Global Water Partnership Central America

CIRA UNAN MANAGUA

# Experiences in climate change adaptation and vulnerability reduction in the water sector: The Case of the Moyúa, Playitas and Tecomapa Wetlands in Nicaragua

Salvador Montenegro Guillén, Founding Director, Nicaragua Center for Aquatic Resource Research (CIRA) of the National Autonomous University of Nicaragua, Managua,
03/26/2012

Experiences in climate change adaptation and vulnerability reduction in the water sector: The Case of the Moyúa, Playitas and Tecomapa Wetlands in Nicaragua

# INDEX

## 1. - Summary

Climate projections and registered observations provide abundant evidence that freshwater resources are vulnerable and can be seriously impacted by climate change, with a range of consequences for human societies and ecosystems (IPCC, 2008).

In the document *Situation of Water Resources in Central America* (GWP, 2011), GWP Central America quotes the Center for the Coordination of Natural Disaster Prevention in Central America (CEPREDENAC), which mentions that Central America is "one of the most vulnerable regions to the impacts of climate change"..."with 123 hydrometeorological events occurring between 2000-2009, that resulted in the deaths of 2,950 people, 5,846,945 peopleaffected and US$ 32,725 million in damages".

The effects of climate change and variability are felt more in countries that historically have less responsibility for contributing to these phenomena. Meteorological phenomena like El Niño and La Niña manifest themselves in the form of droughts or recurring floods that affect food harvests, as well as storms and hurricanes that produce economic and social havoc. This is a clear expression of climate variability and the global changes that severely impact the national economy, environment, agriculture, and food security. The fourth report from the International Panel on Climate Change (IPCC 2007a), stresses that climate change impacts in Latin America will result in an increased frequency of extreme climatological events with strong rains or extreme temperatures.

Water is the primary medium through which climate change effects will be felt by people, ecosystems and economies. As a result, water resource management should be a preventative focus for climate change adaptation (GWP, 2010). In other words, the best way to adapt to climate change is through good water resource management.

Climate change adaptation consists of creating the conditions to resist to thenegative impacts on populations and in terrestrial and aquatic ecosystems (Government of Nicaragua, 2010).

The region's socioeconomic and environmental vulnerability is connected to a long-term development model whose characteristics include: poverty for approximately half the population; socioeconomic, ethnic and gender inequality; limited access to food and drinkingwater; lack of coverage and quality in health services, education, and social safety nets; lack of access to productive capital and credit; and the economic dependence on a limited number of sectors, export products and export countries (ECLAC2010). Climate change will affect all society strata and the environment with strong repercussions in water and agriculture, today and in the future (International Institute for Water Management and FAO, 2008).

Nicaragua receives on average 2,391mm/year of rainfall, equivalent to 311.7km$^3$/year. Infiltrated groundwater is estimated at 59km$^3$/year, and the total volume of produced surface water is185.7km$^3$/year (AQUASTATFAO 2011).As a result, the water wealth per Nicaraguan citizen on an annual basis is 38,787m$^3$/capita/year, or 106,265liters/person/day; much greater than the world average. However, paradoxically Nicaragua faces an ever greater number of conflicts generated by severe scarcity conditions, excessive water exploitation and contamination, and inadequate management in the basins where the majority of the population and economic activities are located.

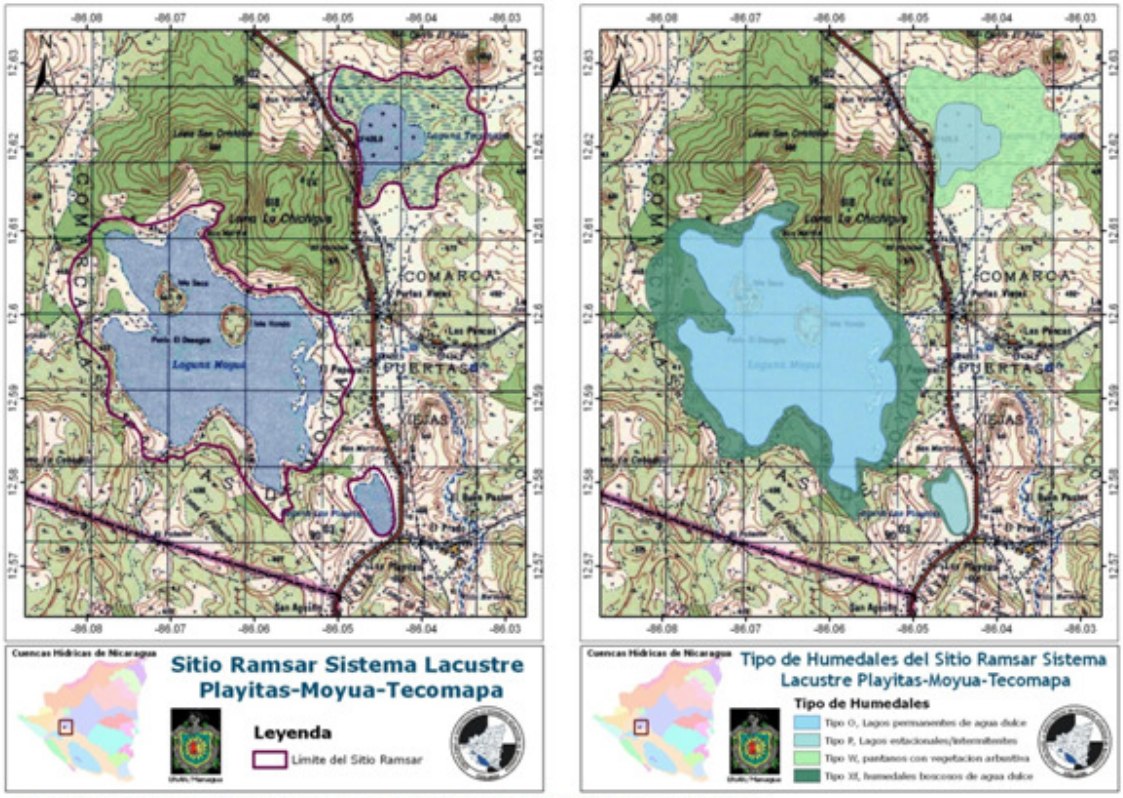
Integrated water resource management is key in order to provide responses to climate change in agricultural production and food security; to increase the contribution to hydroelectricity, to protect forests, other ecosystems and their biodiversity which provide resources and basic services for human beings; and to contribute to the social and health development agenda with the aim of ensuring access to drinking water and sanitation services to the entire population. This implies the

integration of water planning and management in Hydrographic Basins, in conjunction with all levels of government to develop work programs for administrative political regions and to ensure their viability. This also means completing water access coverage of the poor in order to diminish their poverty level and improve their resilience to climate change (ECLAC2010).

In Nicaragua, access to water of adequate quality and quantity is limited by the effects of environmental stressors and their causes at the water basins. These are primarily:

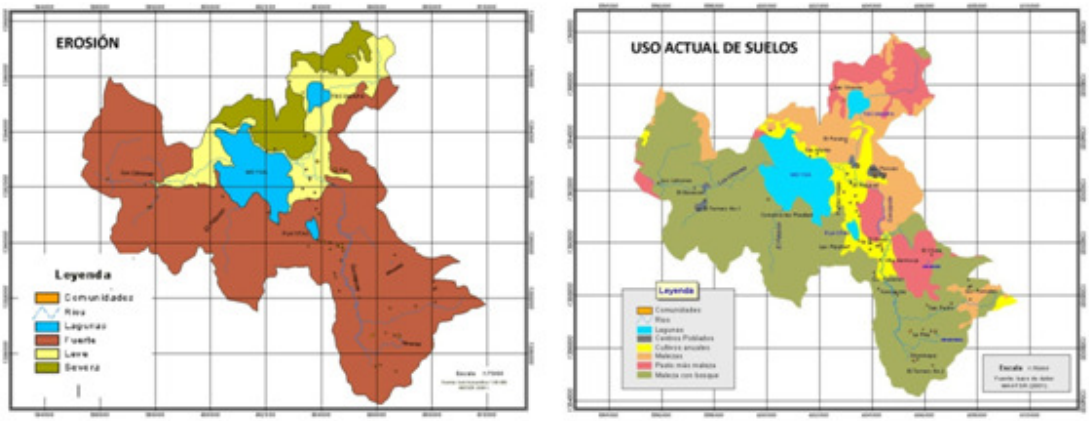
- Deforestation (felling and burning) and resulting erosion
- Agricultural use of forests
- Excessive use of agrochemicals, especially pesticides
- Simplification of ecosystems to plant monocultures (sugarcane, African palm, and rice)
- Urbanization without adequate services (raw sewage, municipal and agro-industrial solid waste),
- Impermeability of infiltrationareas
- Legal loopholes and intergovernmental administrative inconsistencies
- Lack of political will expressed as a lack of opportune action
- Lack of real planning measures and territorial prioritization
- Extreme poverty, especially in rural areas
- Lack of social, economic and environmental development policies for each basin

The solution proposed to the conflicts that are generated by this situation makes it necessary to take advantage of the legal framework and modify the current institutional environment for the administration of water. The definition of a modern, effective and efficient policy framework is also needed. For this national effort, the basin focus is essential, as well as the government's participation and commitment of local authorities, along with the community's participation. These will all make up the muscle for firming up the necessary actions at a territorial level.
With the aim of illustrating how to reduce vulnerability to the effects of climate change in the water sector and promote adaptation measures, the Laguna de Moyúa case has been chosen. This lagoon is a body of water that makes up part of the Laguna Moyúa – Tecomapa – Playitas system, located in the dry area of Nicaragua's northern region and that was recently designated as a Wetland of International Importance by the Ramsar Convention. The reason for choosing this example as a case study was due to the contradictory degradation of soils and other natural resources of this high-value scenic and natural area. These degradation processes include inadequate agricultural and livestock practices applied, destruction of the forest area due to tree felling and burning; general reduction and progressive elimination of species of flora and fauna of their original lands due to the loss of habitat; modification of the wetlands' water regimen in order to designate them for agriculture and livestock use; destruction of migratory and permanent aquatic avifaunato uncontrolled hunting; degradation of subterranean water quality due to infiltration of liquid waste and progressive contamination of surface water with toxic agrochemical residues; diminishment of flow volume for water channels up to their transformation into simple flows of rainwater runoff, and the disappearance of their riparian forests (GraphicNo. 1 illustrates the area's location map).




**Graphic 1: Location Map and Wetland Types of the 1980 Ramsar Site**

The factors mentioned are critical inducement agents that facilitate the move towards an increase in climate change risks. Additionally, progressive generalized environmental degradation has affected the communities' populations whose local economy is based on subsistence agriculture and extensive cattle ranching with little technical sophistication, which also has low levels of viability. Low levels of income, schooling, various hygienic sanitation difficulties and other social problems related to extreme poverty are contradictory in an environment filled with resources that are not aptly used, and that if not protected, will progressively become degraded. Graphic No. 2 shows the erosion and land use map in the sub-basin.

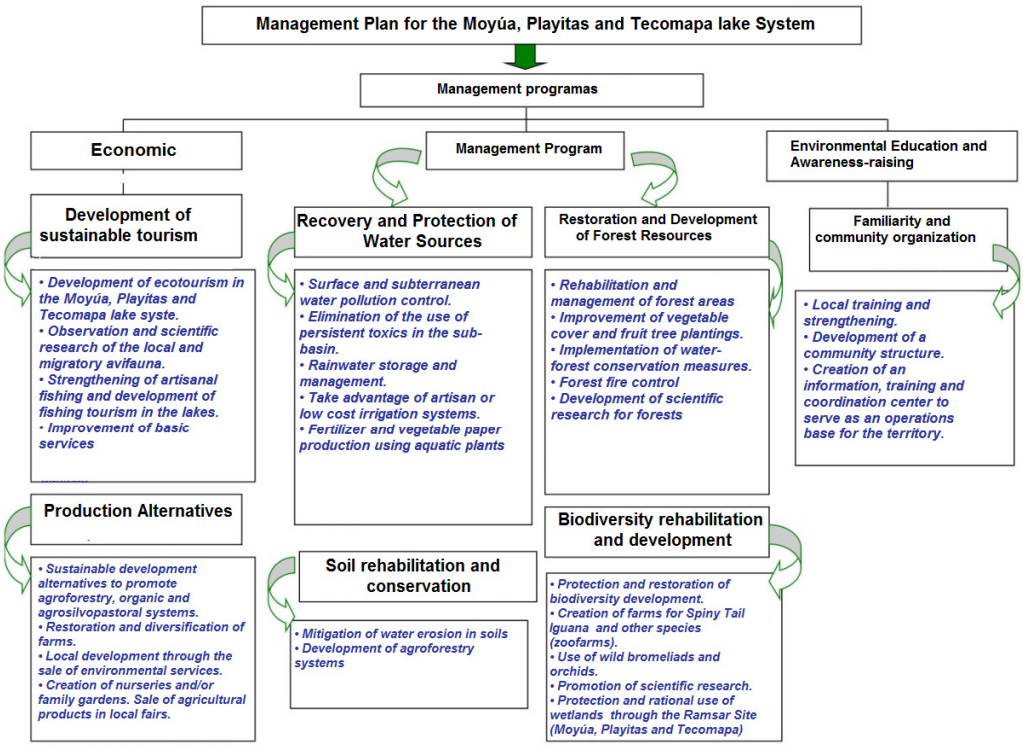



**Graphic No. 2 Erosion and Current Use of Soils in the Moyúa-Playitas-Tecomapa System Sub-basin**

The documented initiative aims to reverse the degradation processes that have led the Moyúa-Playitas-Tecomapa lagoon system to intermittent desiccation, and consequently to the marked impoverishment of the population. The territory has important natural resources such as scenic value, significant potential for recreational and artisanal fishing, ecotourism potential, especially for canoeing and cycling; as well as for a biodiversity reproduction center, and the observation of migratory avifauna, among others; in addition to the advantageous proximity to the capital city.

The objective of implementing the Integrated Water Resource Management Plan (IWRM), in Moyúa's wetlands and its communities is to ultimately rehabilitate its soils, waters, forests, biological diversity, and to harmonize policies and apply regulations for the management of persistent organic pollutants. This will contribute to reduce vulnerability in the face of climate variability in the sub-basin.

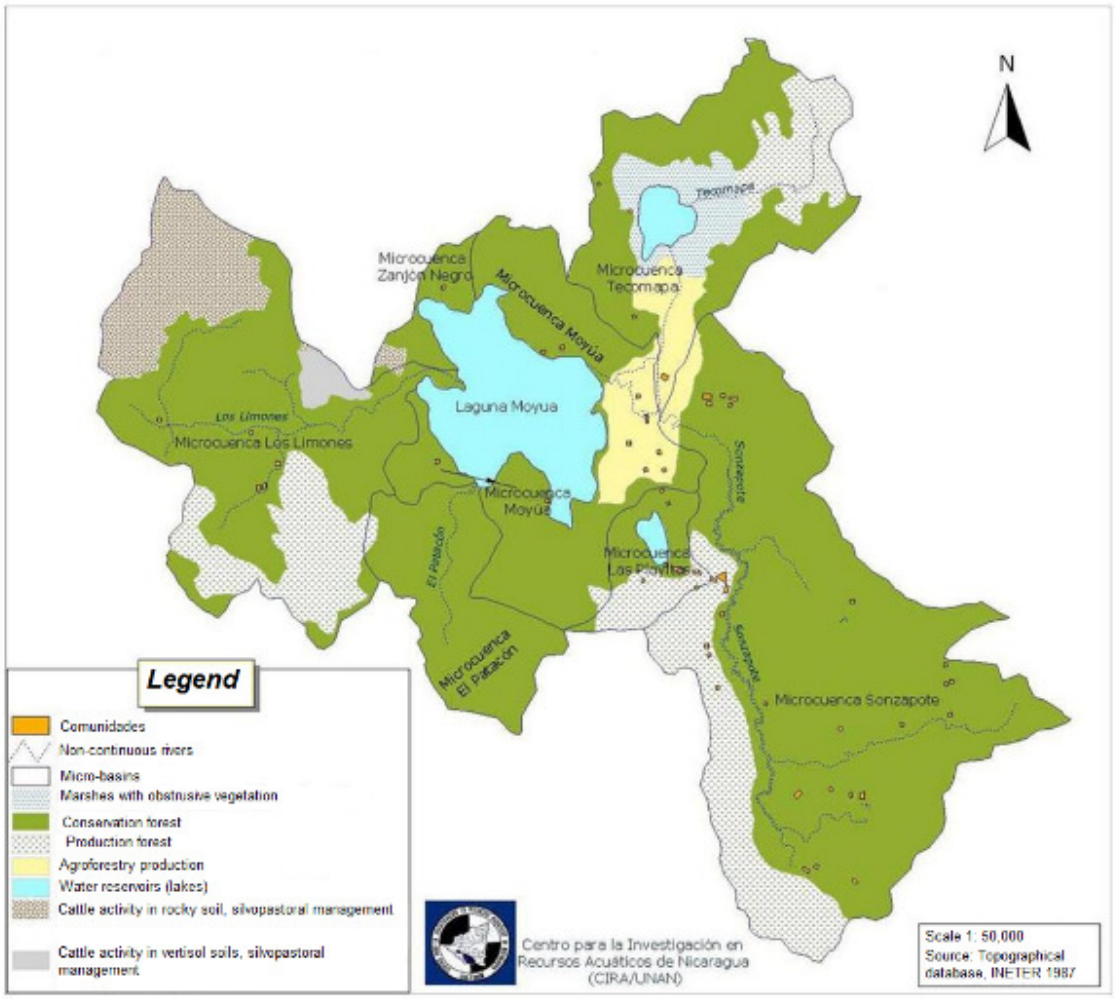
The Integrated Management Plan for the sub-basin's territory, including the three lagoons, Moyúa, Playitas and Tecomapa, was formalized in 2006 and became local law (Municipal Ordinance No.58) by the Darío Municipality Council, Matagalpa Department (Municipality of Ciudad Darío, 2006b).The provisions included the consideration of Economic, Conservation (Environmental Restoration) and Social (Awareness-raising and Training) Programs for the community's integrated development. This plan guides the actions for the rational use and protection of the territory for the next 15 years, which will help restore the resilience of the ecosystem in order to adapt to the impacts of climate change. Graphic No. 3 shows the plan's programs and components and illustrates the activities planned.




**Graphic 3: Programs and subprogram components of the Integrated Water Resource Management Plan for the Moyúa, Playitas and Tecomapa lake System**

The primary objective of these efforts is to achieve the general rehabilitation of the ecosystems and land use planning in the sub-basin, aiming to achieve the Objective Image as illustrated in Graphic 4, whose land use has the following distribution:

| Land use purpose | Hectares | % |
|---|---|---|
| Forestry:<br>Conservation forest<br>Riparian forest<br>Production forest | 6 712 | 80.57 |
| Mixed agriculture and livestock:<br>Agroforestry systems<br>Silvopastoral systems<br>Agrosilvopastoralsystems<br>Clean organic crops | 983 | 9.84 |
| Water reservoirs,<br>Ecotourism, artisanal fishing,<br>irrigation | 635 | 7.62 |




***Graphic 4: Objective Image of the Integrated Management Plan for the Moyúa-PLayitas-Tecomapa lake System***

The initiatives are supported by the population, the municipal authorities, the Nicaraguan Ministry of Environment and Natural Resources, and the National Autonomous University of Nicaragua, Managua, through the CIRA/UNAN.Two Cooperation Agencies (SGP - UNDP, Duchy of Luxembourg) support specific components and activities of the plan. Furthermore, the Ministry of Environment and Natural Resources supported and deemed the proposal to design this lagoon system in the Ramsar Convention on Wetlands of International Importance, and this was achieved in 2011(Ramsar Wetland Convention, 2011).This designation will support the efforts to conserve and protect its natural value and will facilitate the economic use of resources through environmentally-friendly economic practices where community tourism will be a main focus. The conservation axis of which today constitutes the Nicaragua Ramsar Wetland No. 9 (the one assigned with the number Ramsar Site1980), is precisely the Management Plan. The initiative for the use and protection of the Moyúa – Playitas- Tecomapa lagoon system has been developed according to the organization of the balanced cooperation between organized civil society, municipal authorities, academic institutions and key agencies of the centralgovernment to promote its implementation.

The technical and legal value of the validated instrument 'Integrated Management Plan' will contribute to stop destruction processes of the natural resources(especially for forests and water resources) of Moyúa-Playitas-Tecomapa lagoon system, which provide so much value to the focal area; thus, promoting their rehabilitation and conservation. The population's living conditions will improve through agronomic interventions such as sustainable production and the sale of environmental services that will come with environmental planning in the territory, as well as with food security and the reduction of vulnerability to climate change.

The implementation of the Integrated Management Plan for the Moyúa-Playitas-Tecomapa lagoon system will help the territory in the short, medium and long-term by achieving the recovery of the rivers and lagoons' flow, as well as by reducing water erosion and increasing infiltration. This will help achieve proper water resource planning in the focal area. In addition, it is expected that the contamination of surface and subterranean waters will be controlled by eliminating the use of highly-toxic persistent organic pollutants.

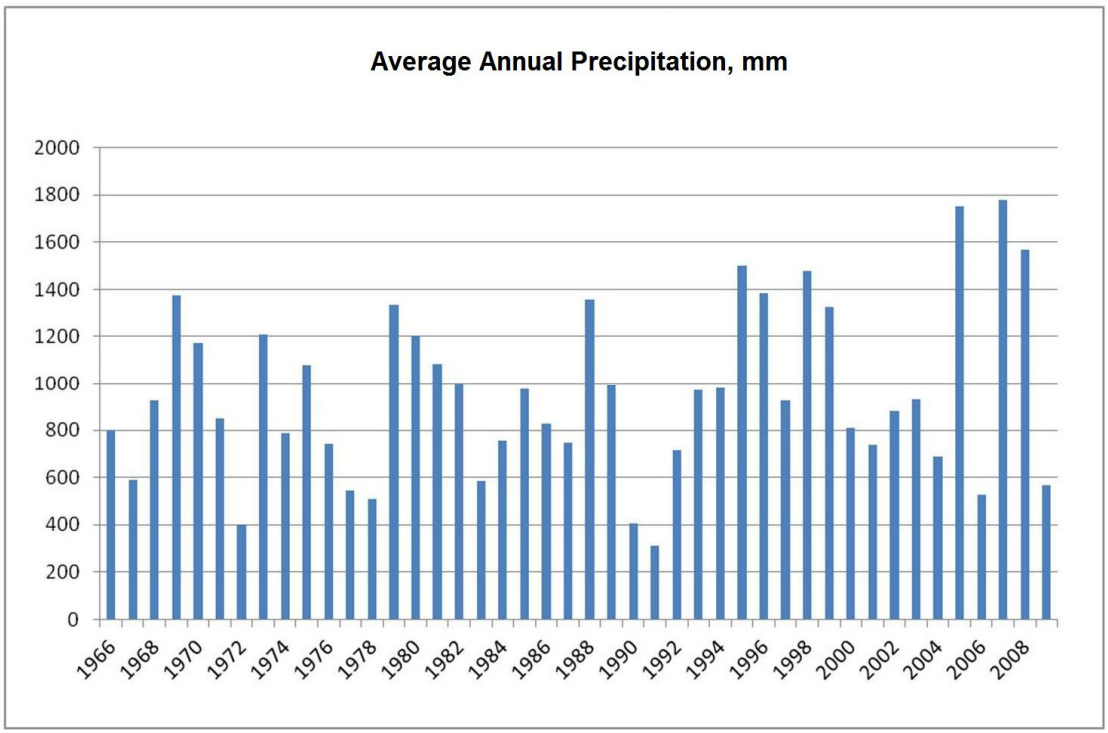
Environmental rehabilitation will be encouraged, promoting the rational use and environmental protection of the Moyúa-Playitas-Tecomapa lagoon system and its environs through training and awareness-raising of the territory's different social actors. It is important to note that the educational value of these efforts is to show community members that the protection of existing natural values and their rational use represents sustainable local development methods and provides viable alternatives to the difficult subsistence conditions they face. They also serve as an adaptation tool of integrated water resource management and in the face of climate change. The degraded condition of the land makes it more likely that extreme events (droughts and floods) cause even more damage in the territory. Rains generated during Hurricane Mitch (1998), caused the destruction of housing and productive lands, as well as 200 deaths in Ciudad Darío municipality. The Matagalpa department, to which this municipality belongs, lost twelve bridges including the primary bridges located on the Pan-Americanhighway that crosses the Moyúa, Playitas and Tecomapa basin. Later, the 2007, 2008, 2010 and 2011 rainy seasons resulted in the loss of harvests and infrastructure, similar to those of Hurricane Mitch, even without the existence of hurricanes. While records do not show catastrophic losses in the national news during the drought periods, the economic and social impacts are silent but extremely severe, thus becoming structural components or poverty factors.
The careful development of ecotourism has been identified as an initial step of the intervention; in order to generate revenue that will allow inhabitants to transform their traditional and low profitability, and high environmental impact activities into environmentally-friendly occupations of greater social production value.
The UNDP Small Donations Program has supported two initiatives that have facilitated the development of this component (UNDP2006, 2009), and has approved a new project to start in 2012.By creating subsistence alternatives in the communities based on ecotourism, the hope is to relieve the tension on biodiversity and allow for the regeneration of the dry forest, while also generating environmental services like carbon sequestration and water infiltration for the benefit of the protection and sustainable use of this dry zone that finds itself in a critical state while having wetlands of international importance. The environmental planning process in the wetland area has started in a coordinated way with the population's social and economic development, which will be further solidified through the management of projects with economic and environmental conservation interests.

## 2.-Description of the area

The Playitas-Moyúa-Tecomapa lagoon system is located in the Matagalpa department, Ciudad Darío municipality, around70km north of the capital. The communities neighboring the wetland are: San Martín, Puertas Viejas, El Papayal, San Vicente and Comarca Las Playas of Moyúa.

This lagoon system is part of the Río Grande de Matagalpa drainage basin, which is the second longest river in Nicaragua. The system is368 km long and has a total drained area of 18 309 km². The focal area includes three lagoons and flooded areas, covering a total of 1,161 hectares. Thesurfacearea of these water bodies are: Laguna de Moyúa (552 hectares), Tecomapa (63 hectares) and Las Playitas (23 hectares).The two smallest lagoons, little frequented by the public, have become only intermittent lagoons on an annual basis due to their inappropriate use for agriculture and livestock activities. Moyúa and Playitas have been used for fishing and agriculture irrigation. Tecomapa has suffered artificial drying due to deliberate drainage and it dries completely especially in times of low water levels. Laguna de Moyúa is more popular and has also dried in past periods of extreme drought (three times in the last forty years: 1972, 1977-78, 1990-1991).However, the lagoons are connected through subterranean water flows and when there are prolonged rains with intensity greater than the average of the area(956.27mm per year),a surface connection between them occurs. During Hurricane Mitch (1998) and the intense rains of 2007, 2010and 2011 the waters reached the border of the Pan-American highway affecting the population that lived at its margins.

Climate variability is seen through the wide fluctuation in the area's precipitation levels. Although there are no meteorological stations in the Moyúa basin territory, the integration of nearby meteorological station registers (within a maximum of ~18 km) illustrates the behavior of the area's precipitation.Graphic No. 5, Annual Average Precipitation, shows the average annual registers of the meteorological stations No. 55009, 55066, 69060 y 69080.These stations' pluviometric registers show a standard deviation of 363.4634 to the annual average, with ample variability ($s^2$ 132 105.6448)in precipitation values.




**Graphic 5: Average Annual Precipitation 1969-2009, integrated pluviometric registers**

The Playitas, Moyúa and Tecomapa lagoons are covered with neotropical vegetation associated with swamp areas. The topography is varied and soils have high contents of clay and organic matter.

The lagoons are visited by local and migratory aquatic birds among which are Northern Jacana, herons, lake ducks, black bellied whistling ducks, sandpipers, etc. Duringthe first months of the year, the lagoons provide food and receive a great number of migratory birds, primarily web-footed and wading birds. A good supply of fish is extracted from the lagoons waters including rainbow bass, breams and tilapias.Vegetables and fruits are harvested in the areas surrounding the lagoons and sold at the edges of the Pan-American Highway under the leafy shade of *samanes* or raintrees.

General characteristics of the area:

Altitude: The elevation of Moyúa and Tecomapa is 416.20 meters above sea-level and Playitas is at 440 meters above sea-level
Annual average temperature is: 26 ºC.
Annual average precipitation: 956.27mm, from May to October.
Vegetation classification:
Type of vegetation: Tropical deciduous forests of very dry warm areas
Forest Ecosystem Zonal No.1. (Salas Estrada, 2002)

Physical characteristics of the area:

***Geology:***
A variety of volcanic lithological units are found in the area and their ages range from the mid-Miocene to the Quaternary period. There also are sedimentary units represented by the recent Quaternary deposits. Tuffs, dacitic ignimbrites with clay and silty soils predominate in the lagoon areas; a weathering product of these rocks with high oxide and silica. There is little presence of sand and the type observed is fine textured. Due to the type of soil, it can be inferred that the porosity is not high, there is a predominance of silty clay or impervious areas. The materials observed and classified in the field were flowerings of dacitic ignimbrites, tuffs belonging to lower Coyol and basalts of the formation of the Coyol Superior. Finally, there are alluvial flowerings from the Quaternary Period and recent Quaternary sedimentary formations of considerable extent, which are clay banks.

***Geomorphology:***
In studies carried out by Vargas (INETER, 1971), two geomorphological units were compared: "Western Foothills" and "Darío High Plains". The Western Foothills are characterized by a steep relief with piles, and esites and basalts of the Coyol group. The rugged characteristic of this unit is lost in the far southwest, declining in the hills towards Managua, lined by broad alluvial valleys. Therefore, the ignimbrites have begun to be replaced with other rocks. The Darío High Plains is an elevated area with some irregularity in its plane that runs from Northwest to Southeast, and is formed by a series of tables separated by narrow and deep creeks which cut horizontal caps of ignimbrites and basalts of the lower and upper Coyol, respectively. The depressions are where the Moyúa, Playitas and Tecomapa lagoons are found.

***Soil types:***
Primarily, there is agriculture and livestock activity in the drainage area towards the lagoons, where the soil is used for growing corn, sorghum, beans and vegetables. The area is not apt for these types of crops due to the lower precipitation in the area; aside from the fact that traditional crops provoke changes in the use of the forest soil. This results in deforestation in the areas that could be better used for broadleaf forest production, combined with agriculture and silvopastoral cattle ranching.

Soils formed by recent alluvial and colluvial materials are found in the area. These are fertile deep soils with a medium fine to well-structured fine texture with good drainage and adaptable to irrigation agriculture. They are adequate for the majority of traditional crops (basic grains, sorghum, cotton and vegetables). These soils are predominantly clay soils in proportion to the area where they are found and their depth varies considerably. Another type of soil formed by fine underlying materials of fine texture, and which belong to the vertisols order, shows moderate permeability and medium level drainage. These are well-structured and fertile, little to moderately affected by alkalinity, and support high productivity. The texture of the soils is another important characteristic to determine their use since the crop to be planted depends on the soil type.

The clay loam and silt-clay soils have the property that in drying they crack or crevice, and in becoming humid with rain or irrigation they expand and become a plastic-like material with a high level of adhesive and permeability. However, through the crevices of the clay or the clay silt,the water penetrates into the sub soil until it slowly reaches the subterranean waters. After this, the

pressure created by the material makes it easy for the water retained in the soil pores to migrate towards the aquifer, enabling a slow water absorption process.

***Sediment characteristics:***
Clay-like sediment is predominant in the lagoons with an average grain size of 0.002 mm in 55% of the particles. The presence of high organic matter content in the lagoons' sediments is related to the runoff received during the rainy season which carries a large quantity of sediments, nutrients, leaves, branches, trunks, etc.; that promote an excessive accumulation of organic matter. The abundant organic materials in the lagoons' sediments indicate that they are trophically productive bodies of water.

***Origin:***
The Moyúa, Playitas and Tecomapa lagoons are natural. This lagoon system is of tectonic origin, which suggests that it was formed by the faults in the north-south system; therefore, the rocks of the east and west flanks have pronounced cracks and slopes that follow this alignment.

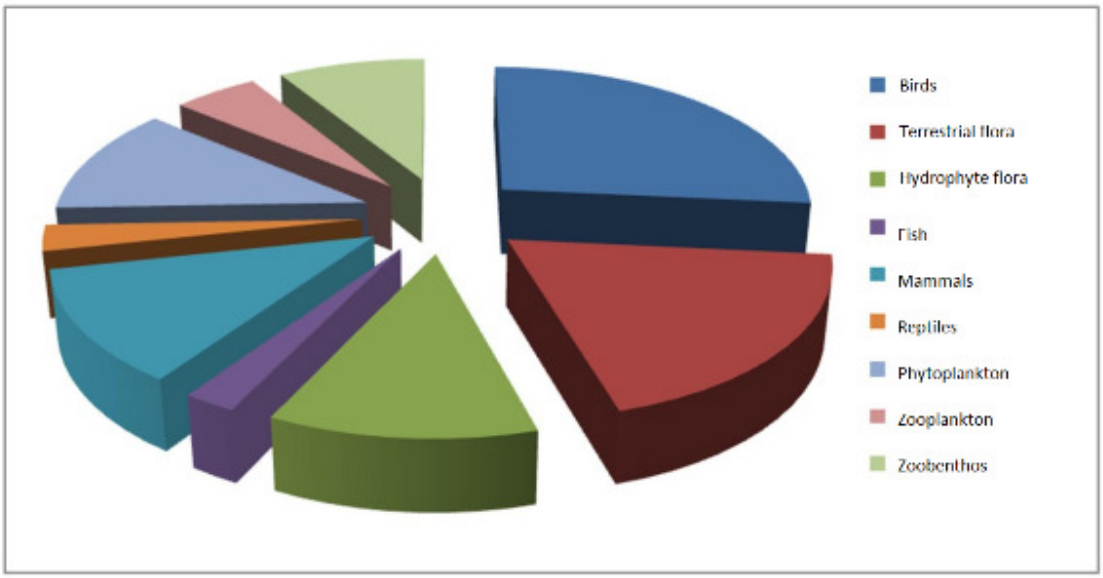
***Hydrology:***
The main source of water that reaches the Playitas, Tecomapa and Moyúa lagoons is rain precipitation. These are the only natural reservoirs of surface water in the municipality's territory and contribute to the economic sustainability of the area due to its fishing and tourism potential and broad biodiversity, particularly of migratory birds. They have been affected with anthropogenic activity; thus, a more exhaustive control of the various water sources in the area is necessary.

The lagoons experience recurrent dry periods, especially during extreme droughts in the area which are associated with variability and climate change. The Playitas lagoon provides water to the aquifer and generally maintains small banks in the summer, but usually at the end of the low water levels period, the aquifer dries entirely. Tecomapa generally stays dry and only when there is a good winter or important natural events it is able to flood. The Tecomapa lagoon has had problems with its water bank as a result of two fundamental causes: deliberate deforestation in its sub-basin and the improper use of the soils in the high areas which have resulted in serious sedimentation processes in the lagoon. The lack of forest cover results in rainwater runoff in the winter towards the lower parts of the drainage sub-basin, taking with it large quantities of soil that are then deposited in Tecomapa. Additionally, there is a lack of legal tools and municipal management, since there are no sanctions against the landowners, who, despite not being owners of the water resources (Law 620, General National Water Law),modify the natural water flow to create derivation and drainage ditches with the goal of providing water to their cattle.

The demand on the use of water resources on behalf of its different users is increasing due to the demographic growth observed in the last several years in the different population centers. This creates additional pressure for water resources. The primary demands for surface water within the area are three: human and animal consumption, irrigation, and fishing.

The ecosystem has 215 species in total. 57 species of birds have been observed, including local as well as migratory species. The terrestrial flora consists of 41 species and the aquatic or hydrophyte of 25. Five fish species have been identified as well as 26 mammal and 6 reptile species. In the waters of Moyúa, 25 algae species have been identified (phytoplankton), as well as 11 species of

zooplankton and 19 species of zoobenthos (the composition of fauna and flora species is in Graphic5, and the List of species is in Annex 1).




**Graphic 6: Fauna and flora groupings in the Moyúa-Playitas-Tecomapa System**

## 3. - The initial situation

Climate change can also significantly alter the variables that affect water quality. These impacts originate from the diverse alterations in the water bodies' hydrology, its physical-chemical and biological attributes and anthropogenic pressure changes. The impacts of climate change are not limited only to changes in precipitation, but also include other factors (GWP, 2010).

The geographic area where the Moyua-Tecomapa-Playitas lagoon system is located belongs to the Ciudad Darío municipality, an area considered one of the driest in Nicaragua's northern region in which annual precipitation is approximately 779 mm. In this territory, the effects of climate variability have been severely manifested, as evidenced during Hurricane Mitch in 1998, the intense rains of 2010 and 2011, and the droughts of 2002 and 2004; all events that contribute to impoverishment and emergencies (OIM-HUD 2001).The correct use of water resources, of the land, the forest and biodiversity is an alternative to improve the living conditions for the population by converting them in the basis for local economic development. The area of interest has valuable heritage sites that ought to be preserved for their contribution to the development of current and future generations, such as their ecosystems of abundant biodiversity which provide multiple services. These ecosystems deteriorate due to the pattern of unsustainable development and will be even more affected due to the effects of variability and climate change, even to levels of extreme impoverishment.

The local economy which is based on non-technical subsistence agriculture and extensive livestock has very low social and economic viability. Low levels of economic income, low schooling rates, severe hygienic-sanitary difficulties and social problems associated to extreme poverty continue

being the most visible results of the lack of resource use and environmental protection measures. Environmental destruction has worsened through deforestation, burning of pasture lands, bad agricultural practices and other activities that have caused and maintained severe erosion of the soils and loss of biodiversity. In 1996, the Emergency Fund for Social Investment (FISE 1996), classified the Ciudad Darío municipality (Matagalpa Department), which is in this sub-basin, as a poor municipality. 87% of Ciudad Darío's population considers themselves to be poor. This situation is more marked in the rural area (91%) than in the urban area (76%).

Besides from being a territory with high poverty levels, fragility and progressive destruction of the ecosystem that is manifested in different ways in the municipal territory, the area immediately surrounding the lagoon system has economically depressed areas with a subsistence economy or extreme poverty. The micro basins have a very delicate and sensitive hydrology whose level is radically affected in periods of extreme rain when their surface discharge reaches critical levels or when there are several years with low precipitation. In the focal area of the project, there are fourteen communities and five farms, and their distribution is categorized in regions. Of the 22 rural regions in the Ciudad Darío municipality, only four are located in the area of focus: The Playas of Moyúa, Talpetate, Ispangual and Puertas Viejas, administratively distributed in two zones. The total number of people in the sub-basin is 2,730 people (OIM-HUD 2001).

The initiative in the Management Plan basically tries to reverse the degradation processes that that have led the lagoons to experience degradation and accented impoverishment of the population. It also aims to rehabilitate the soil, water, forests, biological diversity, and the harmonization of policies and regulations for the management of persistent organic pollutants. It is hoped that the synergistic effect of these recovery efforts will contribute to reducing climate change vulnerability and variability.

The proposal includes implementing the Management Plan in the area of focus with the aimof generating revenues that will allow the population to transform their traditional low-profitability work which has high environmental impacts, to environmentally-friendly occupations of greater social productivity. This can be done by creating alternatives to subsistence for the communities based on ecotourism in a way that can alleviate tensions on biodiversity and at the same time supporting the regeneration of the dry forest, and generating environmental services such as carbon capture and water infiltration for the benefit of the protection and sustainable use of this dry region that is in a critical state.

The International Organization for Migration (IOM-HUD 2001) documented the fragility of the social and economic situation of the Ciudad Darío Municipality and stressed the economic potential for the development of Laguna de Moyúa. Afterwards, the baseline environmental study included a Water Science Master's thesis (Salvatierra, 2003) in the diagnostic which provided biological, physic-chemical, hydrological and basic hydrogeological information about the area studied.

The sub-basin territory, especially the Laguna de Moyúa, has important natural resources such as scenic value, high potential for recreational and artisanal fishing, ecotourism potential, especially for canoeing, and cycling; a biodiversity reproduction center, and the observation of migratory bird fauna, among others. Just the presence of water throughout the year represents enormous value for one of the driest municipalities in the country.

The Moyúa lagoon is considered one of the wetlands of international importance in Nicaragua, especially now that is has been designated as a Ramsar Site.

In the Ciudad Darío municipality dry zone, where water resources are very limited, there is extreme poverty(INIDE, 2005). An option to improve the living conditions for the population is the preservation and proper management of water resources, soil, forest, and biodiversity, making them the foundation for the development of the local economy. The potential of the soils for forest use could support the agro silvopastoral development as an economic alternative for the rehabilitation of soils and livelihood of the impoverished population.

The destruction and consequent reduction of the soils' infiltration capacity could be linked to the vulnerability that these lagoons have in drought periods since they flood in rainy winters and almost disappear in extended dry periods.

As a result, applying the principles that support Integrated Water Resource Management is necessary for the water resources in this area. This is in line with the provisions of the National Water Policy (Government of Nicaragua, 2001), especially according to its Guiding Principles such as No.3 "The basin is the territorial management unit for the integrated administration of water resources", andNo.4 "The development and management of water is based on a participative focus, involving the users, planners and decision-makers at all levels through the processes that align decisions as closely as possible with those directly affected by them". The adaptation required is intimately linked to a sustainable development model that requires great public and private investments in infrastructure that reduce the exposure of the population to vulnerabilities. The National Environmental and Climate Change Strategy in the 2010-2015 Action Plan, establishes that "A policy of sustainable land development will be promoted by developing good agriculture and livestock practices for improved management of lands destined for agriculture, the reduction of wind and water erosion and greenhouse gas emissions, such as adaptive agroforestry production systems as well as silvopastoral systems and the production on slopes, the construction of containment dikes, the establishment of live fences and the establishment of wind-breaking curtains. Similarly, the transfer and implementation of new and improved agriculture and livestock technologies, such as the micro-irrigation districts, should be implemented in a way that is appropriate for the national conditions and needs."

Based on this reality, the CIRA/UNAN- Managua contributed by organizing the population, who were initially brought together in the Intersectorial Community Committee which included five communities and which finally became the People's Association of the Moyúa, Playitas y Tecomapa sub-basin "to promote the economic and social development of the community and territory that makes up the sub-basin and to drive, promote, help and contribute to the environmental protection and natural resources efforts as well as the achievement of sustainable development and the improvement of the community's hygienic-sanitary conditions" (Municipality of Ciudad Darío 2006b).This association, formally registered in the Municipality with the support of the Ciudad Darío mayor's office and the CIRA/UNAN - UNAN Managua, developed the processes according to the logical framework of the identification of problems and solutions proposal that evolved into the Moyúa–Playitas–Tecomapa Lagoon System Management Plan, based on the principles of Integrated Water Resource Management (IWRM).

## 4. - Operations strategy

The approaches used for the implementation of solid water management include adaptation measures in addressing climate change and variability. The capacity to administer the lands, water and forests, strengthens the recuperation capacity in the face of current climate change risks while also developing future climate change adaptation capacity (GWP, 2010).

General adaptation seems easier when it coincides with other objectives and makes it possible to find a solution that benefits all while also supporting additional advantages. Various strategies and actions are possible when the objective is the creation of an economically efficient framework with sufficient flexibility to be able to be modified as scientific knowledge or the capacity to apply it progresses (European Environment Agency, 2009).

The convergence of the effects of climate change, with its associated limits for economic development, transform the lack of access to water from a chronic problem to one that is extremely acute.

The purpose of achieving the rehabilitation of the lands, waters, forests and their biological diversity, the harmonization of policies and regulation for the management of persistent organic pollutants, is based on the territorial, social and economic planning tool. This is oriented towards the rehabilitation of the natural habitat in such a way that flora, fauna and natural processes progressively recover their natural dynamics as much as possible.

The Moyúa experience is an example of planned adaptation. Within this experience the municipalities have adopted the planning tools that take into consideration climate change and variability. The adoption of these tools will contribute to the reduction of vulnerability for the area's population.

The spirit of the initiative contained in the plan is to articulate, organize, support and conduct the efforts, actions and stakeholder interventions in successive phases in the areas that have been defined. This should be done while also taking into account land use, restoration of native forests, water and soil conservation projects, artisanal hydraulic projects and the use of rainwater through water harvesting, contamination of surface and subterranean water due to the use of highly-toxic persistent organic pollutants and the systematic training and awareness-raising of the different social actors in the territory.

The Plan's implementation strategy is to execute it in modules according to the availability of financial resources for the projects described in the Plan's programs and subprograms. In addition, the implementation strategy supports the creation of alliances with institutions, state agencies, cooperation organizations and non-governmental organizations. This process has started with the involvement of the Center for Aquatic Resource Research of Nicaragua(CIRA/UNAN) and the inhabitants of the focal area communities, with the support of the Ciudad Darío mayor's office.

The Center for Aquatic Resource Research, Nicaragua (CIRA/UNAN), is an organization of the National Autonomous University of Nicaragua (UNAN-Managua), and a scientific research institution for the country's waters. Its mission is the development, education and transfer of clean technologies, the provision of scientific-technical services, training, specialized training and

postgraduate training for the sustainable use of national water resources. The primary objective of CIRA/UNAN is to promote the sustainable use and protection of water, soil, forests and the biological diversity of the national and country border water basins as well as to contribute to the country's socioeconomic development through the support of the University Extension program.

Local municipal authorities represent the Nicaraguan government since the Municipal Law (Law No. 40)defined the municipality as an expression of the State in the territory where it exercises its powers through management and corresponding services, competencies or responsibilities on topics that affect its development, environmental preservation and the fulfillment of its population's needs. The Ciudad Darío municipal council is the maximum collegiate authority of the government and the local public administration. The mayor is the maximum executive authority of the municipality and is elected by the population. The mayor coordinates the municipality's work with state institutions, non-governmental organizations, and community organizations that carry out activities in the territory.

With the aim of building greater institutionality and recognition, both at the national and international level, the Ministry of Environment and Natural Resources (MARENA) made a request to the Government of Nicaragua to designate the area a national priority, based on the Ramsar Convention and proposed the designation of the Moyúa – Playitas – Tecomapa lagoon system as a Wetland of International Importance. The request was submitted in 2005 through the fulfillment of the Ramsar Information Sheet (RIS).Due to a number of reasons, the process lasted six years and the designation was finally approved on June 29, 2011. It was officially communicated on November 2011.

The essential characteristics of the basin, its water bodies, wildlife, threats and environmental tensions, allow it to be included in international efforts taking place for the improvement of the conditions of similar water basins. The agreement that Nicaragua signed with the RAMSAR convention, destined for the protection of wetlands across the world, is the most convenient tool to support the municipal efforts that have been included in the management plan through the programs and project guidelines. This designation is part of the support sought to provide greater visibility to the efforts and the need for implementing the provisions in the Programs that make up the Plan. The focus of the plan, which is based on technical elements, has relied on the political will of the municipal authorities in order to support the population in the plan's implementation.

## 5. - Results

Focusing on water security –conceived as "the reliable provision of water in sufficient quantity and of acceptable quality for health, the production of goods and services and subsistence means, as well as an acceptable level of related water risks"(GWP, 2010) –constitutes a solid strategy for early adaptation. This provides immediate benefits to the vulnerable and marginalized populations; and, as a result it promotes the Millennium Development Goals while strengthening the systems and management capacity of long term climate risks.

The Integrated Management Plan for the Moyúa-Playitas-Tecomapa Lagoon System is the tool for the rehabilitation of lands, water, forests, and their biological diversity. The plan will contribute to the improvement of living conditions for the populations through agronomic interventions that are sustainable and productive, and which will include environmental planning of the territory as well

as food security. At the same time, each of these components will positively influence the reduction of vulnerability in the face of climate variability.

Although, the process is in its initial stages of implementation; it is important to understand that it is a long term process and as such it must be assimilated by the population as well as by the local and national authorities; and it must also attract financial supporters. Until now, only two projects of the range of activities in the economic program have been funded. However, concrete benefits have been achieved by the participants during their implementation.

The community members that participated in these projects were benefitted with the implementation of the different activities carried out in their farms, such as:

1. Soil conservation practices have been established and assimilated. Different experiences that were carried out were able to reduce the rainwater runoff and control soil erosion in critical points; thus, achieving a reduction of the vulnerability caused by heavy rains. The participants learned to build intensive soil conservation projects, such as: dead fences, live fences, rock dikes, border terraces, and infiltration ditches, among others. This contributes to the retention and improvement of soils for agriculture and forestry.
2. Beneficiaries from the communities were taught to build and benefitted with the construction of rock reservoirs or storage basins for home rainwater collection. In total, twenty-one storage basins were constructed with their respective smooth zinc covers tied at the ends with wood planks. The community members are using the storage basins and keep them clean and functional.
3. Planting of forests' significant trees. In total, 6,700 fine wood trees were planted including slow growth and rapid growth trees for the stabilization of the soils and use as firewood. The varieties of trees planted mainly include: mother of cocoa, leucaena, *cortez*, oak, *aceituno*, mahogany, *pochote*, *guayacán*, rain trees, black guanacaste, and *gavilán*.
4. Planting of fruit trees. In total, 9,850 fruit trees were planted by the community members including: papaya, acid and sweet guava, pink mango, *mamón*, *achiote*, lime, *pitaya*, cashew, *nancite* and others due to popular demand and of broad local acceptance. Through these fruit tree plantings, medium and long-term improvements in the living conditions of the rural population are achieved. Fruit trees provide important food and other benefits such as the sale of excess fruit; thus, helping the community members by providing food for self-consumption and obtaining additional gains with the sale of products.
5. Community members have contributed to increase the forest cover by planting timber and fruit trees. Therefore, there has been a contribution to environmental restoration of the microzones with the most forest potential; while at the same there is food provision for wildlife. The rehabilitation of the vegetation cover strengthens the area's rainwater infiltration capacity.
6. Distribution of filters for drinking water. These are home-made systems that operate with gravity and contain a ceramic filter, activated carbon and colloidal silver todisinfect water as it drips slowly. The filtration element was manufactured in Brazil, but the gravity system for filtration in the recipient was designed by CIRA/UNAN. In total, 60 home filters were distributed. This activity contributes to the population's quality of life through clean water consumption. The home-made filters have had complete acceptance by the population benefitted who have also asked to extend the benefits of the filters to other communities. These are successful experiences that can be replicated in other municipalities and

communities. Providing access to safe water of good quality for those who have supply and quality problems with water for human consumption, is a topic that needs to be broadened in the future.

7. The beginning of the development of rural community tourism in Laguna de Moyúa and neighboring areas as part of the sustainable development strategy in the sector haspositive impacts in the entire municipality. This will contribute to recovering the ecosystem's capacity for resilience to climate change effects.
8. Construction of tourism facilities such as trails, viewpoints, food services, boating services, cycling, cabins, changing rooms, latrines and other facilities in convenient places. Manual repair of access roads to the lake.
9. The start of the excursion service for tourists, using the docks and resources provided by the projects of the Small Grants Program (SGP-UNDP), with observation circuits for birds and farm visits where visitors are attended.
10. Construction of piers and the removal of obstacles to access them.
11. Local organizational strengthening through trainings, awareness-raising and empowerment of community members, community leaders, auxiliary mayors, among others. The development of local capacities in designing and developing the different projects for rainwater storage, gully and runoff control, and increasing infiltration, is another important achievement. The interest of the population in the protection of new forest parcels is another value added.
12. Community member enthusiasm for the different project activities as well as the change of vision towards the protection of the area's natural resources is an achievement within itself. This has been observed in community members that have been benefitted directly and indirectly according to the project provisions. The project has worked together with the San Martín, El Papayal, Puertas Viejas, Playas de Moyúa and El Prado communities which total approximately 545 people and 132 families. The acceptance of the beneficiaries of the different activities developed in the project, such as the construction of home basins for rainwater capture, the implementation of different soil and water conservation projects, artisanal irrigation systems, the planting of fruit and forest trees, among other activities, not only helped achieve the goals outlined, but in contrast to the participation in traditional projects that provide assistance, they came to own the spirit that is promoted by the Small Grants Program (SGP-UNDP).
13. It is important to highlight the participation of women who are housewives, farmers, community leaders, auxiliary mayors and teachers in all the proposed project activities, as well as the participation of girls and boys.
14. Active and permanent participation on behalf of the municipal technicians assigned by the municipality was achieved since the mayors of following administrations, as maximum authorities of the municipality and together with the city councilors, took ownership of the plan's spirit and projects. One aspect that must be highlighted is the active participation of the members of the municipal council during the preliminary discussions for the initial phase of the project, as well as in its validation and other aspects of the management plan.
15. Establishment of the first intersectorial community committee representing five communities and integrating their members, who will provide continuity to the activities that will be measured in the medium and long term. This committee has been converted into the People's Association for the Moyúa, Playitas and Tecomapa Sub-basin, which has been formalized with the support of the Municipal Council.

To achieve and sustain water security– defined in general terms as the capacity to take advantage of water's productive potential and limit its destructive potential – the project provides a focus for adaptation strategies and an action framework. For the countries that have not achieved water security, climate change will complicate it even more. On the other hand, for those who have water security it will probably be difficult to sustain it. It is probable that all will have to provide additional resources for water resource management.

In order to address water security, a solid and early adaptation strategy that provides immediate benefits to vulnerable and detached populations is required. As a result, the Millennium Development Goals can be promoted while also strengthening climate risk systems and management capacity in the long term (GWP, 2010).

## 6. - Sustainability of the experience

Integrated Water Resources Management (IWRM) offers a focus for managing these dynamics and provides a guide for addressing all levels of commitment assumed by the Plan's participants. IWRM is an approach of global best management practices in order to address water management: it recognizes the holistic nature of the hydrologic cycle and the importance of managing the concessions that it can produce; it emphasizes on the importance of efficient institutions and it is intrinsically a type of adaptive management (GWP, 2010).

From the perspective of sustainable development, the highest priority for adaptation in the water sector should be people and societies' vulnerability reduction in the face of changes in hydrometeorological trends, the increase in climate variability and extreme events. A second priority should be the protection and recovery of the ecosystems that provide some critical services and resources such as those for water and soil. A third one should be the reduction in the difference between supply and demand for water, reinforcing demand moderation measures. Many strategies can serve to achieve these priority objectives; including sharing the losses, preventing the effects and promoting research and education. The impact of climate change can also be reduced through structural, technological, institutional and normative changes (European Environment Agency, 2009).

The sustainability of the experience created by the Integrated Management Plan as a reference point for the areas' planning and development depends on its appropriation by community citizens, agriculture and livestock producers, community leaders and the Municipal Government, as well as of donors and other actors involved. In this first stage of implementation, the generation of visible and concrete achievements of the plan provisions is essential for motivating actors' interest and participation, as well as for ensuring its institutionality. Despite the progress made with the formalization of a structure and legal support, there are difficulties in financing the different components in the Plan, since the risk of not successfully achieving a critical functional level of the plan still persists. It is important to take advantage of new opportunities offered by the Ramsar Convention's designation of the site as a Wetland of International Importance and the interest of the Nicaraguan Government in including the ecotourism development of this area within the "The Coffee Road" Program, focused on Matagalpa, for managing the financing of the projects included in the Plan's Programs.

Next (in 2012), the SGP-UNDP project, previously approved, "Strengthening of Rural Community Tourism in Laguna de Moyúa's Lagoon System" will be implemented in Moyúa. It involves the construction of a Visitor's Center that will serve as a space for discussion of the different activities, as well as a meeting space for the community that offers tourism services to visitors. It will be a space to facilitate the provision of necessary information about tourism services—including prices, locations and visitor options. It will also include a variety of local handcrafts for sale, a guide map with trails, information about flora and fauna, wetland ecology, and a presentation of archeological images of the area.

In the same area as the Visitor's Center, while not necessarily within the same building, there are plans to develop a Biological Station to support the efforts of the Ministry of Environment (MARENA) and the UNAN Managua for investigating the ecology, take advantage of the resources and protect the environment.

## 7. - Lessons learned

This experience, which seeks to achieve the rehabilitation of nature so that it can recover its ecosystem's resilience capacity, has a bottom-up focus. It aims to establish links through which the State and its institutions support organized efforts by the people. The bottom-up focus develops to the extent in which the community takes ownership of: the spirit and need to use and protect the sub-basin's resources as a vehicle to their social and economic development; the usefulness and utility of the initiative, based on the management tools of the Plan; and the building of concrete scenarios that contribute to the reduction of climate change vulnerability considering the IWRM focus. When the implementation projects, which are limited to their natural administrative cycles, are conceived as articulated tissue and cease to exist as specific isolated initiatives dependant on the external will and financial cycles of the organizations; then they become construction blocks in the reality sought for the Objective-Image of the global effort.

## 8. - Recommendations

The Plan's complex structure and interactions imply counting on the technical and executive capacity that will support the preparation of documents, the necessary actions and appropriate financing. In addition it assumes the organization of the work at three levels:

- Territorial dimension
- Sectorial dimension
- Institutional dimension

In terms of the ***territorial dimension***, spaces where the dynamics that overcome the disequilibrium and territorial problems develop have been identified. In practice, this means physical and concrete territorial planning in the direction of the reference provided by the territory's objective- image. The matrices for resolving the problems and specific projects are based on defining the areas or zones in which the particular uses or applications respond to the logic of rehabilitating, correcting, or developing the best options according to the territory's weaknesses or potential.

For the ***sectorialdimension***, the interaction among the forest, agriculture, livestock, tourism, environment, society, economy and other sectors' aspects is expected. Such interaction should be in a way that all sector scan coordinate together in order to mutually complement and support each other; instead of being in contradictory opposition to each other. The projects that will be developed and executed based on this active intersectorial concept will be of greater benefit for the goals of the Plan since the logic of its functions is based on this philosophy and not on unilateral focus points.

Regarding the ***institutional dimension***, the executives in charge of the formulation, planning, execution and evaluation of the programs and projects have been identified as well as their role in providing feedback with the results of the process. This feedback aims to correct and improve the situation as it goes along. This assumes that the municipal capacity exists to interpret and apply the legal, scientific-technical and economic frameworks; and to enrich the management process with necessary specialized information. Similarly to the inter-sectorial dimension, the spheres of competence of the different institutions involved (Central Government, Municipal Government, Non-governmental organizations, other civil society organizations, producers, investors, and interest groups) will work hand in hand during the different phases for the organization of the work.

The establishment of resolutions or ordinances as well as the coordinated action of the responsible bodies (municipality, MARENA, Nicaragua National Forestry Institute -INAFOR, Civil Defense, Nicaraguan Institute of Tourism - INTUR, Concessionaries, Nicaraguan Institute of Aqueducts and Sewage - INAA, Nicaraguan Aqueduct and Sewer Company - ENACAL) and the general population (which act not only as implementers but also as social actors), is the path for the protection, recovery and/or rehabilitation, and proper use of the natural resources of the area.

The Objective Image is a graphic showing the required final result of the planning for lands and forests' use; as a result of the application of the programs. It is not realistic or possible to estimate the amount of time required to achieve this since this variable is dependent on the preparation and execution dynamics of the actions in each of the sub-basin's areas where starting the interventions is extremely urgent.

The actions that will make these objectives possible should be organized, coordinated and supported by the local authorities in cooperation with the area's people and stakeholders. This way the productive activities of the agriculture, livestock, forestry, fishing and tourism sectors will be sustainable and compatible with the environmental characteristics of the basin; thus, achieving a harmonious coordination at the three levels or dimensions mentioned above.

## 9. -Contacts

Angel Rafael Cardoza Orozco, Municipal Mayor of Ciudad Darío. Ciudad Darío, Matagalpa, tel. (505) 2776-2271, 2776-2281.alcaldía@ibw.com.ni
Juana Argeñal Sandoval, Minister of the Ministry of Environment and Natural Resources of Nicaragua.jargenal@marena.gob.ni
Lilliam Jarquín, *National Coordinator, Small Grants Programs, PNUD.*
*Tel: 2254-7963/ 64 ext. 104. P.O.- Box 3260 - Managua, Nicaragua.*lilliam.jarquin@undp.org
María Rivera, Coordinator for the Americas, Ramsar Convention.RIVERA@ramsar.org

Thelma Salvatierra Suárez, Manager of the Research and Development Unit, CIRA/UNAN-Managua. Center for Aquatic Resources Research, Nicaragua, P.O. Box 4598, Managua. Telephones (505) 2278-6981/82. Thelma.salvatierra@cira-unan.edu.ni

Board of Directors of the Moyúa, Playitas, Tecomapa Sub-basin People's Association:
President: Tomás Moreno Rayo;
Secretary: Argentina Castro Medrano;
Treasurer: Narciso Moreno Orellana, Tel 8979 8989;
First member: Vilma del Socorro Gutiérrez;
Second member; Julio Cesar Matamoros Urbina;
Third member: Adolfo Castro Suárez.

## 10.-Persons interviewed

Lilliam Jarquín, *National Coordinator, Small Grants Programs, PNUD.*
*Tel: (505) 2254-7963/64 ext. 104. P. O. Box 3260 - Managua, Nicaragua.*lilliam.jarquin@undp.org

Narciso Moreno, Treasurer of the Moyúa, Playitas, Tecomapa Sub-basin People's Association. Tel (505) 8979-8989

Thelma Salvatierra Suárez, Manager of the Research and Development Unit, CIRA/UNAN-Managua. Center for Aquatic Resources Research, Nicaragua, P.O. Box 4598, Managua. Telephones (505) 2278-6981/82.Thelma.salvatierra@cira-unan.edu.ni

Tomás Moreno, President of the Moyúa, Playitas, Tecomapa Sub-basin People's Association.

## 11. - References

Agencia Europea de Medio Ambiente (2009): Cambio Climático y adaptación de los recursos hídricos. Ministerio de Medio Ambiente y Medio Rural y Marino, Gobierno de España.

Alcaldía de Ciudad Darío(2001). *Resultados del Análisis Ambiental Estratégico*. Plan de Desarrollo Urbano Ambiental de Ciudad Darío. Managua, Nicaragua.

AQUASTAT 2011. (Sistema de Información sobre el Uso del Agua en la Agricultura y el Medio Rural) FAO, Roma2011.( http://www.fao.org/nr/aquastat/)

Castañeda, E., Morales, S. & Zolotoff, J. (2001). Ficha técnica de las aves del sistema de lagunas de Moyúa, Tecomapa y Playitas. Fundación Cocibolca. Nicaragua.

CEPAL (Comisión Económica para América Latina y el Caribe), 2010, La economía del cambio climático en Centroamérica: Síntesis 2010, México.

FAO (2011).El estado de los recursos de tierras y aguas del mundo para la alimentación y la agricultura. Cómo gestionar los sistemas en peligro. Roma, 2011.

Comisión Nacional del Agua de México (Conagua) (2011). Diálogos por el Agua y el Cambio Climático: Llamado a la Acción. Secretaría de Medio Ambiente y Recursos Naturales, C.P. 14210, Tlalpan, México, D.F.

Convención Ramsar sobre los Humedales (1996). Resolución VI.1: Definición de trabajo de características ecológicas, lineamientos para describir y mantener las características ecológicas de los sitios incluidos en la Lista, y funcionamiento del Registro de Montreux.

Convención Ramsar sobre los Humedales (1999). Marco estratégico y lineamientos para el desarrollo futuro de la Lista de Humedales de Importancia Internacional de la Convención sobre los Humedales (Ramsar, Irán, 1971). Resolución VII.11

Convención Ramsar sobre los Humedales (1999). Lineamientos para la cooperación internacional con arreglo a la Convención de Ramsar. "Los pueblos y los humedales: un nexo vital" 7a. Reunión de la Conferencia de las Partes Contratantes de la Convención sobre los Humedales (Ramsar, Irán, 1971), San José (Costa Rica), 10 al 18 de mayo de 1999.

Convención Ramsar sobre los Humedales (2002). Resolución VIII.13.La información sobre los Humedales de Importancia Internacional (sitios Ramsar). "Humedales: agua, vida y cultura"8va. Reunión de la Conferencia de las Partes Contratantes en la Convención sobre los Humedales (Ramsar, Irán, 1971). Valencia, España, 18 a 26 de noviembre de 2002.

Convención Ramsar sobre los Humedales (2011). Noveno Sitio Ramsar en Nicaragua. En:http://www.ramsar.org/cda/es/ramsar-news-archives-2011-playitas-moyua/main/ramsar/1-26-45-489%5E25369_4000_2 .Publicado el 2011.10.18.

Guerrero, F., (2001) Clasificación Climática en Nicaragua. Dirección General de Recursos Hídricos, INETER.

Gobierno de Nicaragua (2010).Estrategia Nacional Ambiental y del Cambio Climático. Plan de Acción 2010 – 2015. La Gaceta, Diario Oficial.

Gobierno de Nicaragua (1993). Ministerio de Economía y Desarrollo/Instituto de Recursos Naturales, 1993: Plan de Acción Ambiental - República de Nicaragua (PAA-NIC).

Gobierno de Nicaragua (2001). Plan Ambiental de Nicaragua 2001-2005. Decreto 25-2001. República de Nicaragua.

Gobierno de Nicaragua (1998). Plan de Acción de los Recursos Hídricos (PARH). Política Nacional de los Recursos Hídricos. Ministerio de Ambiente y los Recursos Naturales, República de Nicaragua.

Gobierno de Nicaragua (2001). Política Ambiental de Nicaragua. Decreto 25-2001. República de Nicaragua.

Gobierno de Nicaragua (2001). Decreto No. 107-2001. Política Nacional de los Recursos Hídricos. La Gaceta, Diario Oficial Año CV, No 233. Managua, 07 de Diciembre del 2001.

Gobierno de Nicaragua (2010a). Decreto No. 44-2010. Reglamento de la Ley No. 620. La Gaceta, Diario Oficial Año CXIV, No 150. Managua, 09 de Agosto del 2010.

Gobierno de Nicaragua (2010b). Decreto No. 44-2010. Reglamento de la Ley No. 620. La Gaceta, Diario Oficial Año CXIV, No 151. Managua, 10 de Agosto del 2010.

Gobierno de Nicaragua (1996a). Decreto No. 9-96. Reglamento de la Ley General del Medio Ambiente y los Recursos Naturales. La Gaceta, Diario Oficial Año C, No 163. Managua, 29 de Agosto del 1996.

Gobierno de Unidad y reconciliación Nacional (2008). Plan Nacional de Desarrollo Humano. Managua, Nicaragua.

Gobierno de Nicaragua (1996b).Ley No. 217 Ley General del Medio Ambiente y los Recursos Naturales. La Gaceta, Diario Oficial Año C, No. 105. Managua, 06 de Junio de 1996.

Gobierno de Nicaragua (2007). Ley No. 620 Ley General de Aguas Nacionales. La Gaceta, Diario Oficial Año CXI, No. 169. Managua 4 de Septiembre del 2007.

GWP (2005). Estimulando el cambio: Un manual para el desarrollo de estrategias de gestión integrada de recursos hídricos (GIRH) y de optimización del agua. Comité Técnico del Global Water Partnership (GWP).

GWP (2011). Situación de los Recursos Hídricos en Centroamérica: hacia una gestión integrada. Global Water Parternship Centroamérica, Tegucigalpa.

GWP (2000). Manejo Integrado de Recursos Hídricos. Global Water Partership – Comité Técnico (TEC). Background Papers, No. 4.

GWP (2010).Claudia Sadoff y Mike Muller: La Gestión del Agua, la Seguridad Hídrica y la Adaptación al Cambio Climático: efectos anticipados y respuestas esenciales. Global Water Partership – Comité Técnico (TEC). Background Papers, No. 14.

INBio (Instituto Nacional de Biodiversidad) (2004): Biodiversidad en Centroamérica.

Instituto Nacional de Información del Desarrollo (INIDE) (2009).Encuesta Nacional Medición de vida.

Instituto Nacional de Información del Desarrollo (INIDE) (2008).Anuario Estadístico.

Instituto Nacional de Información del Desarrollo (INIDE) (2005). Mapa de pobreza Departamental, por el Censo de Población 2005.

Instituto Internacional del Manejo del Agua (2007): Evaluación exhaustiva del manejo del Agua en Agricultura. Agua para la Alimentación, Agua para la Vida. FAO, Londres: Earthscan y Colombo.

INETER (1998). Proyecto de Explotación Pesquera integral en la laguna de Moyúa, Municipio de Darío. Programa de Desarrollo de la Pesca y Acuicultura.

INETER (2000). Cuadrante Topográfico Laguna de Moyúa y Esquipulas 1:50 000. Managua, Nicaragua.

IPCC (2008). (Bates, B.C., Z.W. Kundzewicz, S. Wu y J.P. Palutikof, Eds.) : El Cambio Climático y el Agua. Documento técnico del Grupo Intergubernamental de Expertos sobre el Cambio Climático, Secretaría del IPCC, Ginebra, 224 págs.

IPCC (2007a). Cambio climático IPCC, 2007: evaluación de la vulnerabilidad e impactos del cambio climático y del potencial de adaptación en América Latina, Lima.

IPCC (2007b), Cambio climático 2007: informe de síntesis. Contribución de los grupos de trabajo I, II y III al cuarto informe de evaluación del Grupo Intergubernamental de Expertos sobre el Cambio Climático, Ginebra.

IPCC (2001a), Climate change 2001: the scientific basis. Contribution of working group I of the Intergovernmental Panel on Climate Change, Cambridge, Cambridge University Press.

IPCC (2001b), Climate change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, Cambridge University Press.

IPCC (2001c), "Glosario de términos," Cambio climático 2001: informe de síntesis, Ginebra.

IPCC (2000), Uso de la tierra, cambio de uso de la tierra y silvicultura, Informe especial del Grupo de Trabajo III, IPCC, PNUMA, OMM.

Lezama, M. (1999-2000). Inventario de Anátidos de Nicaragua. Departamento de Ciencias Ambientales, Universidad Centroamericana (UCA).Managua, Nicaragua.

MAGFOR (2001). Base de datos de Matagalpa y Ciudad Darío. Creación de mapas en escala 1:75 000.

Martínez-Sánchez J. C., Zolotoff J. M. y E. Castañeda, (2000).Lista Patrón de las Aves de Nicaragua. Fundación Cocibolca, Nicaragua.

MARENA (Ministerio de Ambiente y los Recursos Naturales) (2008), "Resumen Ejecutivo. Segundo inventario nacional de gases de efecto invernadero, Nicaragua".

Municipio de Ciudad Darío (2006a). Certificación No. 26: Asociación de Pobladores de la Subcuenca de Moyúa, Playitas y Tecomapa.

Municipio de Ciudad Darío (2006b). Ordenanza Municipal No. 58: Plan de Gestión Integral del Sistema lagunar Moyúa-Playitas-Tecomapa. Publicada en la Gaceta diario oficial, Número 210 del Lunes 30 de Octubre 2006, páginas 8403 a la 8413.

NORAD e INETER (1999). *Estudio de Ordenamiento Territorial de los departamentos de Matagalpa y Jinotega*. Documentos 1 y 2.Autoridad Noruega para el desarrollo internacional.

OIM & HUD (2001). *Plan Integral de Desarrollo Municipal. Municipio de Ciudad Darío.* Informe Final. Organización Internacional de Migraciones y Secretaria de Vivienda y Desarrollo Urbano.

PNUD (2006). Proyecto Desarrollo Social y Económico Comunitario en Ciudad Darío mediante Rehabilitación Ambiental (2005-2006). Programa de Pequeñas Donaciones del FMAM (GEF/SGP), Nicaragua. Informe Final.

PNUD (2009). Proyecto Desarrollo del Turismo Rural Comunitario Sostenible en el Sistema Lacustre Laguna de Moyúa, Municipio de Ciudad Darío, Departamento de Matagalpa. Programa de Pequeñas Donaciones del FMAM (GEF/SGP /Gran Ducado de Luxemburgo) en Nicaragua. Informe Final.

Salas Estrada, J.B. (2002). Biogeografía de Nicaragua. Editado por el Instituto Nacional Forestal de Nicaragua (INAFOR). Managua, Nicaragua.

Salvatierra, T. (2003). Plan de Gestión y Desarrollo Integral en la Subcuenca las Playitas, Moyúa y Tecomapa, de la cuenca del río Grande de Matagalpa, Municipio de Ciudad Darío. Tesis Magistral, Maestría en Ciencias del Agua, Centro para la Investigación en Recursos Acuáticos de Nicaragua (CIRA/UNAN-Managua).

Vargas, L. (1971). Geología y Depósitos Minerales de los Cuadrángulos de Ciudad Darío, Terragona, Las Playitas y *Esquipulas*. División de Geología, Catastro e Inventario de Recursos Naturales. Managua, Nicaragua.

Velásquez I. y Martínez A. (2000). Estudio florístico y palinológico de plantas acuáticas emergentes y flotantes en las Lagunas de Moyúa y Miraflor. Trabajo de tesis de Licenciatura en Ecología y Desarrollo. Universidad Centroamérica (UCA). Managua, Nicaragua.

Wetzel, R. (1981). Limnología. Barcelona España.

## Annex 1

Terrestrial flora

| | Scientific Name | Family | Common Name |
|---|---|---|---|
| 1 | *Albizia saman* (Jacq.) Benth. | Mimosaceae | Genízaro |
| 2 | *Albizia caribacea* (Urb.) B.R. | Mimosaceae | Guanacaste Blanco |
| 3 | *Enterolabium cyclocarpum* | Mimosaceae | Guanacaste Negro |
| 4 | *Acasia costarricenses* Schenck | Mimosaceae | Cornizuelo |
| 5 | *Coccoloba caracasana* Meisn. | Polygonaceae | Papaturo |
| 6 | *Thounidium decandrum* (Humbl. & Bonpl.) Radlk | Sapindaceae | Melero |
| 7 | *Chomelia spinoza* | Rubiaceae | Limoncillo |
| 8 | *Cassia grandis*, L. | Caesalpiniaceae | Carao |
| 9 | *Senna nicaraguense*, (Benth) Irwin & Barneby | Caesalpiniaceae | Vainillo |
| 10 | *Parkinsonia aculeate*, L. | Caesalpiniaceae | Tamarindo montero |
| 11 | *Hymenaea coubaril*, L. | Caesalpiniaceae | Guapinol |
| 12 | *Haematoxylum brasiletto* Karst. | Caesalpiniaceae | Brasil |
| 13 | *Guazuma ulmifolia* Lam. | Sterculiaceae | Guazimo de Ternera |
| 14 | *Crescentia alata*, H.B.K. | Bignoniaceae | Jicaro Sabanero |
| 15 | *Tabebuia rosea* (Bertol.) D. | Bignonaceae | Roble |
| 16 | *Ximenia americana*, L. | Olacaceae | Jocomico |
| 17 | *Morisonia americana*, L. | capparaceae | Cebo de mico |
| 18 | *Urea baccifera* | Urticaceae | Chichicaste |
| 19 | *Azadirachta indica* A. Juss | Meliaceae | Nem |
| 20 | *Combretum frusticosum*, (Loefl.) Stunz | Combretaceae | Papamiel |
| 21 | *Terminalia bucidioides*, Standl. & L. Wms | Combretaceae | Guayabo |
| 22 | *Bromelia pinguin* L. | Bromeliaceae | Piñuela |
| 23 | *Karwinskia calderonii*, Standl. | Rhamnaceae | Guiliguiste |
| 24 | *Bumelia mayana* | Sapotaceae | Sombra de Armando |
| 25 | *Thevatia ovabata*, (Cav) A.DC. | Apocynaceae | Chilca Montera |
| 26 | *Stemmadenia obovata*, (Hook. & Arm.) | Apocynaceae | Cachito |
| 27 | *Yucca elephantipes* | Agavaceae | Espadillo |
| 28 | *Opuntia sp.* | Cactaceae | Tuna |
| 29 | *Myrospermum frutescens*, Jacq. | Fabaceae | Chiquirin |
| 30 | *Phaseolus vulgaris* | Fabaceae | Fríjol |
| 31 | *Cordia alliodora*, (Ruiz & Pavon) Oken. | Boraginaceae | Laurel |
| 32 | *Cordia dentata* (Poir.) | Boraginaceae | Tigüilote |
| 33 | *Celtis iguanaea*, (Jacq.) Sarg. | Ulmaceae | Cagalera |
| 34 | *Acacia farnesiana* L. Willd. | Mimosaceae | Aromo |
| 35 | *Mangifera indica*, L. | Anacardiaceae | Mango |
| 36 | *Eucalyptus torreliana*, F. Muell | Myrsinaceae | Eucalipto |
| 37 | *Cedrela odorata* L. | Meliaceae | Cedro |
| 38 | *Sorghum vulgare* | Poaceae | Millón, Sorgo |
| 39 | *Zea mays* | Poaceae | Maíz |
| 40 | *Hyparrhenia rufa* | Poaceae | Zacate Jaragua |
| 41 | *Cymbopogon citratus* | Poaceae | Zacate Limón |

**Hydrophyte**

| | Scientific Name | Family | Common Name |
|---|---|---|---|
| 1 | *Aniseia martinicensis* (Jacq) Choisy | Convolvulaceae | Unknown |
| 2 | *Azolla sp.* | Azollaceae | Helecho de agua |
| 3 | *Caperonia castaneifolia* (L.) St. Hil. | Euphorbiaceae | Unknown |
| 4 | *Cyperus articulatus* L. | Cyperaceae | Junquillo |
| 5 | *Cyperus giganteus* Vahl. | Cyperaceae | Unknown |
| 6 | *Echinochloa crus-pavonis* (Kunth) Schult | Poaceae | Unknown |
| 7 | *Echinodorus subalatus* (C. Martius) Griseb. | Alismataceae | Pico de pato |
| 8 | *Eclipta prostrata* (L.) | Asteracea | Cabeza de pollo, botoncillo |
| 9 | *Eichhonia azurea* (Sw.) Kunth. | Pontederiaceae | Unknown |
| 10 | *Eichhonia crassipes* (Mart.) Solms. | Pontederiaceae | Jacinto de agua, Reina de agua |
| 11 | *Erechtites hieracifolia* (L.) Ref. ex. DC. | Asteracea | Unknown |
| 12 | *Hymenachne amplexicaulis* (Rudge) Nees | Poaceae | Zacate pará |
| 13 | *Limnobium laevigatum* Rich. | Hydrocharitaceae | Unknown |
| 14 | *Ludwigia leptocarpa* (Nutt.) H. Hara | Onagraceae | Unknown |
| 15 | *Ludwigia octovalvis* (Jacq.) Raven | Onagraceae | Unknown |
| 16 | *Neptunia plena* (L.) Benth. | Mimosaceae | Dormilona acuática |
| 17 | *Nymphaea ampla* (Salisb.) DC. | Nymphaeaceae | Flor de mondongo, mondonguillo |
| 18 | *Paspalidium geminatum* (Forssk.) Stapf | Poaceae | Unknown |
| 19 | *Phragmites australis* (Cav.) Trin. Ex. Steud. | Poaceae | Zacate Carrizo |
| 20 | *Pistia stratiotes* L. | Araceae | Lechuga de agua |
| 21 | *Polygonum segetum* Kunth | Polygonaceae | Unknown |
| 22 | *Rhynchospora holoschoenoides* (Rich.) Herter | Cyperaceae | Zacate sontol |
| 23 | *Salvinia sp.* | Salviniaceae | Unknown |
| 24 | *Typha domingensis* Pers. | Typhaceae | Tule |
| 25 | *Urochloa mutica* | Poaceae | Unknown |

**1. Birds**

| | Scientific Name | Common Name | | Scientific Name | Common Name |
|---|---|---|---|---|---|
| 1 | *Tachybaptus dominicus* | Zampullín Enano | 30 | *Pitangus sulphuratus* | Güis Común |
| 2 | *Phalacrocorax brasilianus* | Cormorán Neotropical | 31 | *Tyrannus forficatus* | Tijereta Rosada |
| 3 | *Anhinga anhinga* | Aninga | 32 | *Calocitta formosa* | Urraca Copetona |
| 4 | *Botaurus lentiginosus* * | Avetoro Norteño | 33 | *Hirundo rustica* | Golondrina Común |
| 5 | *Botaurus pinnatus* | Avetoro Neotropical | 34 | *Campylorhynchus rufinucha* | Saltapiñuela Barreteada |
| 6 | *Ixobrychus exilis* | Avetorillo Pantanero | 35 | *Turdus grayi* | Sensontle Pardo |
| 7 | *Ardea herodias* | Garzón Azul | 36 | *Vermivora peregrina* | Reinita Verduzca |
| 8 | *Ardea alba* | Garzón Grande | 37 | *Dendroica petechia* | Reinita Amarilla |
| 9 | *Egretta thula* | Garceta Patiamarilla | 38 | *Sporophila minuta* | Espiguero Canelo |
| 10 | *Egretta caerulea* | Garceta Azul | 39 | *Aimophila ruficauda* | Sabanero Cabecilistado |
| 11 | *Egretta tricolor* | Garceta Tricolor | 40 | *Saltator atriceps* | Saltador Cabecinegro |
| 12 | *Bubulcus ibis* | Garcilla Bueyera | 41 | *Guiraca caerulea* | Piquigrueso Azul |
| 13 | *Butorides virescens* | Garcilla Capiverde | 42 | *Quiscalus mexicanus* | Zanate Grande |
| 14 | *Nycticorax nycticorax* | Martinete Capinegro | 43 | *Molothrus aeneus* | Vaquero Ojirrojo |
| 15 | *Ajaia ajaja* | Espátula Rosada | 44 | *Icterus pectoralis* | Chichiltote Norteño |
| 16 | *Coragyps atratus* | Zopilote Negro | 45 | *Columbina minuta* | Tortolita Menuda |
| 17 | *Dendrocygna autumnalis* | Piche Piquirrojo | 46 | *Aratinga canicularis* | Perico Frentinaranja |
| 18 | *Dendrocygna bicolor* | Piche Canelo | 47 | *Coccyzus americanus* | Cuclillo Piquigualdo |
| 19 | *Anas discors* | Cerceta Aliazul | 48 | *Piaya cayana* | Cucu Ardilla |
| 20 | *Anas clypeata* | Cerceta Aliazul | 49 | *Crotophaga sulcirostris* | Garrapetero Común |
| 21 | *Oxyura jamaicensis* | Pato Cariblanco | 50 | *Ceryle torquata* | Martín Pescador Collarejo |
| 22 | *Pandion haliaetus* | Aguila Pescadora | 51 | *Ceryle alcyon* | Martín Pescador Norteño |
| 23 | *Buteo magnirostris* | Gavilán Chapulinero | 52 | *Melanerpes hoffmannii* | Carpintero Nuquigualdo |
| 24 | *Caracara plancus* | Caracara Crestado | 53 | *Myiodynastes luteiventris* | Cazamoscas Pechiamarillo |
| 25 | *Pardirallus maculatus* * | Rascón Moteado | 54 | *Zenaida asiatica* | Tórtola Aliblanca |
| 26 | *Porphyrula martinica* | Calamón Americano | 55 | *Columbina inca* | Tortolita Colilarga |
| 27 | *Gallinula chloropus* | Polla de Agua | 56 | *Himantopus mexicanus* | Cigüeñela Cuellinegra |
| 28 | *Fulica americana* | Focha Americana | 57 | *Jacana spinosa* | Jacana Centroamericana |
| 29 | *Charadrius vociferus* | Chorlitejo Tildío | | | |
| | | | | | |

**2. Fish**

| | Specie | Common Name | | Specie | Common Name |
|---|---|---|---|---|---|
| 1 | *Amphilopus citrinellus* | Mojarra | 4 | *Parachromis managuensis* | Guapote |
| 2 | *Parachromis dovii* | Guapote | 5 | *Symbranchus marmoratus* | Falsa anguila |
| 3 | *Oreochromis mossambicus* | Tilapia | | | |

| 3. MAMMALS | | |
|---|---|---|
| **Scientific Name** | **Family** | **Common Name** |
| *Alouatta villosa* | Cebidae | Aullador, congo |
| *Cebus capuchinus* | Cebidae | Mono Cara blanca |
| *Bradypus griseus* | Bradypodidae | Perezoso de tres garfios |
| *Choloepus hoffmani* | Bradypodidae | Perezoso de dos garfios |
| *Dasypus novencinctus* | Dasypodidae | Cusuco, armadillo |
| *Sylvilagus sp.* | Leporidae | Conejo |
| *Agouti paca* | Dasyproctidae | Guardatinaja |
| *Dasyprocta punctata* | Dasyproctidae | Guatuza |
| *Coendou mexicanus* | Erethizontidae | Puercoespín |
| *Sciurus sp.* | Sciuridae | Ardilla |
| *Nasua narica* | Procyonidae | Pizote |
| *Procyon lotor* | Procyonidae | Mapachín |
| *Potos flavus* | Procyonidae | Cuyuso |
| *Mustela frenata* | Mustelidae | Comadreja, |
| *Macrogeomys matagalpae* | Geomyidae | Rata taltuza |
| *Didelphis marsupialis* | Didelphidae | Zorra cola pelada |
| *Manzama americana* | Cervidae | Cabro |
| *Odocoileus virginianus* | Cervidae | Ciervo Cola blanca |
| *Felis concolar* | Felidae | Tigrillo |
| *Felis pardalis* | Felidae | Tigrillo |
| *Felis tigrina* | Felidae | Tigrillo |
| *Felis weidii* | Felidae | Gato montés |
| *Felis (Panthera) onca* | Felidae | Tigre o Jaguar |
| *Tayassu pecari* | Tayassuidae | Zahino |
| *Tayassu tajacu* | Tayassuidae | Jabali |
| *Tapirus bairdii* | Tapiridae | Danto o Tapir |

| 4 REPTILES | | |
|---|---|---|
| **Scientific Name** | **Family** | **Common Name** |
| *Micrurus micruros* | Opistoglifa | Coral |
| *Ctenosaura similes* | Iguanidae | Garrobo negro |
| *Boa constrictor* | Boidea | Boa |
| *Crotalus durissus* | Crotalidae | Cascabel |
| *Lachesis muta* | Viperidae | Matabuey |
| *Iguana iguana* | Iguanidae | Iguana verde |