000: Data Base of the "Proyectos de Mitigación y Adaptación al Cambio Climático de El Salvador" (Mitigation and Adaptation to Climatic Change Projects in El Salvador).

V. Vulnerability and Adaptation to Climate Change

1. Socio-economic Scenarios.

In order to evaluate the impact of climatic change by sectors, as well as to analyze the mitigation options of the various sectors, it is necessary to establish climatic and social economic reference lines and scenarios for the diverse time horizons. Both the reference line and social and economic scenarios without climatic change[13], describe and analyze the most important non environmental factors sensitive to change after 1990, which could influence the dynamic of or development of the economy and society of El Salvador, in order to establish a reference framework and a comparison of future scenarios or situations. The key indicators that represent and describe Salvadoran future alternate scenarios (programmed and trends) are identified and calculated for the years 2025, 2050 and 2100.

a. Programmed Scenario.

Coincides with the projection of governmental or leading institutions, which consider the ongoing set of policies, actions and projects

b. The Trend Scenario.

Reflects the trend manifested in the last years, which will prevail or show very little variation, and could change drastically due to serious reasons.
Five factors could mainly determine the probability of a programmed or trend scenario in the near future. These factors and macro policies are:

a. The globalization process and the building of regional blocks
b. The commercial and regional integration policy of El Salvador
c. The sector economic policy
d. The social policy
e. The territorial and environmental policy.

1.1. Demographic Indicators.

1.1.1. BaseLine.

Taking 1990 as a reference point, 4 demographic processes outstand, which are changing the population profile of El Salvador:

a. The drop in the population rate of growth and the global reproduction rate
b. The drop in international migration
c. Their relative maturity or aging of the population
d. Population urbanization.

[13] Please refer to the complete study: "Escenarios Socioeconómicos para la Evaluación de los Impactos del Cambio Climático".

Chart 5.1 Baseline Demographic Indicators					
	Demographic Indicators	Units	1970	1990	1995
D1	Population	Million	3.598	5.110	5.669
D2	Population under 15 years	% Total	46.37	40.79	37.40
D3	Population between 15 and 64 years	% Total	50.86	55.00	58.00
D4	Population over 64 years	% Total	2.77	4.21	4.61
D5	Annual population growth rate	% annual	3.57	2.10	2.06
D6	Percentage of urban population	% PU/PT	40.76	61.77	62.48
D7	Percentage of males	% PM/PF	101.2	96.0	96.0
D8	International migration balance	Thousands / year	-18.0	-27.6	-7.7
D9	Fertility rate	Child /women	6.30	3.70	3.40
D10	Age Median	Age	16.73	18.92	20.2

Source: Umaña, 1998. Corrections Aguilar, 1999.

1.2.2. Programmed and Trend Scenarios 2025, 2050 and 2100.

Chart 5.2 Projected Demographic Indicators								
	Demographic Indicators	Units	Programmed			Trend		
			2025	2050	2100	2025	2050	2100
D1	Population	Million	9.062	11.155	11.938	9.726	13.345	19.048
D2	Population under 15 years	% Total	25.67	20.28	17.28	28.86	24.64	20.89
D3	Population between 15 and 64 years	% Total	66.93	64.53	59.21	64.26	62.66	60.64
D4	Population over 64 years	% Total	7.39	15.19	23.51	6.89	12.70	18.47
D5	Annual population growth rate	% anual	0.83	0.14	0.00	1.27	0.71	0.30
D6	Percentage of urban population	% PU/PT	73.85	87.89	94.75	98.0	99.0	99.0
D7	Percentage of males	% PM/PF	97.4	97.4	96.5	97.8	98.4	98.3
D8	International migration balance	Thous/year	0.0	0.0	0.0	0.0	0.0	0.0
D9	Fertility rate	Women/child	2.15	2.00	1.96	2.66	2.44	2.23
D10	Age Median	Age	29.21	36.83	42.57	27.14	32.12	37.15

Source: Umaña, 1998. Corrections, Aguilar, 1999.

1.3. Social Indicators.

1.3.1. Reference Line.

Chart 5.3 Baseline Social Indicators					
	Social Indicators	Units	1970	1990	1995
S1	Literacy	%	56.6	74.9	79.0
S2	Schooling	E7-18/P7-18	42.46	65.52	71.86
S3	Permanent housing	%		57.9	65.9
S4	Housing with electrical power	%	33.9	69.3	73.9
S5	Housing with firewood stoves	%	78.47	63.50	57.55
S6	Rural housing with firewood stoves	%	93.78	88.26	86.25
S7	Child mortality <1year	‰	107.5	47	36.4
S8	GDP social expense	%	5.19	4.00	4.06
S9	Population under poverty level	%		58.7	47.5
S10	Population under extreme poverty	%		27.7	18.2

Source: Umaña, 1998.

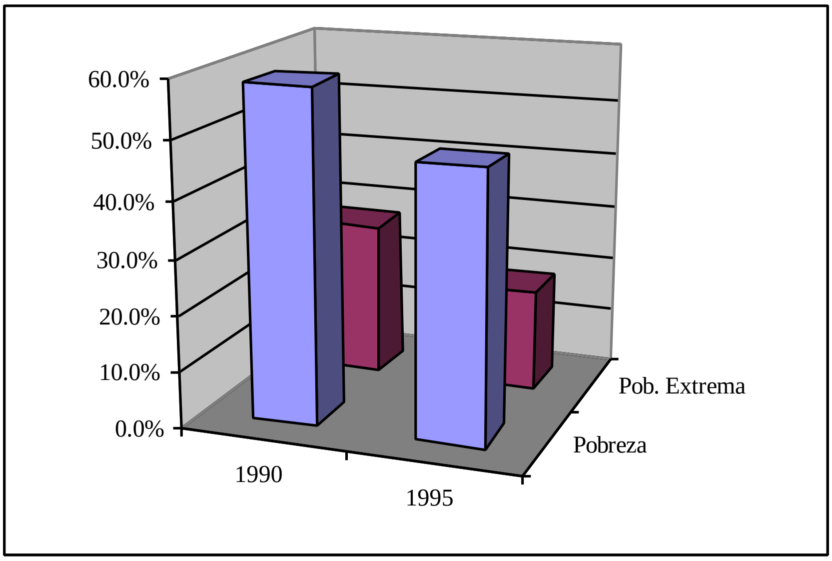


Fig. 5.1: General and Extreme Poverty, 1990 and 1995.

1.3.2. Programmed and Trend Scenario 2025, 2050 and 2100.

Chart 5.4 Projected Social Indicators									
	Social Indicators	Units	Programmed			Trend			
			2025	2050	2100	2025	2050	2100
S1	Literacy	%	93.3	96.8	97.9	86.5	87.7	88.0
S2	Schooling	E7-18/P7-18	92.01	94.59	94.99	84.03	84.91	85.00
S3	Permanent housing	%	77.5	83.1	86.5	71.0	76.8	82.6
S4	Housing with electrical power	%	98.5	99.8	99.9	96.3	97.8	98.0
S5	Housing with firewood stoves	%	20.19	8.14	5.10	22.69	12.49	10.07
S6	Rural housing with firewood stoves	%	67.53	46.05	17.68	68.18	48.82	25.68
S7	Child mortality <1year	‰	11.4	7.2	5.1	23.7	14.2	6.1
S8	GDP social expense	%	7.59	11.97	14.76	7.59	9.51	9.99
S9	Population under poverty level	%	31.4	23.5	18.8	40.4	32.3	24.2
S10	Population under extreme poverty	%	12.0	9.0	7.2	15.5	12.4	9.3

Source: Umaña, 1998.

1.4. Economic Indicators.

1.4.1. Baseline.

Chart 5.5
Baseline Economic Indicators

	Economic Indicators	Units	Baseline		
			1970	1990	1995
E1	GDP 1990 colones	Million ¢	30,309	36,427	49,156
	GDP 1990 dollars	Million US$	3,988	4,793	6,468
E2	GDP growth rate	% annual	3.90	4.80	6.40
E3	GDP per capita 1990 colones	Colones p/c	8,423	7,128	8,672
	GDP per capita 1990 dollars	US$ p/c	1,108	938	1,141
E4	Primary GDP	% GDP	18.68	17.13	13.60
E5	Industry GDP	% GDP	28.03	21.75	21.19
E6	Services GDP	% GDP	53.29	61.12	65.21
E7	Exports in relation to GDP	Exp/GDP		12.91	17.53
E8	EAP 15 years in million	Persons	1.160	1.796	2.131
E9	Economic dependence relationship	Dependent person		2.15	1.90
E10	Gross participation rate	EAP/PT	32.3	35.1	37.6
E11	EAP employed	PEAO/EAP		90.44	91.89

Source: Umaña, 1998.

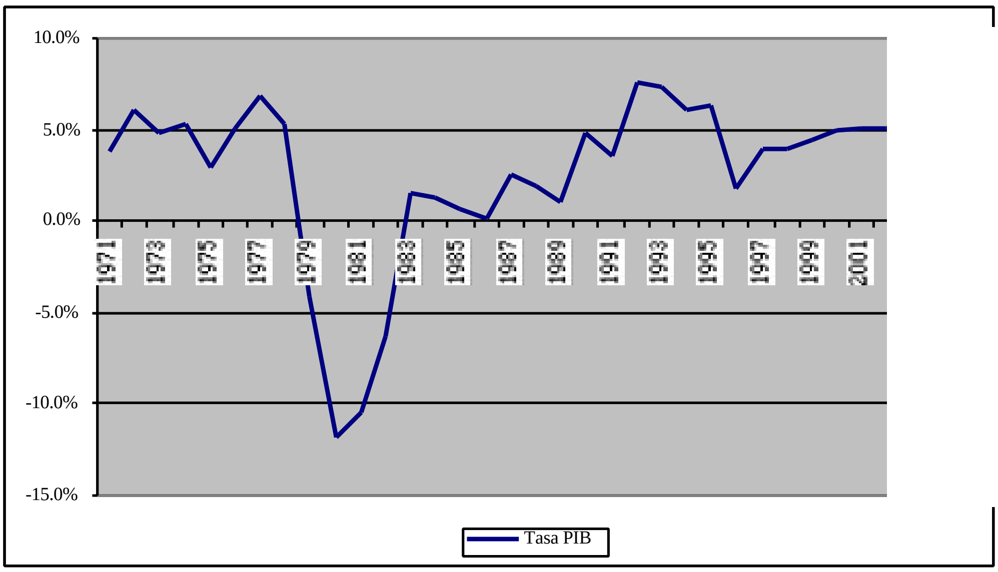


Fig. 5.2: Actual GDP Growth Rate, 1990 System.

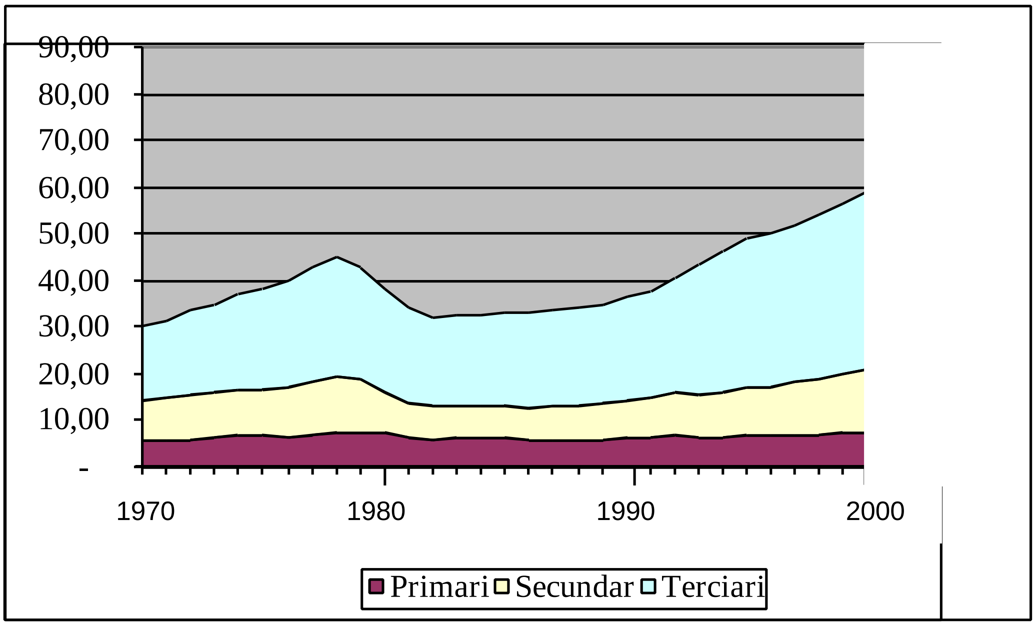


Fig. 5.3: GDP Structure in the Primary, Secondary and Tertiary Sectors.

1.4.2. Programmed and Trend Scenarios 2025, 2050 and 2100.

Chart 5.6
Projected Economic Indicators

	Economic Indicators	Units	Programmed			Trend		
			2025	2050	2100	2025	2050	2100
E1	GDP 1990 colones	Million ¢	218,477	582,425	2,553,298	156,051	416,006	1,823,731
	GDP 1990 dollars	Million US$	28,747	76,635	335,960	20,533	54,738	239,965
E2	GDP growth rate	% annual	5.40	4.00	3.00	3.51	3.51	3.0
E3	GDP per capita 1990 colones	Col. P/c	24,108	52,211	213,886	16,045	31,172	95,743
	GDP per capita 1990 dollars	US$ p/c	3,172	6,870	28,143	2,111	4,102	12,598
E4	Primary GDP	% GDP	10.43	9.25	9.25	8.69	6.04	4.74
E5	Industry GDP	% GDP	22.99	22.99	22.99	22.12	22.12	22.12
E6	Services GDP	% GDP	66.58	67.76	67.76	69.20	71.84	73.15
E7	Exports in relation to GDP	Exp/GDP	59.89	76.80	80.74	72.52	93.00	97.77
E8	EAP 15 years in million	Persons	4.408	7.144	8.821	4.493	8.054	13.202
E9	Ec. dependence relationship	Dep. Pers.	1.19	0.66	0.44	1.34	0.78	0.54
E10	Gross participation rate	EAP/PT	48.6	64.0	73.9	46.2	60.4	69.3
E11	EAP employed	PEAO/EAP	93.99	94.00	94.00	92.39	93.10	93.54

Source: Umaña, 1998.

1.5. Territorial Indicators.

1.5.1. Baseline.

Chart 5.7
Territorial Indicators of the 1970-1995 Baseline

	Territorial Indicators	Units	Baseline		
			±1970	±1990	1995
T1	Coverage of permanent crops	HaAcp/HaT	8.30%	8.11%	9.15%
T2	Permanent coverage (dense forests and mangroves)	HaB/HaT	8.63%	5.07%	3.85%
T3	Forest coverage T1 + T2	(1+2)	16.93%	13.18%	13.01%
T4	Urban soil coverage	% HaUr/HaT	0.65%	1.40%	1.58%
T5	Concentration in MASS	P.MASS/PT	19.91%	29.20%	29.94%
T6	Concentration in five main cities	P5C/PT	31.1%	40.8%	41.5%
T7	Concentration at the coast (33 municipalities)	P 33 MC/PT	15.2%	13.8%	14.1%
T8	Participation of the northern region	PN/PT	17.24%	12.78%	12.34%
T9	Demographic density	PT/Ext. km^2	173	246	273

Source: Umaña, 1998.

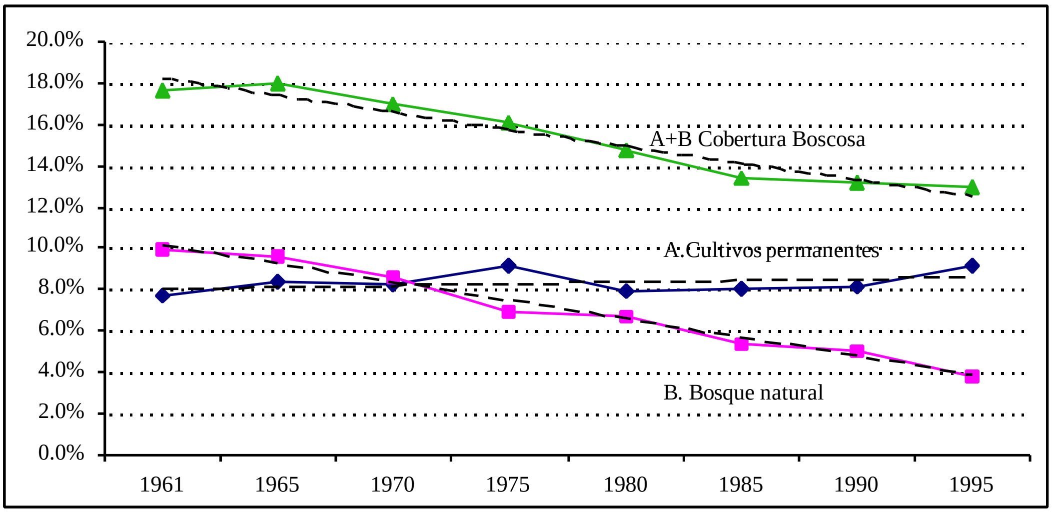


Fig. 5.4: Forest Coverage Trend in El Salvador.

1.5.2. Programmed and Trend Scenario 2025, 2050 and 2100.

Chart 5.8 Projected Territorial Indicators									
	Indicator	Units	Programmed			Trend			
	Territorial Indicators		2025	2050	2100	2025	2050	2100
T1	Coverage of permanent crops	HaAcp/HaT	9.15%	10.20%	13.20%	7.96%	7.58%	7.39%
T2	Permanent coverage (dense forests and mangroves)	HaB/HaT	6.94%	10.24%	16.83%	0.75%	0.57%	0.43%
T3	Forest coverage T1 + T2	(1+2)	16.09%	20.44%	30.03%	8.71%	8.14%	7.82%
T4	Urban soil coverage	% HaUr/HaT	2.98%	4.36%	5.03%	4.24%	5.88%	8.39%
T5	Concentration in MASS	P.AMSS/PT	34.61%	36.90%	37.90%	51.90%	59.81%	66.56%
T6	Concentration in five main cities	P5C/PT	48.7%	55.6%	57.1%	65.0%	75.5%	78.6%
T7	Concentration at the coast (33 municipalities)	P 33 MC/PT	15.2%	15.2%	15.2%	15.2%	15.2%	15.2%
T8	Participation of the northern region	PN/PT	9.47%	9.12%	8.52%	8.82%	7.62%	5.34%
T9	Demographic density	PT/Ext. km2	437	538	576	469	643	918

Source: Umaña, 1998.

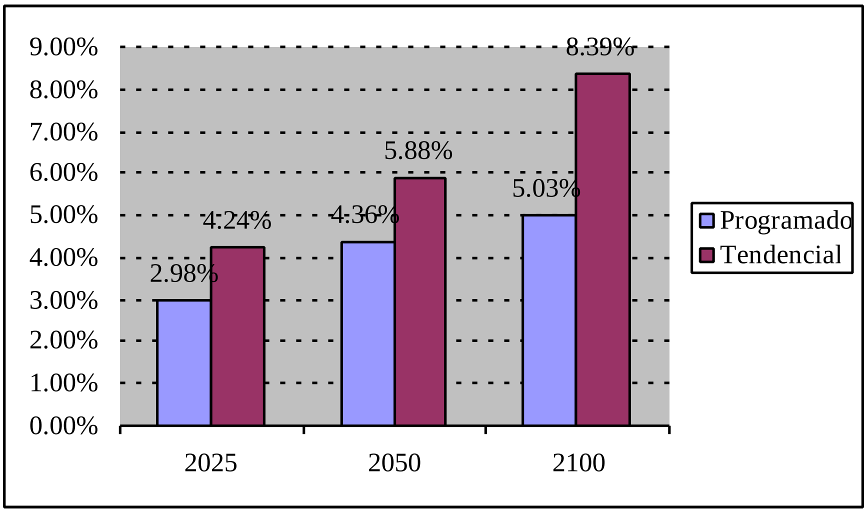


Fig. 5.5: Urban Coverage of Soil at the National Level

1.6. Normative – Institutional Indicators.

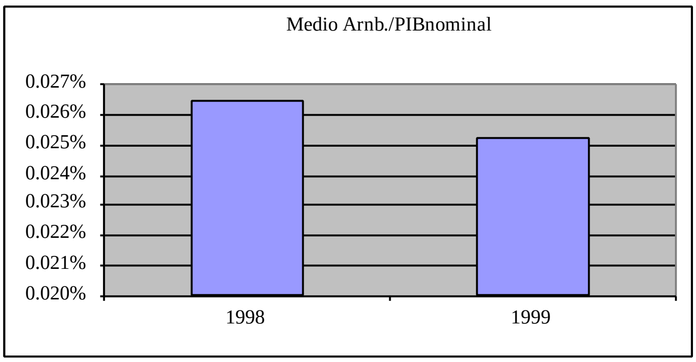
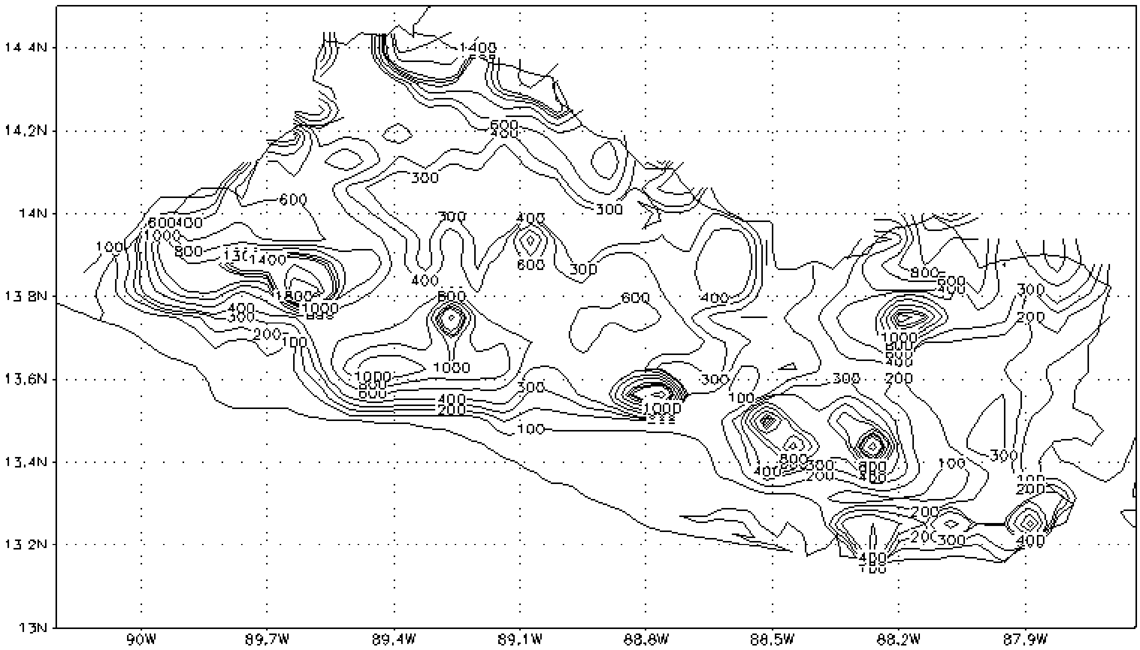


Fig. 5.6: Environmental Budget with respect to the GDP

2. Climatology of El Salvador: Baseline Climate Scenarios.

There is a general agreement on the fact that a 30 year period is sufficient to calculate, with statistical meaning, the frequency distribution of various variables and particularly to obtain a good representation of some weather variability features, especially those related to inter annual variability[14].

The baseline climate scenario for El Salvador[15] was based on a regular grid, with a 5 minute latitude/longitude resolution for the 1961-1990 period. Air, surface temperature and rainfall are the climatic variables involved.



Map 5.1: Topography of the Republic of El Salvador (inmsnm).

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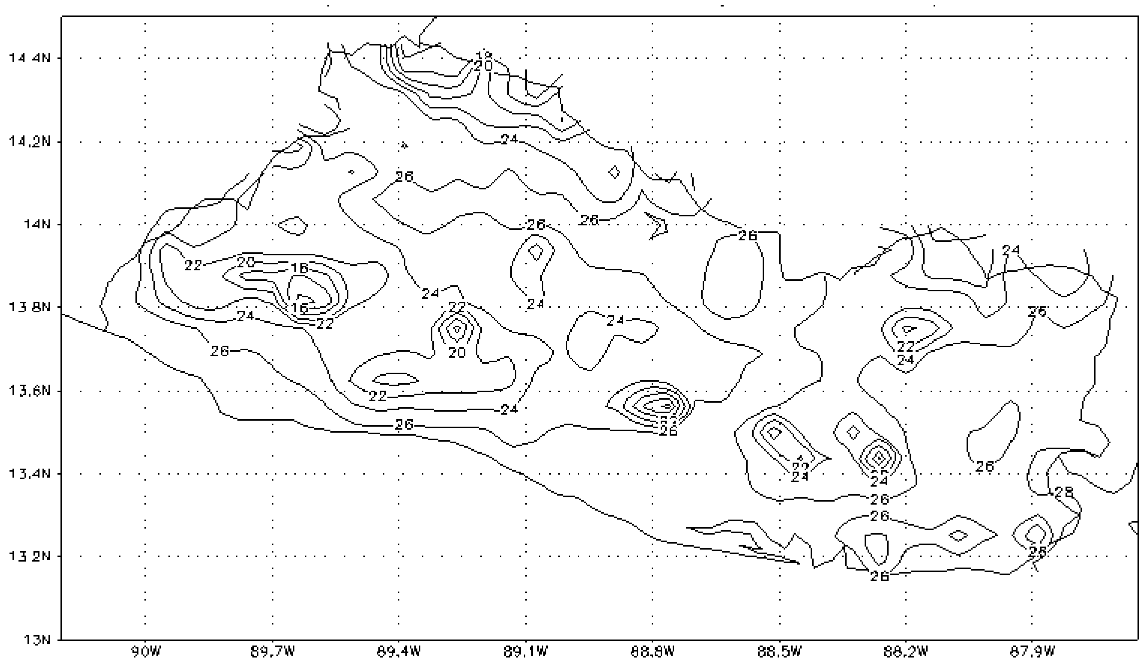
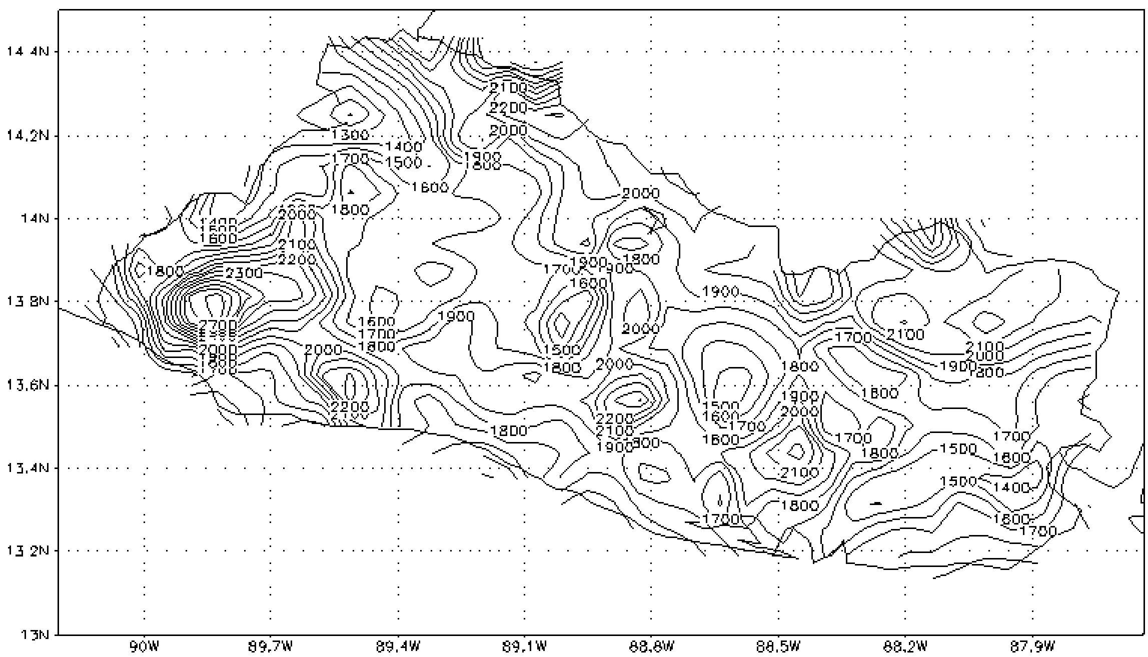
[14] Parry and Carter, 1998.
[15] Refer to the complete study: "Escenarios Climáticos de Referencia para la República de El Salvador".



Map 5.2: Air annual average temperature field for currentclimatology (in ^{o}C).



Map 5.3: Annual rainfall field for current climatology (in mm)

2.1. Climatology.

One of the characteristics of climate in El Salvador is the relatively small annual thermal variation[16], with greater values in April and a drop in December and January, which are the coldest months of the year. Rainfall shows a contrast in the monthly distribution of rain accumulation, establishing a sharp difference between the dry and rainy seasons. The relative reduction of total rainfall values during July and August, associated to "dog days", can also be observed .

Chart 5.8
Median, standard deviation (S.D.), minimum (Min.) and maximum (Max.) values for temperature and rainfall in months, quarters and years. 1961-1990 Period

Month	Rainfall (mm)				Temperature (^oC)			
	Median	S.D.	Min.	Max.	Median	S.D.	Min.	Max.
January	3.7	5.3	0.7	26.2	23.9	0.6	22.6	25.5
February	3.7	4.2	0.7	16.4	24.4	0.8	22.7	26.2
March	14.7	11.7	3.4	52.3	25.7	0.6	24.8	27.0
April	53.2	28.1	19.5	113.1	26.4	0.6	25.0	27.7
May	194.8	54.2	85.8	327.8	26.0	0.6	25.0	28.0
June	339.1	67.5	198.0	484.4	25.0	0.6	23.9	26.2
July	263.2	77.6	126.3	424.0	25.1	0.6	24.1	26.0
August	296.8	67.8	151.2	507.0	24.9	0.6	23.9	26.2
September	368.6	74.7	237.9	503.5	24.4	0.5	23.6	25.8
October	228.9	73.3	65.7	380.3	24.4	0.4	23.7	25.2
November	49.2	43.0	8.8	163.0	24.1	0.7	22.6	25.8
December	7.7	8.4	0.6	36.2	23.8	0.7	22.1	26.0
DEF	15.1	11.0	2.9	48.3	24.1	0.5	23.3	25.2
MAM	262.7	53.1	165.0	392.8	26.0	0.5	25.2	27.1
JJA	899.2	130.8	660.8	1198.8	25.0	0.5	24.2	26.0
SON	646.7	119.0	374.0	888.8	24.3	0.5	23.5	25.5
Annual	1823.6	172.4	1525.8	2127.2	24.8	0.5	24.2	25.9

2.2. Inter-annual variations of the Air Surface Temperature and Rainfall.

The climate in El Salvador shows a relatively small variation of average values, the same as the majority of countries in the tropical zone, compared to other countries located at higher latitudes. Notwithstanding, climatic phenomena happen from year to year causing a significant impact in the country's economic and social life.

The sound knowledge of climatic variations and the various temporary scales facilitates capability building to adopt the necessary measures to reduce negative impacts and leverage positive ones. This aspect is of great value in the assessment of the potential impacts of climatic change, since the examination of weather effects on social and economic sectors facilitates the establishment of appropriate response strategies, to adapt to future climatic changes.

[16] Guzmán, 1995.

2.2.1. Air Surface Temperature.

A simple inspection of the air surface temperatures in El Salvador, allows to appreciate the significant increase in values in the 80's. The estimated values of the linear trends indicate the ocurrance of a warming process of approximately 0.04° C/year, which means that during the 1961-1990 period, the annual average temperature increased in approximately 1.2 °C. The 1980 period was the warmest and 1987, 1990 and1983 were the hottest years (with unusual values of 1.1°C, 0.8°C and 0.7°C, respectively).

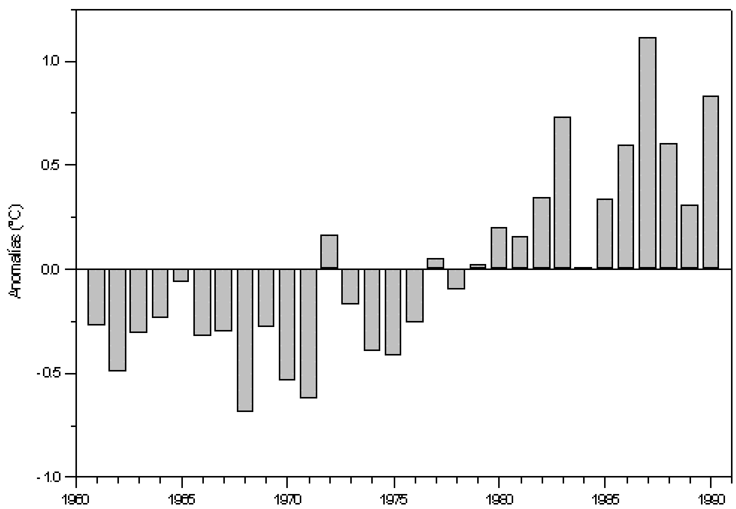


Figure 5.7: Unusual air surface temperatures in El Salvador, referred to the 1961-1990 period median

Every quarter of the year showed significant increases, which are slightly more intense during the December – February and June – August quarters.

It is important to highlight that annual temperature abnormalities show an important change in value during the mid 70's, consistent with the important warming of the low troposphere layers, which started around those years[17].

[17] Naranjo and Centella, 1996.

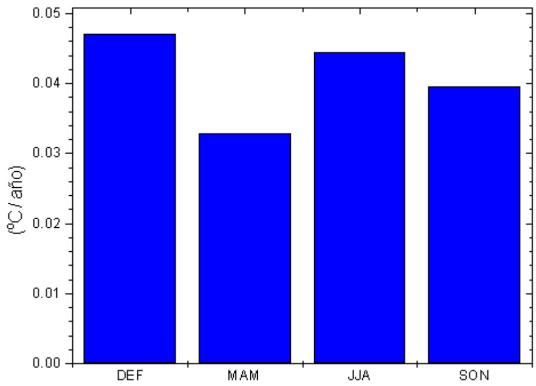


Figure 5.8: Estimated Trends (°C/year) for average temperatures per quarter.

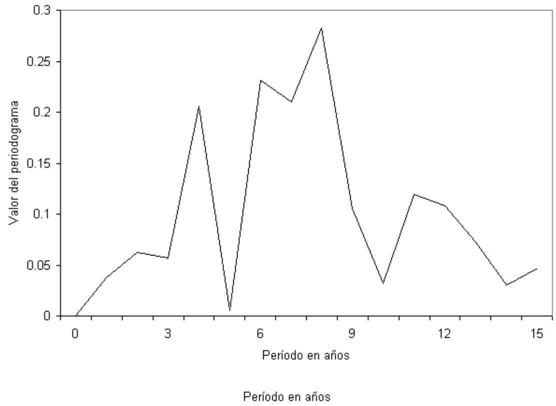


Figure 5.9: Chart showing the period of abnormal temperatures displayed in Fig. 5.7

Fig. 5.9 shows the outcomes of the spectrum analysis of the temperature annual abnormalities series, with the previous elimination of the trend using a square function. As can be appreciated, the existence of cyclic variations in the 4 to 8 year range seem to exist. Nevertheless, it was determined that none of the signals were statistically meaniningful (employing a Fisher F[18] statistics), so no conclusions were reached in this regard.

2.2.2. Rainfall.

One of the most outstanding features of the annual rainfall series for the considered period, is the alternate existence of significant rainfall deficit periods mixed with others with higher accruals than the historical average ones.

The estimated trend for annual values was not statistically significant, contrary to the temperature in this case, indicating a reduction of only 0.38 mm/year. This decreasing trend, in total annual rainfall, although slight, seems to be caused by the reduction in rainfall during the Sepetember – November quarter.

[18] Wei, 1994.

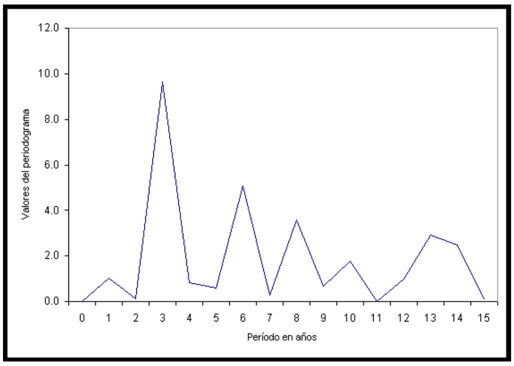


Figure 5.10: Changes in the total rainfall rates in El Salvador referred to in the 1961-1990 period average.

The chart of total rainfall abnormalities, allows to appreciate that the intense accrued annual rainfall reduction periods, seem to be related to the years where the ENSO event was developed. In fact, the outcomes of the spectrum analysis regarding the series of abnormal annual rainfall show the existence of variations ranging from 3 to 6 years, with only one significant one, which was the one with the highest frequency (0.05 significance level).

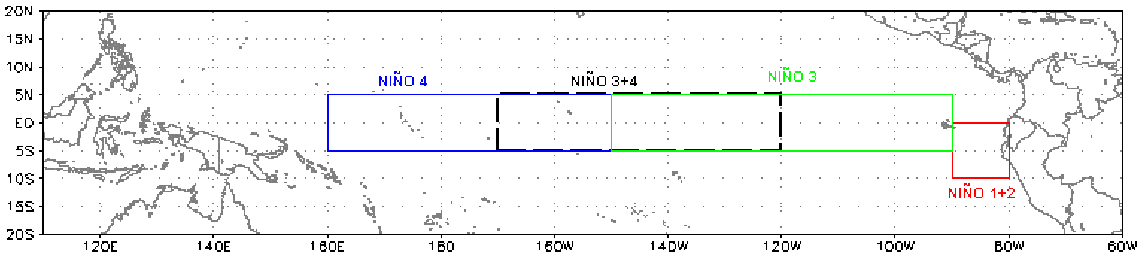


Figure 5.11: Regions with abnormal SSTA.

In order to determine the level of relationship between the prevailing conditions in the geographical area where the ENSO event is being developed (cold and warm events) and the country's rainfall, a correlation analysis between Sea surface temperature abnormalities (SSTA) in different regions of the Pacific Ocean, known as El Niño 3-4, El Niño 3 and El Niño 1+2, and the series of de-phased monthly rainfalls throughout time. The findings of this analysis allow to determine the period elapsed from the development of determined conditions in the Pacific (El Niño or La Niña) and the occurrence of effects on the country's rainfall regime.

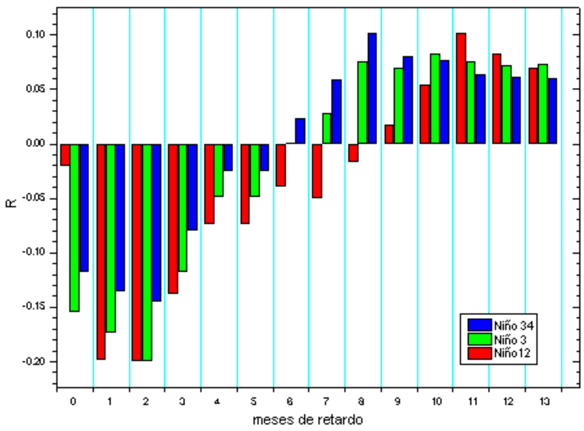


Figure 5.12: Correlation between the SSTA in several regions Equator Pacific and the rainfall averages for several months of delay.

The results obtained clearly indicate that if all the El Niño regions are considered, the greatest relationships are obtained for the 1 and 2 months of delay, which were highly significant statistically speaking, since these relations have a minus sign, it can be affirmed that the development of SSTA with a plus sign (related to El Niño) tend to produce a rainfall drop in the country, while SSTA with a minus sign (associated with La Niña) tend to foster and increase in rainfall accumulations.

If the relationships with the each El Niño region are differentiated, the 2 month delay is the most important for the SSTA observed in El Niño 1+2 and El Niño 3. It is worth noting that the variations observed in the relationships with each El Niño region are consistent with the way in which temperature abnormalities develop in the Pacific ocean. Likewise, the intensity of these relationships seem to be closely related to the closeness of these areas to the country.

It is important to highlight that the statistical links described, only allow to describe the existence of a relationship between the ENSO ocean component and rainfall in El Salvador, understanding that the ENSO is a Ocean – atmosphere interruption phenomena, it is necessary to develop future studies to more accurately and profoundly describe potential relationships using indicators related to the atmosphere circulation in that region of the Pacific.

3. Climate Scenarios to Evaluate the Impact of Climate Change.

The evaluation of the vulnerability to climatic change seeks to assure the optimum use of available climatic resources: first, by measuring positive and negative impacts; and second, by assessing the adaptation measures to respond to the impacts in order to obtain an advantage from the positive impacts and to minimize the negative[1] ones. To this end, it is necessary to obtain a quantitative representation of changes in climate, in other words, to project temporary and spatial patterns on future climate.

It is believed with a good margin of confidence, that the increase of GGE atmospheric concentrations can produce an increase in global temperature. Nevertheless, estimates on how high gas concentrations can affect regional climates enjoy low levels of confidence, accompanied by a large number of uncertainties. It is also true that climatic changes can vary[2], as well as the future social economic and environmental conditions. For this reason, there is no possibility to make reliable predictions of a regional scale climatic change. Despite the above difficulty, it is necessary to offer an idea of how current ecosystems, human lives or the economy could be affected, by offering more information to decision makers. This is why; representations of the future climate are used, rather than predictions to determine when a specific sector is potentially vulnerable to climatic change. Said representations are called climatic change scenarios, and could be defined as follows: "A representation of an internally consistent future climate, built on scientific principles and which can be used to understand the responses of environmental and social systems in face of the future climatic change "[3].

There are a great variety of methods to create climatic change[4] scenarios, which can be grouped in synthetic scenarios (also known as incremental), analogous and the ones that can be built from the exits of general circulation models (GCM). The most used to date is the GCM since it is one of the best scientific tools to project scientific climate[5]. The GCM are trio-dimensional number representations employed to simulate the behavior of the global climatic system (including the atmosphere, the oceans, the biosphere, the criosphere and the surface of the earth).

GCM outcomes can be combined with the exits of the simplest climatic models to assess the outcomes of the first under a great variety of assumptions on future emissions. This idea was used to develop regional climatic change scenarios in Europe using the STUGE[6]. The Climate Research Unit of the East Anglia University in the United Kingdom created two computerized programs, MAGICC and SCENGEN, which can be employed to build scenarios using the same principle.

3.1. The Creation of Climate Change Scenarios.

The creation of climate change scenarios is one of the most important stages of the vulnerability study, since the direction of evaluation outcomes depends on them. In this way, scenarios should be selected based on a carefully planned and balanced decision.
The same method used by Hulme (1996) and Centella et al (1998a) was used to create the climate change scenarios in El Salvador[7]. This method combines the outcomes of the Simple Circulation Mode (SCM) to reproduce the exits of the GCM under different assumptions on GHG emissions or climate sensitiveness. In the case of this study, the three GCM exits were used: HADCM2, ECHAM3TR and UKHI.

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[1] Parry and Carter, 1998.
[2] IPCC 1990, 1992.
[3] Vinner and Hulme, 1992.
[4] Carter, et al, 1993.
[5] Benioff et al, 1996.
[6] Vinner and Hulme, 1998.
[7] Please see the complete study: "Scenario s de Cambio Climático para la Evaluación de los impactos del Cambio Climático en El Salvador".

3.1.1. Emission Scenarios.

Out of the set of Emission Scenarios (ES) defined by the IPCC[8], the emission scenarios IS92a, IS92c and IS92f were selected for this study. These scenarios represent the future GGE projections considering the various assumptions on world population growth, the global growth of the economy, technological development, the limitations in the use of energy sources from fossil fuels and the development of agriculture, among others.

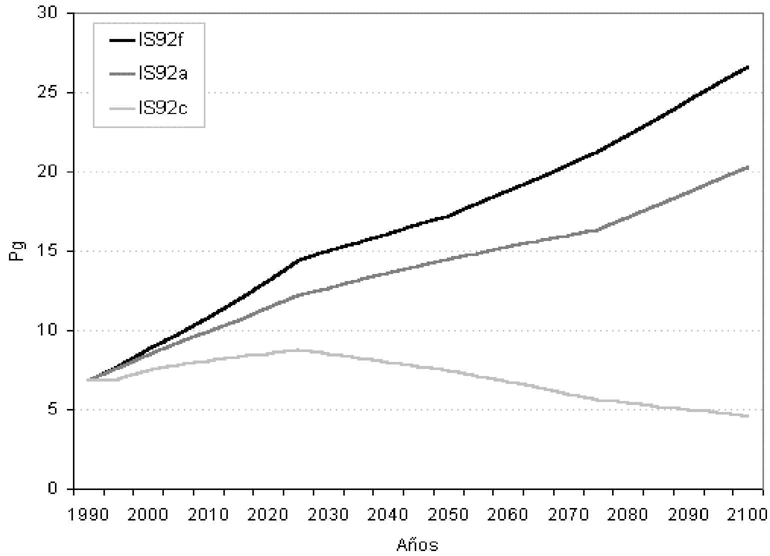

Figure 5.13: Evolution of CO_2 Emissions for
The emission scenarios IS92a, IS92c and IS92f.

3.1.2. Global Temperature Projections and the Sea Level Rise.

To obtain Global temperature projections (GT) and the increase in sea level (MG) for a determined ES, it is necessary to convert emissions into atmospheric concentrations. Later, the radiative forcing is estimated, from which global warming depends.

The most important parameter is climate sensitiveness (ΔT_{2x}), which is the measure of the change in the global average temperature for a determined radiative forcing. If we use ΔT_{2x} = 2.5 °C, 1.5°C and 4.5°C (which are the best estimates and the low and high limits of the sensitiveness values considered by the IPCC, respectively) the values GT and MG were estimated for each ES, with respect to the period from 1961-1990 and to the year 1990.

[8] Leggett et al, 1992.

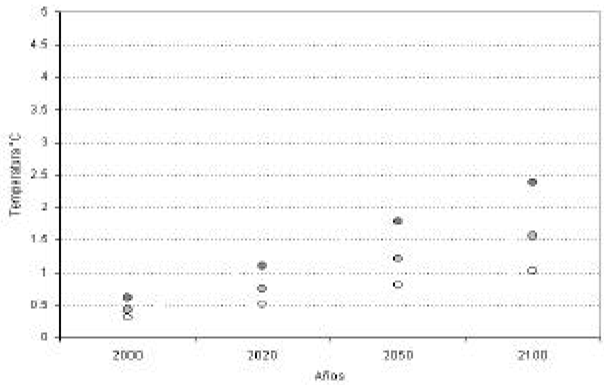

Figure 5.14: Projected global warming under the IS92k emission scenario. The circles in white, light grey and dark grey are associated with the climatic sensitiviness values of 1.5°C, 2.5°C and 4.5°C, respectively.

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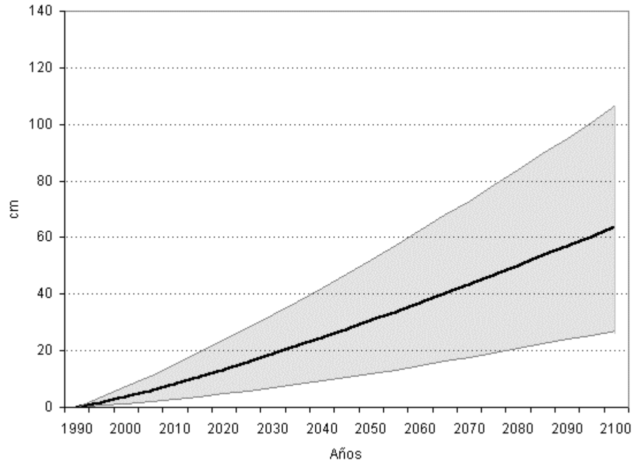
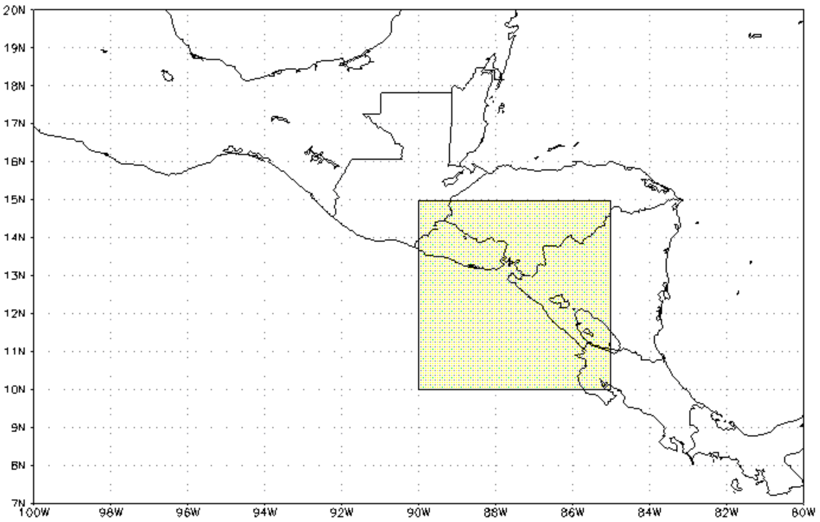


Figure 5.15: Projection of the increase in sea level under the IS92a emission scenario. The line is associated with the projection, considering an average climatic sensitiveness (ΔT_{2x}=2.5°C). The shaded area indicates the range of estimates considering the extreme values of ΔT_{2x} (1.5°C y 4.5°C).

3.2. Future Climate Projections for El Salvador.

3.2.1. Temperature and Rainfall.

In accordance with the outcomes of the three GCM's, extracted from the SCENGEN grid, in which El Salvador is located (Map 5.4) and considering the IS92a ES with an average climatic sensitiveness, the projected climatic change for El Salvador indicates an increase in temperature ranging from 0.8°C to 1.1°C in the year 2020, up to 2.5°C to 3.7°C in the year 2100.
Rainfall outcomes have even more uncertainties, since the projections cover ranges from –11.3% to 3.5% in the year 2020 up to -36.6% to 11.1% in the year 2020. If the other ES are taken into account, the resulting pattern is similar and changes can only be observed in the magnitude of the values resulting from the existing differences in the forcing associated to each emission scenario.



Map 5.4: The SCENGEN grid which falls over El Salvador, and for which the temperature and rainfall change values were extracted.

Within the three model projections, the HADCM2 indicates a significant reduction of rainfall and a higher warming level. UKHI projects a rainfall increase and lower warming; and the ECHAM3TR, does not present a variation in rainfall but a lower temperature increase, similar to theUKHI.

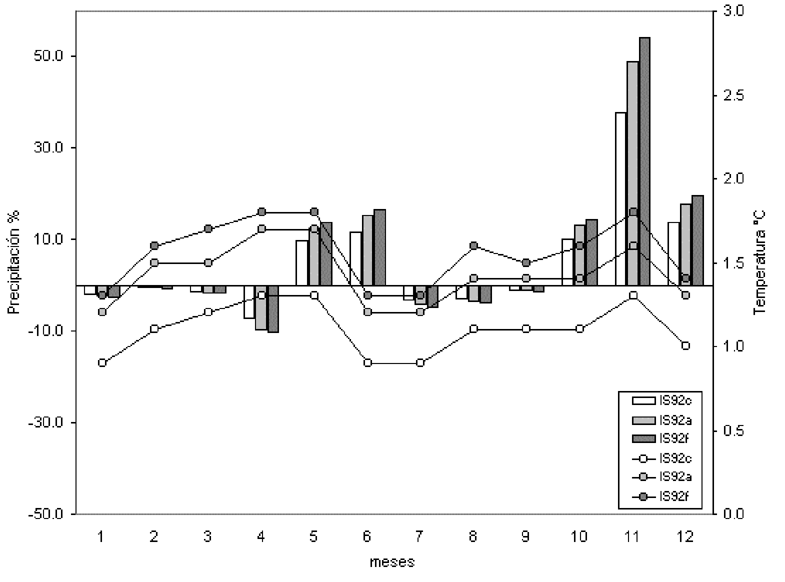


Figure 5.16: Annual variation pattern of temperature change (lines) and rainfall (bars) for the various ES from the outcomes of the UKHI model. Year 2050.

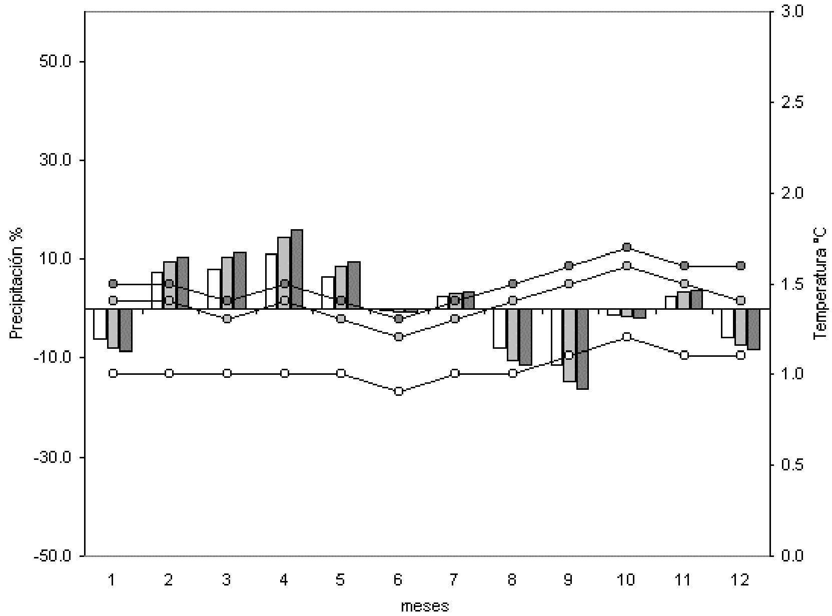


Figure 5.17: Temperature change annual variation pattern (lines) and rainfall (bars) for the various ES, from the outcomes of the ECHAM3TR model. Year 2050.

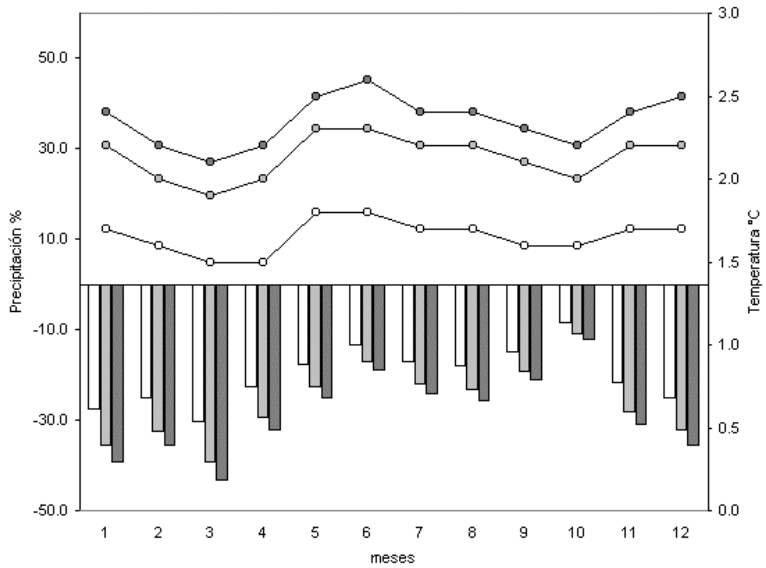


Figure 5.18: Temperature change annual variation pattern (lines) and rainfall (bars) for the various ES. Outcomes of the HADCM2 model. Year 2050.

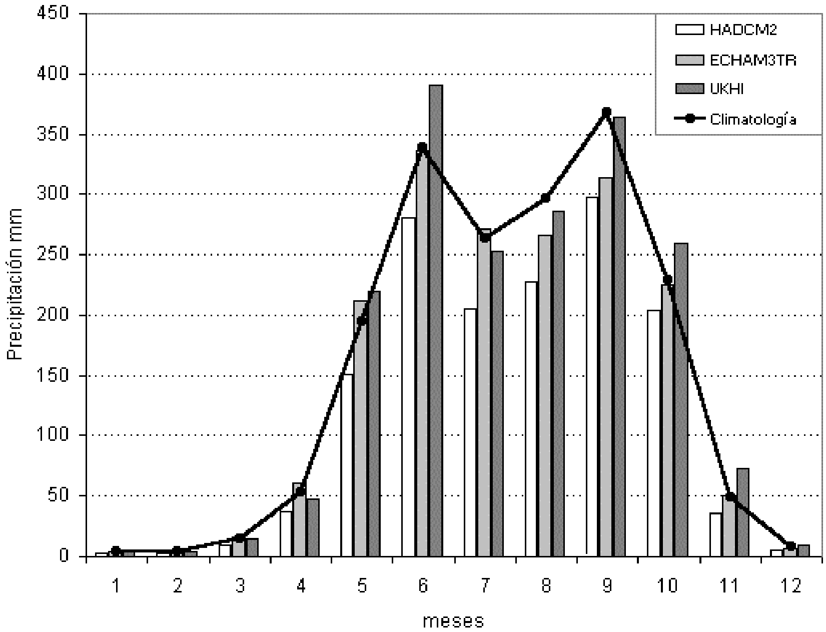


Figure 5.19: Rainfall annual variation pattern for the year 2050, in accordance with the exit of the three GCM and considering the IS92a ES.

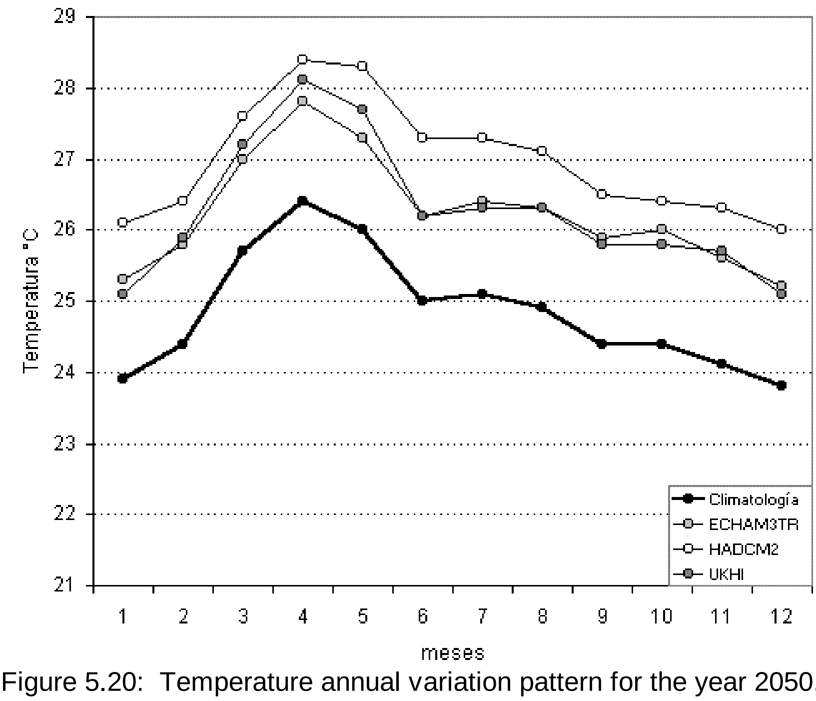


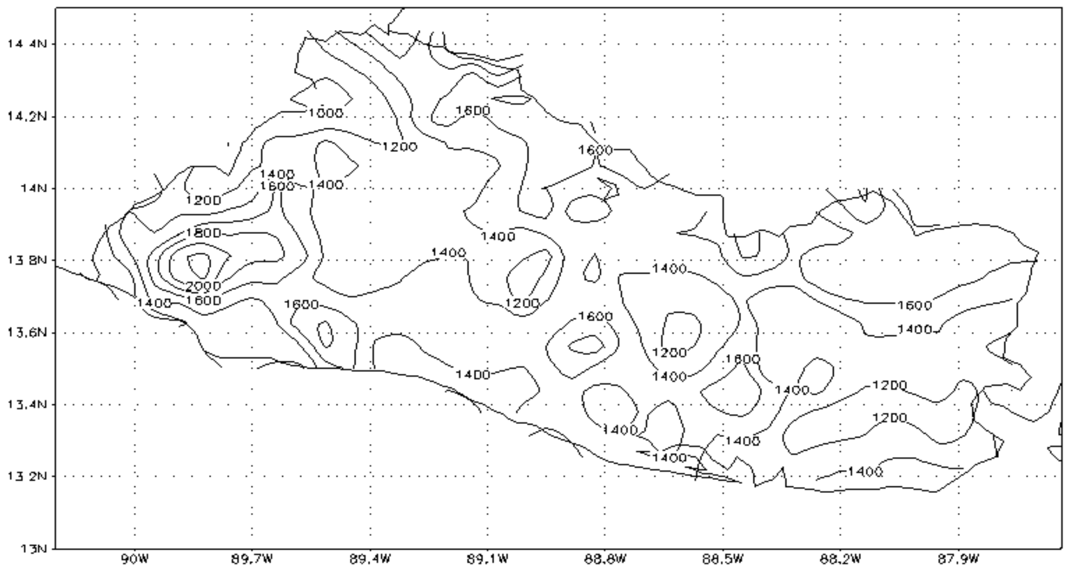
Figure 5.20: Temperature annual variation pattern for the year 2050, in accordance with the exit of the three GCM and considering the IS92a EE.

Figures 5.19 and 5.20 show annual rainfall and the temperature in the year 2050, in accordance with the projections of the three GCM, with an average climatic sensitiveness, and taking into account the IS92a scenario. An important feature reflected in rainfall patterns, is the trend to intensify "dog days" even under the projections of the UKHI model. This fact is appreciated in the projections under all the GHG future ES and could have an effect on various food production related sectors or on hydric source usage, reason why it should be thoroughly considered in impact assessments.

The temperature projections of the three models show a clear growing trend for all the months, with no important changes in the annual variation pattern structure. The discussed outcomes only reflect average concessions for a period of time (in this case, 30 years-focused on 2050), therefore, the variations related to inter annual climatic variability are not taken into account.

By combining change projections with climatology, temperature spatial patters and monthly seasonal and annual rainfall can be produced. It must be taken into account that the structure of these fields is totally influenced by the one on climatology, since the change affects all the country.

The previously described outcomes may vary, based on the sensitiveness of the climate to a determined forcing, which can occur earlier or later if the sensitiveness is greater or lower, respectively.



Map 5.5: Annual rainfall spatial distribution (mm) in El Salvador in the year 2050, in accordance with the projection of the HADCM2 model and assuming an average climate sensitiveness under the ES IS92a.

3.2.2. Sea Level Rise Projections.

The outcomes regarding the potential rise in sea level of the GCM are global and it is not probable that said rise can be homogeneous throughout the planet. Spatial variations could happen based on the reason for the warming in the various parts of the world's ocean and the spatial variations in atmospheric pressure over the ocean, among other elements.

Within the framework of the climatic change impact assessment studies of El Salvador, the information to estimate the relative movement between the earth surface and the ocean in El Salvador's coast line should be available. This aspect should be thoroughly analyzed, so that global projections may be corrected based on the already explained elements.

4. Climate Change Impact Assessment in the Agricultural Sector along the Coast Line.

El Salvador is one of the most environmentally depleted countries and also one of the most populated in Latin America, its rate of birth and the size of its territory render it highly vulnerable, for both its natural ecosystems and economic and social aspects. This was evidenced in 1998, with Hurricane Mitch.

This study identifies the potential climatic change impacts on the agricultural production along the coastline[9]. The vulnerability of said sector was assessed in order to propose the necessary adaptation measures to face climate variations, expressed in changes in temperature, rainfall and the rise of sea level.

4.1. Baseline of the Coastal Zone: 1960-1990 Period.

4.1.1. Location.

The coastal line, as an area of study, is geographically located to the north of the Equator, between parallel 13° 09' 16.12" and 13° 50' 29.18" North Latitude and the 87° 41' 02.81" and 90° 07' 56.26" meridians of west longitude.

The Salvadoran coastline is 338 kilometers long, of which 310 are part of the study. The coastline starts at the mouth of the Paz River, which is a natural border with Guatemala, running through the southern part of Ahuachapán, Sonsonate, La Libertad, San Salvador, La Paz, San Vicente, Usulután, San Miguel, to end in the Fonseca Gulf in the department of La Unión.

Thirty three municipalities are found along the 310 kilometers of the coast line, located inside the 9 departments above mentioned, which are also part of this study.

In order to define the coast line within the framework of the study, a broad area has been considered to establish the biophysical status and the social, economic and productive conditions of the region.

The study has considered the coastline as the insular part closely related to the sea and its currents, which is also the area where rivers flow; constituting the land portion subject to important changes in shape and habitat, due to the combined action of fresh and salty waters, with or without man's intervention.

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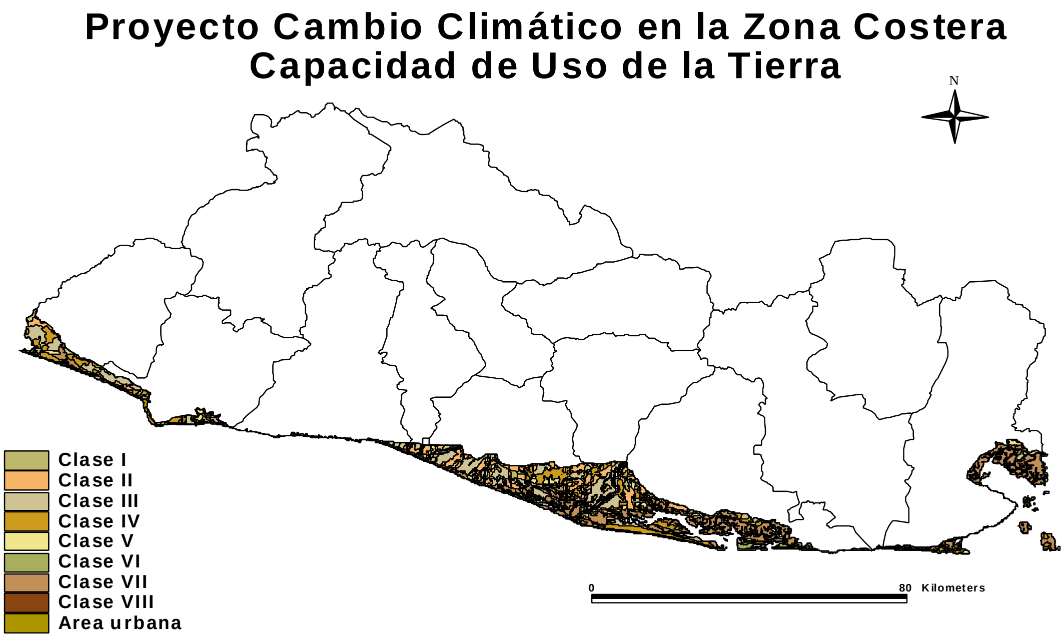
[9] Please refer to the complete study: "Evaluación de los Impactos del Cambio Climático en el Sector Agropecuario de la Zona Costera de El Salvador". Tobar, 1999.

The coastline part of the study is 1,711.9 square kilometers long, of which 78.7% is land, 18.1% mangroves and the remaining portion corresponds to channels, estuaries and marshes. The most important areas, regarding food production are: a) the western coastal lowlands, b) the central coastal lowlands and c) the eastern lowland. These zones are divided into three important components: coastal lowlands, mangroves and beaches.

Climate Change Project in the Coastal Area
Land Use Potential



4.1.2. Social Economic Aspects .

Regarding social and economic aspects, the nine coastal departments have a population that in 1990 averaged 13.9 of the country's total population.

The population of the coastal municipalities under study, represent 26% of the total average population of those municipalities. The average population density in these municipalities is 163 inhabitants per square kilometer. In average 73% of the coastal population is concentrated in the rural zone.

4.1.3. Agriculture Production Structure.

Agriculture and fishery, also including aquaculture constitute an important source of income in the coastal area. There is also salt and shrimp production specifically concentrated in the departments of Usulután and La Unión.

The use of soil is divided into ravine bushes and unmanaged pastures occupying 39% of the area, followed by annual crops and slope pastures smaller than 10% which occupy 35.9% of the total area. Less important are dense forests (3.2%); and mangroves (8.3%), coconut plantations (0.7%), and an urban area that uses 1.2% of the surface.

In some zones, the main agricultural activities are: pasture, sugar cane, maize, sorghum, plantain, sesame seed, watermelon, rice and peanuts. These crops have been produced under the single crop and association practices. In other areas, the main farming activities at the end of the 80's and early 90's were: basic grains, sugar cane, cotton, sesame seed, melon and watermelon.

Subsistence livestock occupies 5.5% of the livestock area in the zone, but the double purpose exploitation and milk occupy 89% and 5.5% respectively.

4.1.4. Fishery.

The domestic maritime territory has an approximate area of 122 thousand km^2, reaching out to 200 sea miles. This area is 6 times larger than the continental territory, reason why the sea is a valuable resource which has not yet been exploited, but that nevertheless generates important income for the country with its share in the GDP generation and employment. The Salvadoran coastline is approximately 315 km long, with a platform area ranging from 0 and 500 m out of 20,510 km^2.

The total volume of sea fishery and aquaculture between 1980 and 1990 was significantly reduced, and in 1982 and 1983, the lowest fishery volumes were recorded for the period. On the other hand, it was observed that the share of the various fishery modalities have also suffered significant changes, since after 1985 the volume of primitive fishery exceeded industrial fishery, and aquaculture started to gain spaces during that same year, due to the production of projects that were started at the beginning of the decade.

The contribution of the fishery sector in GDP generation increased between 1980 and 1990 as a result of an increase in fishery volumes from 2.13% in 1980 to 4.95% in 1990, which is a twice as large in the studied period.

4.1.5. Environmental Degradation Dynamics.

The poor use of natural resources significantly contributes to environmental degradation, and the main problems related to this situation along the coastline are:

a. Deforestation and the lack of plant coverage, and the consequent loss of biodiversity, due to the expansion of cotton crops, coconut and sugar cane that almost eliminated all the forests in the lowlands along the coastline. Also, the excessive application of pesticides that were part of the cotton production in El Salvador which caused negative effects on people's health in the neighboring areas especially the estuaries.

   On the other hand, the production of basic grains has caused large contamination problems in the area under study due to the inadequate application of fertilizers and pesticides.

b. Erosion and the consequent loss of soils due to the runoffs in the highlands and lowlands of the basins that flow into the coastlines. This makes us think about the problems caused by the use and management of natural resources in the fragile slope areas.

c. The permanent cutting of trees in the mangroves is driving the mangrove population and other marine resources away from that habitat.

d. The salinization of soil due to the floods and the mismanagement of irrigation waters. Likewise, the cutting of the mangroves reduces the natural salt retention filters, causing the cultivated fields to be more salty every day.

4.1.6. Inter-annual Climate Variability.

Inter-Annual climatic variability is represented in the country by the presence and recurrence of droughts and floods. The effects of the droughts directly impact the low income populations. They usually strike after flood periods leaving no time to the productive sectors that cultivate small plots to recover from poverty. Nevertheless, the effects are felt in all the sectors, since they mainly attack the basic grain crops impacting both the price of the same as well as their trade and transportation.

An important feature of the country's drought is the existence of dry and hot periods during the rainy season, known as the "dog days". According to recent studies[10], the true danger of dog days for agriculture is not the lack of rainfall, but t the presence of more or less long dry periods, that exhaust the soil water reserves and affect crops at a time when they demand greater amounts of water.

With respect to floods, it has been observed that under extreme climatological events, when the water exceeds 200 mm/day throughout the national territory, 11 flooding areas can be identified in areas where the rivers flow, which have a concave shape with slopes lower than 1% of the river's flow length.

The total area subjected to floods in the area under study is 68.3% , with only 54,251 Ha. outside the risk of floods, and a large surface of the fertile soil cannot be exploited in less than seven years, which is the estimated period for the return of extreme rainfall events, with the consequent serious floods.

4.2. Climate Change Scenarios.

In general, the assumptions used to build climatic change scenarios[11] reflect a large range of uncertainties associated with this type of projections, which are reflected in the temperature increase ranging from 0.8 °C in the year 2020 up to 3.7 °C in the year 2100; and the rainfall variations in -11.3% the year 2020 and -36.6% and +11.1% in the year 2100.

Sea level rise climatic scenarios used here correspond to the global trend identified by the IPCC[12] through the scenarios IS92 a-f, where three possibilities were considered:

- An low/optimistic scenario (IS92-c) that considered that sea level could rise in 13 cm, under the basic hypothesis of low climate sensitiveness (T=1.5 °C), a low emissions scenario (IS92-c) and low melting parameters.

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[10] Molina, 1998.
[11] Centella et al 1998a.
[12] IPCC, 1995.

- An intermediate scenario (IS92-a) that foresees 49 cm of sea elevation (with spraying effects) and 55 cm (with constant sprays) based on an intermediate climate sustainability (T=2.5 °C), in an intermediate emission scenario (IS92-a) and intermediate melting parameters

- A high/pessimistic scenario (IS92-e) in which the rise of sea level ranges between 94 cm (with sprays) and 110 cm (with constant sprays). The hypothesis that sustains this scenario is the high climate sensitiveness (T= 4.5°C), a high emissions scenario (IS92-e) and the prevalence of high melting parameters.

4.3. Climate Change Impacts.

The vulnerability analysis of agricultural production along the coastline in face of a climatic change, implies the need for a damage assessment, understood as an economic, social or environmental loss or the level of disruption caused by said event.

4.3.1. Agricultural Production Losses due to Droughts.

The effects of droughts have been thoroughly studied in recent years in El Salvador, due to the worsening of the effects of the ENSO phenomena in the last decades, the coastline cannot escape this phenomena, causing reductions in agricultural production due to the droughts, since the climatic scenarios displayed the possibility that both temperatures and rainfall will change intensifying dog days.

Sensitization outcomes show that the magnitude of losses caused by droughts in the area under study, would mean in the case of corn between 3.1 and 7.5 million US$ in the years 2025 and 2100 respectively.

With regards to losses, it has been estimated that in the case of basic grains, these would be 10.9 million US$ in the year 2025, and would practically double in the year 2100 when the losses amount to a total of 24.9 million US$.

The trend scenario reflects losses increasing from 8.4 to 14.7 million US$ in the years 2025 and 2100, respectively. This suggest that the benefits of increasing productivity should go hand in hand with the cultivation of varieties resistant to droughts, or of a shorter harvest period in order to obtain a positive net increase.

Floods also affect livestock and fishery since they affect the production of pastures and cause stress to the animals. The combined effect of these two lead to production and productivity drops in this sub sector. Likewise, the increase in drought periods and the frequency of the same, as shown in the ENSO, brings negative consequences on fishery activities. The impacts of rainfall changes due the ENSO causes the species to migrate looking for deeper waters. This migration is translated in the volume of artisan fishery declining in approximately 16% and 23% in the case of shrimp for exports.

4.3.2. Losses in the Agricultural and Livestock Production caused by Floods.

The vulnerability of the coastline is also affected by floods, which cause greater losses than droughts. This indicates that a flood control program is needed, as well as the reordering of the territorial spaces in the country’s main watersheds.

Under a program scenario, where production would consider substantial enhancements in the yields of the main crops in the area, it is evident that if the erosion, sedimentation and runoff control practices are not promoted, production losses would reach 27.4 and 45.3 million US$ in the years 2025 and 2100, respectively.

Under the trend scenario, the situation would still be serious, since losses would be 21.1 and 26,8 million US$ in the years 2025 and 2100 respectively.

The identification of flood related production losses, indicates that to the extent that losses worsen, the productivity enhancements gained with better technologies in the farming sector are also lost. This is evident when comparing the losses in the programmed and trend scenarios, where the first ones are greater than the second.

The losses produced in other crops or farming activities such as sugar cane and livestock production should be added to the losses caused by the floods in basic grain cultivated plots. The study estimated that the floods in the Paz, Jiboa and Grande river basins in San Miguel, show the high vulnerability of these activities in the face of floods, since 60% loss levels are reported in average for sugar cane and 80% for pastures and livestock; the latter has more than 150 hectares along the coastline.

Both droughts and floods cause losses in livestock production, mainly due to the reduction in pastures, ranging from 25 and 100%, depending on the depth of the floods and their drainage periods, and also to the appearance of diseases in animals.

Floods also affect salt and shrimp production, strongly impacting continental fishery, since the shrimp ponds located along the coastline become contaminated with the sediments and the overflows of rivers.

4.3.3. Effects of the Sea Level Rise.

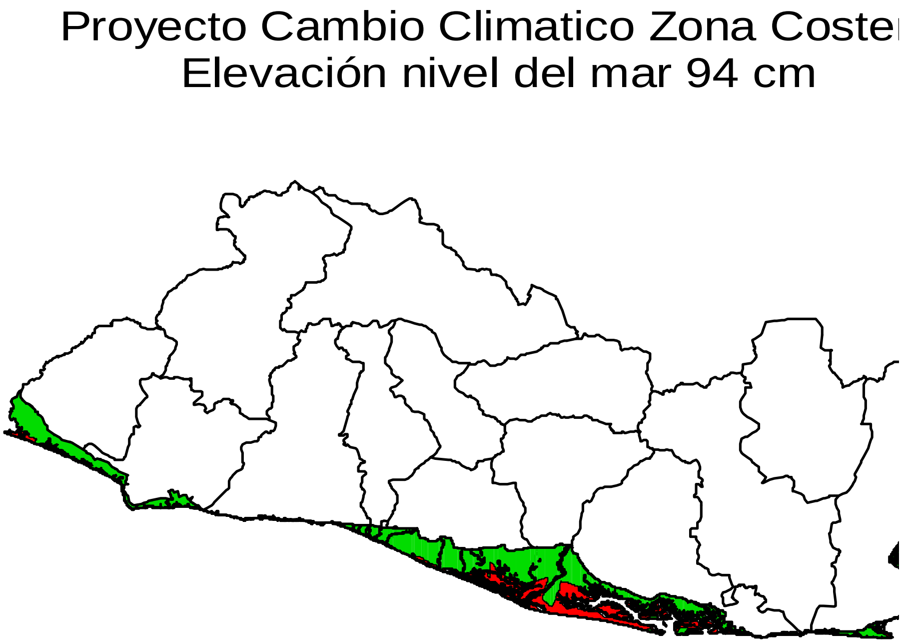
The probability of a rise in sea level would be the most negative effect along El Salvador's coastline, due to the loss of agriculture and livestock dedicated areas and also the areas with human settlements as well as the loss of infrastructure, such as bridges, roads, ports and airports.

According to calculations and considering global projections, the coastline will be exposed to an area loss in the next 100 years ranging from 10% of the total area (141 km2) under the optimistic scenario that considers 13 cm of sea level rise, up to 27.6% (400.7 km2) under a pessimistic scenario of 1.1 m rise in sea level.

The expected changes in the flooded areas show that the mangroves are the most affected areas, and therefore, that is necessary to carry out more profound studies on the vulnerabilityfo these areas and the effects to the environment and economic activities.

The rise of sea level would affect agriculture and livestock activities due to the loss of basic grain dedicated areas from 48.3 km2 in the optimistic scenario to 136.2 km2 in the extreme pesimistic scenario.

Coastline Climatec Change Project
94 cm Rise in Sea Level



The sea level rise should would also render these areas inadequate for sugar cane, pasture and shrimp production elevating the losses estimated in this study.

The possible rise in sea level would also bring negative consequences in salt and shrimp production, since these companies would not be able to work due to the flooding caused by the rise in sea level, with the consequent drop in production and GDP share. Likewise, the potential trend in the elevation of the sea level, represents a threat to the mangroves, which would also increase the salinity of the coastline reducing productivity and consequently the loss of muscles and crustaceans.

4.3.4. Disturbances and Losses in Natural Ecosystems.

The rise in sea level could cause an increase in coastline salinity. A strong impact on mangroves is foreseen, due to the inland displacement of the coastline. Mangroves would be exposed to greater levels of salinity and the structure of species would be modified with the displacement of said species due to the salinity tolerance levels. Nevertheless, the specific effects on the mangrove subsystem should be evaluated in a study directly on these ecosystems vulnerability.

The increase ground water salinity levels would reduce the harnessing of fresh water for farming activities, since there is an opposite relationship between soil salinity and the reduction in crop production.

The loss of bio-diversity is also a risk associated to climatic changes and the potential rise in sea level. The loss of bio-diversity would be evident with the extinction or reduction of several sea and continental animal and plant species.

To the extent that mangroves are exhausted due to tree cutting or floods, and the rise of the sea level, and the consequent contamination rise due to rainfall or sedimentation, the impacts on the coastline would worsen. Diminishing their economic potential.

Although the mangrove ecosystems can tolerate temperature variations, sedimentation and salinity, the coast line vulnerability would be threatened by the dramatic changes in the main basins of the country, where the trend and programmed scenarios show continuous erosion and deforestation, that only worsen in magnitude.

4.3.5. Loss of Infrastructure.

The impacts of climatic change will worsen if the sea level rises, since this will lead to the loss of irrigation channels, levies, drainages, barns, stables, fences, machinery and equipment schools, clinics and power networks, as ell as the salt and shrimp production areas.

Likewise, the rise in sea will bring serious consequences on ports, airports, airports, landing strips. Nevertheless, the scope of this study does not allow to quantify the economic impacts on these facilities.

Likewise, the rise in level would tend to reduce salt and shrimp production areas, in such a way that the penetration of water in acquiculture dedicated zones would reduce the production of shrimp and salt. .

4.3.6. Loss of Property and Lives in Human Settlements.

The impacts of climatic change are not only manifested in the loss of goods and human lives, but also in the increase in health costs and the control or eradication of vectors.

In accordance with the social and economic scenarios[13], although the percentage of the population that will live in the 33 municipalities along the coast will not vary in the long term, the absolute population value will significantly increase. To the extent that the total population along the coastline tends to increase, the risks of a potential rise in sea level worsen, since there is the possibility that urban and sub urban areas could be reduced.

4.3.7. The Decline in Jobs Generation.

Climate changes will bring unemployment due to the reduction in production in areas with tourist and recreation potential. The drought and the potential rise in sea level would cut the labor in the area.

An average cut in employment of 1.75 million days/person is expected in the coastline farming areas, equivalent to 61.1 million colones (US$ 7 million) that would not be paid, thus stressing poverty.

The impact would worsen if the sea level rises, since useful areas with agriculture potential would be lost, reducing job generation in 483 thousand/days/person under the optimistic scenario and 965 thousand in the intermediate scenario and 1.4 million under the pessimistic scenarios assumptions.

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[13] Umaña, 1998.

Agriculture labor reduction would lead to the amount of 16.9 million colones (US$ 1.9 million); 28.9 million colones (US$ 3.3 million) and 40.9 million colones (US$ 4.7 million) in unpaid salaries under the optimistic, intermediate and pessimistic scenario respectively.

The reduction in fishery activities would also affect employment. Based on the ENSO Report regarding the reduction in reported fishery levels (16% in artisan fishery and 23% in industrial fishery) and if this decline percentage is equated to labor, there would be a reduction of 736 days / person in artisan fishery and 144 days person per year in industrial fishery.

In economic terms, this implies a drop in salary payments equivalent to 28.6 millioncolones (US$ 3.3 million), out of which 77% would not be generated artisan fishery and 23% from industrial fishery.

5. Climate Change Impacts Assessment on Food Security.

The same as with the other agricultural and livestock activities, basic grain production has reduced its percentage share in the GDP in the last years. Nevertheless, this sub sector continues having a strategic importance not only for the farming sector, but also for the global Salvadoran economy, due to the importance of basic grains in the basic food basket of the population and the fact that small farmers produce the same, and that said sub sector is the main source of income and self consumption for an important part of the country's rural population.

At the conceptual meaning, food security is "the status by which people enjoy the timely, physical, economical and social access to the food they need with the quality and quantity expected, for their consumption and biological use, guaranteeing a general condition of welfare that will lead to their development". Therefore the availability, access and biological use of food is indispensable to achieve food security".

5.1. Food Security in El Salvador: Baseline (1989-1999).

During the 1989-1999 period and in accordance with the basic grain analysis made by the Ministry of Agriculture of El Salvador, there are approximately 240,266 basic grain producers (not counting the Land Reform, Phase I Cooperatives), with a population of approximately 1,441,600 persons[14], out of which 36% are under extreme poverty and 41% under the poverty level. The same source reports that 76.3% of said producers work in plots smaller than 5 "manzanas", with limited or no access to credit, scarce technical assistance, marginal soils and low storage capacity, which increases their vulnerability to post harvest losses and price fluctuations.

Regarding the area dedicated to basic grain cultivation, more than 75% of agricultural exploitations dedicated to basic grains are concentrated in plots smaller than 5 "manzanas". Maize absorbs 26.4% of the total land dedicated to basic grains, and Sorghum 12.1%, Beans 5.8% and rice 1.5%.

[14] Assuming six members per family.

The CADESCO study (1991) offers a similar figure, estimating the total number of basic grain producers in 244,000 of which 23.5% only produce for self consumption.

Regarding the effects of climate on basic grain production, several studies have been carried out due to the presence of the ENSO phenomena, with different consequences on production. According to the "Coyuntura[15]" Report" the historical negative impact on basic grain production is quite meaningful. During a drought, the average drop in yields is 14% in white corn, 9% in sorghum, 13% in rice and 8% in beans when compared to normal years. Additionally, abnormal rainfall like the one occurring with the ENSO, cause losses in beans, with an average reduction of 23% in white corn yields, 15% in sorghum , 25% in rice and 13% in beans.

Climatic variables under this study were analyzed by the FAO[16], which reports the existence of a strong relationship between basic grain production, and all the crops and temperature conditions, and rainfall availability and distribution.

5.1.1. Production.

Climatic variability has historically affected basic grain production, reducing physical yields. The ENSO caused considerable damage in 1986/1987, 1987/1988 and 1991/1992; since the production expectations were not fulfilled. This phenomena has directly affected the rainfall pattern regime, the transition from the dry to the rainy season, prolonging the dry season, thus impacting all agricultural line items.

With regards to basic grain production in the 1961 and 1995 periods in the country, corn shows the most significant variations, since although the general trend was towards an increase in production, three sharp drops were observed. Beans and rice show a different trend presenting a significant drop in 1987, which caused a strong reduction in the annual production average. Rice and bean crops showed little variations in production, which explains why the period shows sustained increases in total production.

5.1.2. Cultivated Area.

Regarding the basic grain cultivated area, it can be observed that in the early 80;s the total cultivated area was reduced. After the 1982/83 harvest, the general trend has been to increase, specially after the 1990/91 period, when the cultivated area increased thanks to the end of the war.

To establish the reference line in this study, the analysis outcomes of the areas deemed optimum to cultivate the main basic grains consumed by Salvadorans are presented, based on temperature, altitude, the absence of dog days and rainfall..

Chart 1.20: Optimum areas to cultivate basic grains

Crop	Altitude (msnm)	Temperature (ºC)	Rainfall (mm)	Km_2
Maize	0 – 600	18 - 30	600 – 1,200	5,346.43
Beans	400 -700	15 - 27	500 – 2,000	4,718.89
Rice	100 - 600	25 - 35	1,500 – 2,000	5,632.91

Source: Estimates based on the CENTA- FAO Project data.

[15] OAPA, MAG, 1998
[16] ECOCROP.

5.1.3. Yields.

Basic grain cultivation yields show a trend similar to beans, whose trajectory has declined during the second sub period, and increased during the third. Opposite to this, maize and rice show the contrary, that is, productivity increases between 1984/89 and drops in the 90/95 period, not fulfilling their yield expectations.

These reductions in productivity levels are influenced by at least two factors: a) the cost increase of production inputs, which leads to a reduction in the use of the same: b) Greater input requirements due to soil impoverishment and c) sales price reductions, discentivising production.

5.1.4. Food Availability

El Salvador has great unbalances and challenges to insure the adequate, timely and sufficient availability of food, part of the basic diet of the poor and specifically of the most vulnerable groups (children under five years of age), pregnant women and lactating mothers, as well as of groups at risk such as school children, women, teenagers, and the elderly.

Food insecurity is analyzed in terms of availability, access and biological use of food, as well as its incidence in the population's nutritional status, particularly of those under or at relative poverty levels.

Maize, rice and beans are the population's basic diet, and are therefore the main source of proteins and calories, contributing in more than 50% to the daily caloric intake per capita, specially in the rural area. Sorghum is consumed in certain areas of the country as part of the family diet.

Maize and beans are mainly produced by small farmers, under the framework of a subsistence economy, whose priority is to cover the food needs of the family group and generate certain income with surpluses to cover other family needs. In general, small farmers produce on marginal lands with very little access to technology and low yields and low profitability levels. They produce the maize and beans required by the urban population of the country.

The relationship between availability and demand, measured in production terms and established based on the basic basket, calculates the food gap for the crops part of the study.

Chart 5.21: Per capita requirements (1981-1995)

Crop	Daily per capita caloric intake requirements
Maize	307.35 g/person/day
Beans	44.77 g/person/day
Rice	31.73 g/person/day

Rice has historically shown a deficit trend, with a growing food gap in the last years; but at the same time a high level of food dependency is also observed, much higher for Maize y Beans.

The food gap (need vs. availability) for basic grains shows sharp fluctuations in the last years: in 1985 it amounted to 75.1 thousands MT; in 1991, 0.2 MT, while it reached 195.7 thousands MT in 1995.

Domestic food availability does not guarantee food security in the homes of the population, since consumption is strongly conditioned by income levels and access to food products. The last consumption survey[17] reveals that generally speaking the diet is lacking energy, proteins, iron, folates, iodine and vitamin A, in the metropolitan, urban and rural, which reflects the little variation in food consumption and the limited access of the population, since Maize and Beans are the main diet components.

5.1.5. Import and Exports Trend.

Basic grain exports in El Salvador do not influence global demand; nevertheless this could change with the drop in tariffs and the prevailing Central American prices.

Production scarcity has been covered by imports, which in no way means that the per capita needs included in the basic basket are being satisfied

Although total production levels are directly related to the cultivated area and productivity, the latter is conditioned to soil quality and technology. Therefore, if we consider that basic grain production in El Salvador is attributed to small farmers that plant on slopy areas, production increases are determined by the increase in cultivated area[18].

5.1.6. Income and Employment.

El Salvador has been included among the countries with an intermediate income thanks to the growth in economy that brought about a per capita income in 1994 around US$1,440. Nevertheless, as far as the reduction of extreme poverty is concerned, and the enhancement of the quality of life of the population, particularly in the rural areas shows an important gap between the urban and rural per capita income.

Urban per capita incomes represented US$ 2,200 a year, while in the rural area these incomes only amount to US$500. The majority of the rural area populations cannot access the basic basket with this income, since in 1995 it amounted to US$ 1,100 in the rural area. In the urban area it reaches US$ 1,512; nevertheless the minimum urban salaries represent US$ 1,550, which indicates that the majority will have to be earmarked to the acquisition of food.

This situation shows that the majority of the rural and urban populations are at risk for food insecurity. As was seen, the average income in the rural sector cannot cover food demand, while the average urban income is earmarked to satisfy food demand in 90%. Therefore, it is a matter of chronic and structural food insecurity.

5.1.7. Poverty and Food Insecurity.

There are two ways to estimate poverty levels. The Poverty Line (PL), which identifies the number of poor contrasting the income level with the price of the basic basket, and the Unsatisfied Basic Needs (UBN) that deems that the homes who do not satisfy the need for housing, basic services, school for children under 7 and 12 years and the level of crowdedness, as a minimum, are poor.

[17] ESANES,1988.
[18] Lindarte, E. and Benito.

Extreme Poverty estimates in El Salvador are generally based on the price of the basic basket and relative poverty is based on the expanded basket, which is twice the size of the basic food basket. With this methodology, the Multiple Purpose Household Survey (Encuesta de Hogares y Propósitos Múltiples) of 1992 and 1994 shows the following information:

During the period between both surveys the number of poor families increased in El Salvador (from 48.2% to 52.4%) with a two fold increase in extreme poverty in the rural (from 14.3% to 34.8%)[19]. It is not surprising that poverty in El Salvador is mainly rural poverty, given the production conditions and markets prevailing in the hands of small producers and landless farmers.

Less than the fourth part of the population of El Salvador and more than one third of the rural population do not have the income level necessary to cover food demand, reason why food insecurity and poverty have augmented during the period under analysis, mainly affecting the female population.

It is not probable that the food gap will narrow based on domestic production, either because the food production growth rate does not increase at the same rate of population growth or because of the low availability of soils adequate for basic grain production. Nevertheless, this food deficit has not been so high thanks to imports.

5.2. Scenarios without Climate Change or Baseline Scenarios.

5.2.1. Programmed Scenario without Climate Change.

Information has been projected to the years 2020, 2050, and 2100 based on the data on climatology, cultivated areas, production and basic grain yields corresponding to the reference line. This situation represents a programmed scenario, since the growth trends have not reached the acceptable technology limits regarding yields and the increase in cultivated areas estimated by the FAO, which is 1% up to the year 2020 and constant after that.

Chart 5.22: Projections of Areas Cultivated with Basic Grains (1995-2100)

Year	Corn (Ha)	Beans (Ha)	Rice (Ha)
1995	294,056	60,420	11,538
2000	309,056	63,502	12,127
2005	324,824	66,741	12,745
2010	341,390	70,146	13,395
2015	358,804	73,724	14,079
2020	377,107	77,485	14,797
2025	377,107	77,825	14797
2050	377,107	77,485	14,797
2100	377,107	77,485	14,797

Source: Projections based on DGEA data and FAO estimates.

[19] MIPLAN.

Chart 5.23: Basic grains Programmed Scenario (2000-2100)			
Hundred weights/Ha for the period	Maize	Beans	Rice
2000	45.8	17.9	69.8
2010	48.4	18.4	78.9
2020	50.6	18.9	87.9
2025	51.6	19.1	92.5
2030	52.5	19.2	97.0
2040	54.3	19.6	106.0
2050	55.9	19.9	115.1
2060	57.3	20.1	124.2
2070	58.7	20.4	133.2
2080	59.9	20.6	142.3
2090	61.1	20.8	151.3
2100	62.3	21.0	160.4

Source. Merino, 1999: prepared based on trends.

Chart 5.24: Projections on Basic Grain Production , Programmed Scenario without Climatic Change (thousands de qq/thousands de TM)			
Year	Maize	Beans	Rice
2000	14,154 / 643	1,136 / 51	846 / 38
2020	19,075 / 866	1,461 / 66	1,301 / 59
2025	19,459/ 884	1,488/ 67	1,369/ 62
2050	21,067 / 957	1,540 / 70	1,703 / 77
2100	23,475 / 1,066	1,631 / 74	2373 / 108

Source. Merino, 1999. Corrections , Aguilar, 1999: Based on yields and areas cultivated.

With regards to the population a programmed social and economic scenario was used[20], which states the reduction in the growth rate, reaching a zero approximately by the year 2100.

Chart 5.25: Population projections. Programed Scenario.		
Year	Growth rate	Population (Thousands)
2020	1.1	8,580
2025	0.83	9,062
2050	0.14	11,155
2100	0.0	11,938

Source. Umaña, 1998. Corrections, Aguilar, 1999.

Based on food availability and population projections, the need for basic grains as it related to expected consumption was estimated. Individual requirements were used as the reference point, which are 307.35 g/person per day for maize, 44.77 g/person per day for beans and 31.73 g/person per day for rice.

Chart 5.26: Demand Estimates for Basic Grains Programmed Scenario without Climatic Change				
Year	Population (thousands)	Beans (thousands TM)	Rice (thousands TM)	Corn (thousands TM)
2020	8,580	140.0	99.4	962.5
2025	9,062	147.9	105.0	1,016.6
2050	11,155	182.0	129.2	1,251.4
2100	11,938	194.8	138.3	1,339.2

Source: Merino 1999: Based on Basic Basket Consumption Data 1991.

[20] Umaña, 1998.

The comparison between the supply and demand of grains allows to appreciate that the food gap between production and needs for each one of the basic grains, reflects a deficit which is larger for maize and lower for rice; nevertheless, if the external availability is good this gap can be narrowed through imports, assuming that the country has enough Net International Reserves NIR).

Chart 5.27: Status of the basic grain food gap (thousand MT) Prograammed Scenario without Climatic Change			
Year	Beans	Rice	Maize
2020	-74	-40.4	-96.5
2025	-80.9	-43	-132.6
2050	-112	-52.2	-294.4
2100	-120.8	-30.3	-273.2

Source: Merino, 1999.

5.2.2. Trend Scenario without Climate Change.

This trend scenario has been carried out by using the utilized cultivated land in the programmed scenario. Yields were calculated taking 30% less than expected, with the consequent reduction effect in projected production for the years 2020, 2025, 2050 and 2100. Grain demand is based on the rate of growth of the population according to the trend scenario shown in the Study of Social and economic Scenarios.[21].

Chart 5.28 Projections for basic grains production (thousand qq/thousand MT)			
Year	Beans	Rice	Maize
2020	13,357/605.8	1,022/46.3	910/41.3
2025	13,614/ 618.8	1,032.9/ 46.9	957.4/ 43.5
2050	14,756/669.2	1,077/48.8	1,567/71.1
2100	16,445/745.8	1,139/51.7	1,661/75.3

Source: Merino, 1999: Based on yields and cultivated areas.

Chart 5.29: Status of the basic grain food gap (thousands MT) Trend Scenario without Climatic Change			
Year	Beans	Rice	Maize
2000	-100.6	-63	-396.2
2020	-111.8	-69.1	-472.3
2050	-168.9	-83.5	-827.9
2100	-259.1	-145.3	-1,391.1

Source: Merino, 1999.

When analyzing the trend Scenario, where population increase prevails over the estimates of the programmed Scenario, and with a reduction in 30% in food production, we have a food gap with a growing trend up to alarming levels, with corn at the highest deficit levels. This situation renders the country totally dependent on imports, unless local production substitutes are found for basic grains, which still seems very remote.

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[21] Umaña, 1998.

Although the greatest deficit is found in cereals, when we evaluate the protein levels we see that Beans have 22% of this nutrient, and merits special attention since it supplements the aminoacids deficit of Maize. No other protein sources are available to the low income populations according to the current food consumption habits of the population.

5.3. Scenarios with Climate Change.

5.3.1. Regional Impact.

Climate variations and the effects on food security have become the subject of many research efforts; given the growth in population it is necessary to identify future trends with regards to food availability. According to global studies[22] an average temperature increase of 0.2°C every decade is expected which could alter plant growth due to temperature and rainfall variations and nutrient sequestration potential. Climate variations may generate extreme climatic events, such as the warming of high latitudes, progression of Rainfall from the monzón to the Pole and less underground water availability.

Impacts could vary depending on the type of crop, and temperature rise could reduce cultivation lands, due to the shortening in crop development time; Likewise, the amount of soil humidity could be affected regardless of the changes in rainfall. Higher temperatures would favor the evaporation increase, and therefore reduce the level of humidity necessary for plants to grow. Water availability affects plant growth, since any increase or reduction in the amount of rainfall can seriously affect production.

There is general consensus on the fact that a 1°C warming, without changes in rainfall, would reduce maize crops in 5%, but that a combined increase in temperature of 2°C and rainfall drop reduces the average production in 20%[23].

Other researches report that grain production areas potentially affected by global warming and drought, could reduce harvests in 10 to 20%, without considering potential production losses due to poor soil quality and cropping on inappropriate lands.

5.3.2. National Impact.

5.3.2.1. Climatic Changes.

The outcomes of the climatic change Scenarios[24] show a broad range of uncertainties associated with these types of projections, which are reflected in the temperature increases from 0.8 °C in the year 2020 to 3.7 °C in the year 2100; and rainfall variations from -11.3% in the year 2020 to -36.6% and +11.1% in the year 2100. Within the framework of this study the climatic change Scenarios used are shown in the following chart:

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[22] Echecatl, 1996ª and 1996b.
[23] Echecatl, 1996b.

[24] Centella et al 1998a.

Chart 5.30 Temperature and Rainfall. Years 2020 y 2100				
Variable	Scenario 1		Scenario 2	
	2020	2100	2020	2100
Temperature °C	+ 1.1 °C	+3.5 °C	+1.1 °C	+3.5 °C
Rainfall (mm)	- 11.3%	- 36.6%	+ 3.5 %	+11.1 %

Source: Centella, et al 1998a.

5.3.2.2. Productivity Changes.

Literature regarding the response of the various crops to temperature and rainfall changes is scarce in El Salvador. These studies are based on the incidence of dry periods during the rainy season, dog days, since during these periods a marked reduction in rainfall together with an increase in average temperature is evident. Damage quantification as a result of drought has only been recorded for severe drought but not for moderate or weak droughts[25].

Chart 5.31 Basin Grain Estimated Losses under dog days conditions (%)				
Year	Maize	Beans	Sorghum	Rice
1972	57.5	27.3	42.2	56.1
1976	32.8	15.6	25.0	15.7
1987	3.6	83.8	56.8	18.0
1991	20.3	20.8	1.5	15.2
1994	32.0	10.0	30.	14.0
1997	24.1	4.2	0.0	16.3

Source: Romano, 1997

The above chart suggests the idea of an average loss during the 1972-1997 period equivalent to 28% for Maize, 27% for Beans, 31% for Sorghum, and 22% for Rice.

5.3.2.3. Food Demand.

The social and economic Scenarios[26], for the programmed Scenario shows that population would increase in 50% in the year 2020 as compared to 1995, doubling in the year 2100, which leads to an equal increase in food demand.

Chart 5.32 Food Gap under the Programmed and Baseline Trend Scenarios without Climate Change for the years 2020 and 2100. (thousand MT)						
Period	Programmed Scenario			Trend Scenario		
	Maize	Beans	Rice	Maize	Beans	Rice
Year 2020	-96.5	-74	-40.4	-472.3	-111.8	-69.1
Year 2100	-273.2	-120.8	-30.3	-1,391.1	-259.1	-145.3

Source: Charts 5.27 y 5.29.

This increment in food under the described scenarios would cause an unsatisfied demand, only worsened by the lower yields caused by climatic change variables.

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25 Romano, 1997.
26 Umaña, 1998.

5.3.2.4. Food Supply.

Food supply is determined by the total production obtained domestically and imports when the demand exceeds domestic supply. Domestic supply trend, even without climatic change , lead to serious problems to guarantee the nutrition of the country's population, situation that is worsened by the potential fall in domestic supply when temperature and rainfall variables change.

A. Area with Production Potential.

In accordance with FAO's publication on rainfall and temperature [27], the areas with basic grain potential will follow the trend shown on Chart 5.33. This chart shows that only climatic change Scenario No.1 maize will present a serious limitations regarding cultivation areas, in such a way that total production would be affected by a cultivation area reduction as well as by the drop in yields.

Chart 5.33: Area with Basic Grain Production Potential under Climatic Change Conditions (thousand ha)

Crop	Climate Scenario 1		Climate Scenario 2	
	2020	2100	2020	2100
Maize				
Potential	1,419.5	264.0	1,494.0	816.1
Projected	377.1	377.1	337.1	377.1
Beans				
Potential	2,046.1	1,443.4	1,504.1	552.7
Projected	77.5	77.5	77.5	77.5
Rice				
Potential	600.5	46.0	485.2	816.1
Projected	14.8	14.8	14.8	14.8

Source: Land Data System. CENTA-FAO-Holland Project , 1999: Scenarios with climatic change for the years 2020-2100 for basic grains and coffee.

B. Domestic Supply with Yield Reduction.

Given the diversity of outcomes regarding changes in basic grain production modifications in face of climatic variations, the calculation of available demand was made considering:

Chart 5.34: Estimated losses of basic grains (%)

Cultivo	2020	2100
Maize	20	30
Beans	20	26
Rice	20	25

Source: Merino, 1999: own calculations based on Romano, 1998.

Chart 5.35: Food Yield Projection for the year 2020. (qq/ha)

Crop	Reference Scenario		Climatic Change Scenario	
	Programmed	Trend	Programmed	Trend
Maize	50.6	35.4	40.5	28.3
Beans	18.9	13.2	15.1	10.6
Rice	87.9	61.5	70.3	49.2

Source: Merino, 1999: calculated based on Chart 5.34.

[27] Ecocrop 2.

Chart 5.36: Food Yield Projections for the year 2100. (qq/ha)				
Crop	Reference Scenario		Climatic Change Scenario	
	Programmed	Trend	Programmed	Trend
Maize	62.3	43.6	43.6	30.5
Beans	21.0	14.7	15.5	10.9
Rice	160.4	112.3	120.3	84.2

Source: Merino, 1999: calculated based on Chart5.34.

Chart 5.37: Food Supply for the years 2020 y 2100 under Climatic Change Conditions (thousand MT) with yield reduction					
Crop	Area (ha)	Food Supply 2020		Food Supply 2100	
		Programmed	Trend	Programmed	Trend
Maize*	264,000	485.9	339.6	523	365.9
Beans	77,485	53.2	37.3	54.5	38.3
Rice	14,794	47.3	33	80.8	56.6

Source: : Merino, 1999.

(*)Estimated according to Chart5.33 that the potential area of maize production will drop to 264 thousand ha. by the year 2100.

C. Domestic Supply with Production Increase.

Considering an increase in production of 10% for all crops, the results shown on Chart5.38, were obtained, which affect yields of the reference line for both the trend scenario and the programmed scenario. The 10% increase was taken from various domestic and international studies on this topic.

Chart 5.38: Food Yield Projections for the year 2020 Under Climate Change Conditions (qq/ha)				
Crop	Baseline Scenario		Climate Change Scenario	
	Programmed	Trend	Programmed	Trend
Maize	50.6	35.4	55.7	38.9
Beans	18.9	13.2	20.8	14.5
Rice	87.9	61.5	96.7	67.7

Source: Merino, 1999.

Chart 5.39: Food Yield Projections for the year 2100. Under Climate Change conditions (qq/ha)				
Crop	Baseline Scenario		Climate Change Scenario	
	Programmed	Trend	Programmed	Trend
Maize	62.3	43.6	68.5	48.0
Beans	21.0	14.7	23.1	16.2
Rice	160.4	112.3	176.4	123.5

Source: Merino, 1999: Calculated based on Chart 5.34.

Chart 5.40: Food Supply for the years 2020 and 2100 under Climatic Change conditions (thousand MT) with yield increase.					
Crop	Area (has)	Food Supply 2020		Food Supply 2100	
		Programmed	Trend	Programmed	Trend
Maize*	264,000	668.3	466.8	821.9	575.9
Beans	77,485	73.3	51.1	81.4	57.1
Rice	14,794	65.0	45.5	118.6	82.9

Source: Merino, 1999.

*Estimated according to Chart 5.33 that the potential area for maize would drop to 264 thousand ha. by the year 2100

5.3.2.5. Food Gap.

Food gap has been determined by the unsatisfied demand required to provide the population with the satisfaction of their food needs.

Chart 5.41 show the outcomes of food supply under the climatic Scenario that reduces basic grain production. The analysis of this Chart allows to identify serious food supply problems, worsened under the reference situation..

Chart 5.41 The Food Gap for the years 2020 and 2100 with Productivity Reduction Under Climate Change conditions (thousand MT)				
Crop	Programmed Scenario		Trend Scenario	
	2020	2100	2020	2100
Maize	-476.6	-816.2	-622.9	-973.3
Beans	-86.8	-140.3	-102.7	-156.5
Rice	-52.1	-57.5	-66.4	-81.7

Source: Merino, 1999. Calculations based on charts 5.34, 5.35, 5.36 y 5.37.

Chart 5.42 Food Gap for the years 2020 and 2100 with Productivity Increase Under Climate Change conditions (thousand MT)				
Crop	Programmed Scenario		Trned Scenario	
	2020	2100	2020	2100
Maize	-294.2	-517.3	-495.7	-763.3
Beans	-66.7	-113.4	-88.9	-137.7
Rice	-34.4	-19.7	-53.9	-55.4

Source: Merino, 1999: Calculations based on charts 5.38, 5.39 y 5.40.

Based on calculations, the food gap improves under the productivity increase situation , but will show a maintenance trend for the next 100 years if adaptation measures are not implemented to allow, among other things, to reduce the losses due to climatic change, and the change in the techniques used to manage crops.

5.3.2.6. Social Consequences.

Crop productivity changes as a consequence of climatic change, affect health and nutrition, education and poverty levels . To the extent that basic grain productivity levels drop, there will be a significant drop in employment and a price increase which worsens poverty levels and the non satisfaction of basic needs. Negative changes in the diet strongly affect mortality, morbidity and people's life expectancy.

5.3.2.7. Economic Consequences.

Given the fact that basic grains are an important part of the GDP, any change in grain production will directly affect the GDP behavior in that sector. Also given the fact that the cultivation and labor in basic grain production is mainly a family business, the greatest effect of climatic change would not be on rural employment but rather on rural family income and food security. The end result of this phenomena would be the depletion of the consumers purchase power.

Based on the above, it is possible to deduce that climatic change will also modify the inflation index, since food is one of the main components to calculate the Consumer Price Index (CPI) To this respect, the studies carried out [28] indicate that during the drought years unusual increases in food prices have occurred, in such a way that it is possible to establish a relationship between drought and inflation. After the drought in 1972, maize consumer prices increased in 50%, bean prices in 50%, and rice in 20%. So actual salaries, which are nominal salaries adjusted by the IPC, resent the occurrence of droughts to the extent that a sharp reduction is observed in the last years..

If we take food price projections as a reference for the year 2020[29], equivalent to US$87 per ton of maize, and of US$ 190 per rice ton, and considering the food gaps previously calculated, an increase would be expected in the value of imports like the ones shown in Chart 5.43.

Chart 5.43
Currency Needs to Import Maize and Rice. Year 2020. (thousand US $)

Scenario	Maize		Rice	
	Programmed	Trend	Programmed	Trend
Reference (without climatic change)	8,396	41,090	7,676	13,129
Under Climatic Change Conditions:				
Yield Increase	25,595	43,126	6,536	10,241
Yield Drop	41,464	54,192	9,899	12,616

Source: Merino, 1999. Correction Aguilar, 1999: prepared based on the food gap. Tejo, 1996.

5.3.3. Adaptation Measures.

In face of the studied scenarios it could be expected that social adjustment mechanisms would exist with regards to basic grains, such as: migrations conditioned by peasant economic crisis, and the increase of the cultivated area to compensate losses caused by the negative effects of climate.

Besides the above mentioned adjustments, which could take place unplanned and cause other problems, the following adaptation measures could be implemented:

[28] Romano, 1997.
[29] Tejo, 1996.

a. Generation of new varieties resistant to pests and diseases, tolerant of droughts and salinity. Genetic Engineering can contribute to improve the productive potential and desirable features of the varieties to be cultivated.

b. Cultivation of different varieties. This activity should be thrusted by technology transfer programs to disseminate the varieties with greater capacity to resist the negative effects of climatic change.

c. Improvement of water supply and irrigation systems to reduce seasonability of production and to face the loss of humidity of soil.

d. Incorporation of soil plant coverage to keep it humid and face hydric erosion.

e. Development of detection systems and early alert detection of climatic disturbances, for which meteorological forecast technology and equipment is necessary. This would not only thrust measures to make slow adaptations and safe the lives and property of the population in the event of drastic changes in climatological conditions

f. Updating of harvest forecasts, using the GIS. The use of this methodology should be included in agricultural planning and the orientation to farmers, to make the activity more efficient.

g. Promote food surveillance systems that will allow to adequately respond to the population's supply needs and to help guarantee the market for producers.

h. Promotion of investments in farming and the development of activities after production, as well as the support to research, infrastructure and services. .

i. Promotion of insurance and reinsurance market operations to compensate for losses due to natural disasters. This measure should be driven not only at the national level but also at Central American and the Caribbean to establish regional reassurance "pools" operated by international companies with sufficient capacity to provide capital to cover significant costs in the event of natural disasters.

j. Promote scientific research and technology development, creating and strengthening the entities involved in food production.

k. Establishment of economic policy measures to promote the investment in basic grain production, and create mechanisms to increase technical and financial assistance for farmers.

l. Development of sustainable agriculture practices, supported on ecology and the preservation of biodiversity and natural resources.

m. Foster farming zoning programs for the better use of soil to adjust cultivation times with climate forecasts. And simultaneously promote the use of varieties more resistant to negative climatic conditions and in harmony with the environment.

n. Given the fact that basic grains constitute the pillar for food and nutrition security of the population, the institutional development of those entities that promote human development should be strengthened, focused on food security.

The promotion of these measures, as well as others that help to adapt to the negative effects of climatic change, should be supported by global and sector policies coherent with the country's development programs and plans.

6. Adaptation Projects.

Within the framework of USAID's assistance to El Salvador to face the damages caused by Hurricane Mitch, the Agency assigned supplementary funds amounting to US$4,000,000 for the execution of a tri national project on the sustainable management of the shared Lempa River watershed (Guatemala, Honduras y El Salvador). Likewise, NOAA and USGS have contributed AID funds to that project, which will be executed by these two entities and the SICA, with the participation of CRRH, CEPREDENAC and CCAD.

The purpose of the project is to improve the regional capacity to mitigate the effects of disasters, specifically in the tri national management of the Lempa river basin. The expected outcomes of this project are:

a. The establishment of an institutional framework for the sustainable tri national water management:

   Tri national agreements for the management of shared watersheds would be expected, either between governmental entities, private or mixed.

b. Institutional arrangements for an effective water management:

- A shared data network among the three countries on the institutional management of the basin will be designed so that the designated institutions may exchange information on watershed management and systematic disaster mitigation.
- Inter-institutional agreements would be signed for the systematic exchange of information.

c. Development of a plan for the sustainable management of the Lempa watershed, and to mitigate disasters:

- Preparation of a basin sustainable management plan, as a bases for the signing of tri-national agreements.
- Preparation of response plans in face of disasters, at the municipal level, based on the risk analysis of selected communities.

d. Establishment of a data system and procedures for decision making.

- Development of a data base. Generation of critical information and computerized models for watershed management and disaster mitigation.
- Design of a monitoring system and procedures for basin management and disaster mitigation. Development of a GIS to manage the basin.
- Installation of automated meteorological stations, with telemetric connections and the establishment of a forecast center, management of a hydrological model, the purchase of equipment to process data and training to use it