

# Lake Cocibolca/Nicaragua

## EXPERIENCE AND LESSONS LEARNED BRIEF

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### 1. Introduction

Lake Cocibolca (Figure 1), also known as Lake Nicaragua, is the largest freshwater lake in Central America and one of the largest in the Americas. The history of Nicaragua and Central America has developed linked to the interests of conquerors

and foreigners who sought to grasp the geopolitical assets of the Nicaraguan freshwater inland sea and its connection to the Caribbean through the San Juan River. This magnificent lake occupies the middle section of the tectonic valley shared with two other watersheds: Lake Xolotlán (Managua) is the upper watershed, Lake Cocibolca (Nicaragua) is the middle



Figure 1. The Lake Cocibolca-San Juan River Basin.

watershed and the San Juan River is the lower watershed. This area forms the largest international drainage basin in Central America, with a total area of 41,600 km<sup>2</sup>, of which 70% or 29,000 km<sup>2</sup> are in Nicaraguan territory and 30% or 12,600 km<sup>2</sup> in Costa Rica.

## 1.1 Background

### 1.1.1 The Country

The Pacific Coast of Nicaragua was settled as a Spanish colony in the early 16th century. Independence from Spain was declared in 1821 and the country became an independent republic in 1838. Britain occupied the Caribbean Coast in the first half of the 19th century, but gradually ceded control of the region in subsequent decades. Governments were formed with people of the higher classes belonging to two parties which successively gained power by force, weakening and impoverishing the country in a long struggle that lasted more than three centuries. As part of a war in 1850, and in connection with the interest of the Transit Company (which carried passengers during the California Gold Rush from San Juan del Norte Port in the Caribbean, through the San Juan River and Lake Cocibolca, to Port San Juan del Sur on the Pacific Ocean coast), a filibuster invaded Nicaragua, became President and destroyed the capital, Granada. After ousting him, a brief calm period arrived but later foreign interventions backed a military regime which governed from 1936 until 1979. Violent opposition to governmental manipulation and corruption spread to all classes by 1978 and resulted in a short-lived civil war that brought the Sandinista Liberation Front guerrillas to

power in 1979. Nicaraguan alleged sympathy to leftist rebels in El Salvador caused the United States to sponsor anti-Sandinista Contra guerrillas through much of the 1980s. Free elections in 1990, 1996, and again in 2001 saw the Sandinistas defeated. The country has slowly rebuilt its economy during the 1990s, but was hard hit by Hurricane Mitch in 1998.

Important information on Nicaragua, which covers the majority of the lake basin, include the following:

- The economy is based on natural resources: gold, silver, timber, fish, and agriculture; and money shipments from relatives abroad to their families remaining in the country;
- Industries are based in food processing, chemicals, machinery and metal products, textiles, clothing, petroleum refining and distribution, beverages, footwear, and wood;
- Industrial production growth rate: 4.4% (2000 est.);
- Electricity production: 2,233 billion kWh (2000);
- Electricity production by source: fossil fuel (82%), hydroelectric (9%) and other (9%) (2000);
- Agriculture products include coffee, bananas, sugarcane, cotton, rice, corn, tobacco, sesame, soy, beans; beef, veal, pork, poultry, and dairy products;
- Exports are mainly commodities such as coffee, shrimp and lobster, cotton, tobacco, beef, sugar, bananas and gold totaling \$609.5 million (2001 est.);
- Imports are finished goods and commodities like machinery and equipment, petroleum products and consumer goods totaling \$1.6 billion (2001 est.); and,
- Demography: Table 1 shows estimations based on 2002 data.

**Table 1. Demographic Statistics for Nicaragua (based on 2002 data).**

Total Population	5,023,818 people
Age structure	0-14 years: 38.3% 15-64 years: 58.7% 65 years and over: 3%
Population growth rate	2.09% (2002 est.)
Birth rate	26.98 births/1,000 population
Death rate	4.76 deaths/1,000 population
Infant mortality rate	32.52 deaths/1,000 live births
Life expectancy at birth	69.37 yrs
Total fertility rate	3.09 children born/woman
Literacy	total population: 68.2%
GDP per capita	US\$507
GDP	US\$2.398 billion
GDP growth	5.5%
Inflation	11.5%
Population under poverty line	47.9% (1998)
Population under extreme poverty line	17.3% (1998)

**Table 2. Physical Information on Lake Cocibolca.**

Parameter	Value
Total surface area	8,000 km <sup>2</sup> at 31.40 m asl
Total volume	104 km <sup>3</sup>
Length along major axis	160 km
Maximum width	70 km
Maximum depth	Approx. 45 m
Mean depth	Approx. 13 m
Minimum historical water level	29.57 m (May 1886)
Maximum historical water level	33.84 m (November 1861)

Additionally, Nicaragua is extremely susceptible to natural hazards such as hurricanes, destructive earthquakes, volcanoes, and landslides. Slash and burn agriculture of subsistence not only destroys forests but also causes destruction of soils which erode and lose fertility, and is a major cause of environmental fragility.

### 1.1.2 The Watershed

There are three subsystems or component basins in the larger catchment: the Lake Xolotlán (Managua) watershed (6,669 km<sup>2</sup>), the Lake Cocibolca (Nicaragua) watershed (23,844 km<sup>2</sup>) and the San Juan River watershed (11,125 km<sup>2</sup>). Of the 23,844 km<sup>2</sup> of the Lake Cocibolca basin, 19,693 km<sup>2</sup> (83%) are in Nicaragua and 4,151 km<sup>2</sup> (17%) are in Costa Rica. Other information on the lake and its basin is given in Table 2.

Rainfall in the watershed varies from an average of 1,200 mm/yr in the northwest at Malacatoya, to an average of 4,000 mm/yr at the upper watershed of Río Frío in southeast in Costa Rica. The water balance for Lake Cocibolca over a 40-year period is given in Table 3.

**Table 3. Water Balance for Lake Cocibolca (40-year average).**

Type of flow	Quantity (in m <sup>3</sup> /s)
Direct precipitation	401
Inflow from rivers	268
Groundwater	196
Seepage from Lake Xolotlán	5
Total Inflow	870
Evaporation from surface (calculated)	399
Outflow (at San Carlos through San Juan River)	476.6
Total Outflow	875.6

There are thirty-two municipalities on the Nicaraguan side of the watershed and ten on the Costa Rican side of the border. There are differences between both social and economic conditions of the two countries, which can be seen from the indicators shown in Tables 4 and 5.

For many years, transportation on the San Juan River and Lake Cocibolca has been an important factor in the socioeconomic and political development of Nicaragua. Interest in the construction of an inter-oceanic route tapping the potential of the San Juan River and Lake Cocibolca dates back to Spanish colonial times. The first historical data records that the San Juan River and Lake Cocibolca were used to transport the riches discovered on the western coasts of South America

**Table 5. Indicators of Health and Education in Lake Cocibolca-San Juan River Basin, Costa Rican Side.**

Indicators	Average
Illiteracy (%)	15.37
Birth rate (per 1000)	31.26
Mortality (general; per 1000)	3.33
Infant mortality (per 1000)	14.48
Neonatal (per 1000)	8.6
Unemployment (%)	5.77
Water supply	
Piped water (%)	71
River water (%)	25
Rain water (%)	4
Sewerage	
Septic tanks (%)	61
Latrines (%)	38.5
Bush (%)	0.5

Source: PROCUENA San Juan project.

**Table 4. Indicators of Health and Education in Lake Cocibolca-San Juan River Basin, Nicaraguan Side.**

Indicators	Rivas	Granada	Masaya	Boaco	Chontales	San Juan	Total
School enrollment (%)							
Preschool	20.1	25.1	28.1	10.85	10.9	16.8	18.2
Primary	86.7	87.3	99.6	73.7	61.6	76.0	80.4
Secondary	21.1	18.9	38.8	16.6	16.4	7.0	25.0
Technical	n.a.	1.3	0.05	0.2	0.5	0.4	0.7
Health (%)							
Malnutrition	27.8	26.6	31.8	31.4	23.2	18.1	26.0
Sewerage (%)							
Urban	41	20	41	53	n.a.	1	31.2
Rural	86	64	85	69	77	17	66.3
Pipe-borne water (%)							
Urban	92	100	92	92	75	64	86.3
Rural	31	44	59	25	35	15	34.8

Source: PROCUENA San Juan project, based on data from SILAIS, MINSAL, INIFOM, and INEC.

and shipped to Spain during the conquest of the continent. History shows that since 1504, Nicaragua has made over 10 attempts to construct an inter-oceanic canal. To date, however, none of the projects have come to fruition. As of July 2003, there are new attempts to organize a canal company ([http://news.bbc.co.uk/hi/spanish/latin\\_america/newsid\\_3107000/3107937.stm](http://news.bbc.co.uk/hi/spanish/latin_america/newsid_3107000/3107937.stm)).

With the discovery of gold in California (1848), transiting persons from the United States and Europe sought a faster route to the gold mines through the San Juan River and Lake Cocibolca. Reports from that time indicate that in 1853 some 20,800 persons traveled from the East Coast to the West Coast of the United States using that route. Other data show that some 2,000 passengers were transported via that route on a monthly basis. However, an earthquake that occurred in July 1863 increased sedimentation in the San Juan River mouth, greatly increasing the difficulties of navigating that part of the river. Later, the construction of the transcontinental railway across the United States in 1869 put an end to the great demand for passenger transport through Nicaragua.

Nevertheless, at the beginning of this century, interest in commercial navigation through Lake Cocibolca resumed. Of the studies conducted since the 1900s on the construction of an inter-oceanic canal, the following are noteworthy:

- Isthmian Canal Commission, 1899-1901
- U.S. Army Corps of Engineers, 1929-1931
- Canal Study Commission, 1970
- Japanese Commission, 1989

Further projects related to the construction of an inter-oceanic canal have been presented more recently, using either the waters of the San Juan River and Lake Cocibolca or building a railway connecting the Caribbean Sea to the Pacific Ocean, or a combination of the two.

A number of boats that operate on Lake Cocibolca and in the San Juan River and its tributaries, facilitate the trading of goods with the Pacific region of the country and the transport of passengers to towns located in the western sector of the lake and in the Pacific zone. In some communities like North San Juan, existing water-based transportation routes between communities in Costa Rica is well known. Practically all the trade in between these communities takes place through Puerto Viejo in the Sarapiquí canton. Also, emergency medical attention and sometimes other basic services, such as telephone communications with Nicaragua and education, are obtained through Costa Rica, along the waterways.

The main port facilities located in the San Juan River basin are the following: San Juan del Norte, El Castillo, and Sábalo, located on the San Juan River; Granada, San Jorge, San Carlos, and San Miguelito, located on the banks of Lake Cocibolca; and Moyogalpa, Altigracia, and Solentiname, located on Ometepe Island and in the Solentiname Archipelago, respectively. Los Chiles, Puerto Viejo, and Barra Colorado are ports situated

on the tributaries flowing from the southern sector of the basin. A feasibility study of the local transportation system in Lake Cocibolca and in the San Juan River conducted in 1970 found that the economic and financial benefit of the project was positive. Since then, however, there have been no new estimates on local navigation in these water bodies.

Navigation on the San Juan River and in Lake Cocibolca are affected by the progressive sedimentation of both water bodies. Navigation is also an important source of pollution of the water resources, due to the fact that boats are washed and serviced in both water bodies. The waterbodies, therefore, become depositaries of hydrocarbon residues, agricultural chemicals, basic grains, pigs, domesticated animals, and other products that are transported across these bodies of water.

The basin's water resources have great potential for hydroelectric generation. The considerable flow rates, combined with significant altitude changes within the basin, have led to the development of this type of project in the San Juan River basin. To date, there are four known hydroelectric development proposals to use the average flow rate at which Lake Cocibolca empties into the San Juan River as the source of the power supply. The projects are: Tipitapa-Tamarindo, Brito, Brito Residual, and Interlagos. None of these options have been discarded as of this time.

The construction of any of these projects will mean substantive changes in the average flow rate of the San Juan River, reducing it by some 36%. This will undoubtedly have a strong impact on navigation in the river. Aspects to be considered if these projects are implemented should be their effects on the aquatic life in the San Juan River and Lake Cocibolca, the local human populations, flora and fauna existing in the area to be inundated by the proposed dams, and the environmental impact that will result from all the associated construction works.

In addition to the large projects discussed above, there are currently several public and private hydroelectric projects in the southern sector of the San Juan River basin, which are at different stages of development. The private projects are approved by the ICE and carried out by private firms.

The possible conflicts in water use are discussed whenever an option for hydroelectric power or inter-oceanic canal construction is presented, especially since between 300 and 400 m<sup>3</sup>/s of the existing river flows abstracted to meet the requirements for potable water and irrigation water supplying suitable farmland in the Pacific region of Nicaragua.

On the banks of lakes Xolotlán and Cocibolca and in the León-Chinandega plain, there are 742,000 hectares of land suitable for irrigation (152,000 ha in the Lake Xolotlán zone, 432,000 ha in the area of Lake Cocibolca, and 158,000 distributed in the León-Chinandega area). The potential, available water in the León-Chinandega plain and along the banks of the lakes is approximately 0.745 km<sup>3</sup>. This volume could provide the

water supply to irrigate approximately 138,000 ha, resulting in a shortfall in the amount needed to irrigate some 600,000 ha. To make up for this shortfall, a number of different alternative projects have been proposed, all of them drawing on Lake Cocibolca as the source. The most recent study, "Irrigation Strategy for Pacific Nicaragua", envisaged damming the waters of the San Juan River at San Isidro, maintaining the water level of Lake Xolotlán at 32 m asl, draining water from Lake Cocibolca into Lake Xolotlán by constructing a canal on the Tipitapa River, and pumping the water available up to the 100 m asl mark. This scheme would then irrigate, using gravity, the 600,000 ha needing irrigation that are below this elevation. This project envisages generating power through the Tamarindo River, the replenishing of Lake Xolotlán, and the provision of drinking water supplies to towns requiring this service, including Managua.

Like the hydroelectric projects, this proposed project would change the average flow rate of the San Juan River, which, in turn, will heavily impact navigation of the river. Aspects to be considered with this project should be the effects on aquatic life related to the San Juan River, lakes Cocibolca and Xolotlán, the existing flora and fauna in the area to be flooded by the proposed dam, and the environmental impact of the construction and all related works. There is conflict in the use of water for this irrigation project because, the wider the area irrigated, the less water available for power generation and the drinking water supply.

Though the drinking water supply is a problem in the basin, it does not place any particular pressure on the resource because of the limited size of the demand. However, municipal and industrial wastewater does indeed pose a threat to water quality. Due to the fact that most of the population discharges its wastewater in riverbeds, streams, or directly in the lake or river with no prior treatment, the quality of the water of those bodies of water has noticeably deteriorated. Critical points in this regard are San Miguelito, San Jorge, Granada, Juigalpa, San Carlos, El Castillo, Sábalo and San Juan del Norte.

## 1.2 Political and Administrative Situation of the Basin

The area of the Lake Cocibolca-San Juan River basin system respects the physical boundaries of the watersheds of the hydrographic basin which do not coincide, in either of the two countries, with the political-administrative boundaries. This factor complicates the management of socioeconomic information, usually available in accordance with the territory's political-administrative division. In Costa Rica, the political-administrative division is by provinces and "cantons" or municipalities. The Project of Formulation of a Strategic Action Program for the Integrated Management of Water Resources and the Sustainable Development of the San Juan River Basin its Coastal Zone (PROCUENCA; under auspices of the Organization of American States (OAS) and United Nations Development Programme (UNDP)), defines an area which completely encompasses the cantons of La Cruz, Upala, Guatuso, Los Chiles, San Carlos, Sarapiquí, and Pococí; other

cantons are partially within this area. However, due to the fact that they do not have a significant impact on the dynamics of the basin, they have not been considered in that study.

In the case of Nicaragua, the political-administrative division is defined in terms of departments and municipalities. The Nicaraguan sector includes the entire San Juan River Department and important parts of the Departments of Masaya, Granada, Boaco, Chontales, and Rivas, with a total of 32 municipalities. PROCUENCA is at this moment the most important initiative to document the situation on the watershed to prepare a management plan.

PROCUENCA has calculated the population living within the project's boundaries at 1,067,952. This number is an approximate figure because the registers in both countries were defined on the basis of canton and municipality and not of the basin. The population belonging to the Nicaraguan sector is 779,339, or 73% of the basin's population; the population belonging to the Costa Rican sector is 288,613, representing the remaining 27%.

The geographic distribution of this population is not homogeneous. This is most notable in the case of Nicaragua, where 42% of the population is concentrated in four municipalities, and the most important cities (Masaya, Granada, and Juigalpa) are located within three of these. The remaining population is distributed over 29 municipalities. The average population density is approximately 46 inhabitants/km<sup>2</sup>. 55% of the population is rural.

In the Costa Rican sector, the population is predominantly rural (85% of the total). There is just one main urban center, Quesada City, capital of the San Carlos canton. The average density is 22 inhabitants/km<sup>2</sup>. These numbers can be misleading since there are extensive zones with very limited populations, and parks, as well as reserves that are uninhabited.

## 1.3 Environment

The waters of the Lake Cocibolca-San Juan River basin flow through at least eight distinct terrestrial ecosystems, including:

- dry tropical forest to the east, north, and west of Lake Cocibolca;
- cloud forest in the high areas of the Central Volcanic Cordillera of Costa Rica;
- moist tropical forest to the south and southwest of Lake Cocibolca and in the eastern foothills;
- very moist tropical forest in the San Juan Valley and on the coastal plains;
- gallery forest along river banks;
- wetlands to the south of Lake Cocibolca and at the confluences of the Colorado and Tortuguero rivers with the San Juan;
- second-growth forest, meadows, and agricultural land in extensive areas of the basin; and,

- coastal forest and mangrove swamps on the Caribbean coast.

Because of this range of ecosystems and associated habitats, the Lake Cocibolca-San Juan River watershed has a wealth of biodiversity. Its location in the natural biological corridor running the length of Central America has made it a meeting ground for species from the subarctic areas of North America and others from the subtropics of South America. To a great extent, its natural history is unique. The low population density in a few parts of the Lake Cocibolca-San Juan River basin has kept it relatively pristine, although there is little information on the potential future impact of human migration trends and the spread of agriculture in the basin.

Regional studies now being carried out by the Central American Committee on Water Resources, with international cooperation, led to the conclusion that the fresh water in the Lake Cocibolca-San Juan River basin is the only source capable of meeting the foreseeable development needs of the semi-arid Pacific slope of Central America, the region's most populated area. Thus, it is likely that this system will come under increasing pressure of human exploitation. In addition, because the Lake Cocibolca-San Juan River basin is also a common westward passageway for anticyclones from the Atlantic to the Pacific, the threat of hurricanes and tropical storms, on top of the threats posed by volcanic activity and seismic pressures that already make this freshwater supply especially vulnerable, further exacerbating the human pressures likely to be experienced within this hydrologic system.

However, there are other threats to the Basin, coming from residues of pesticides and other agrochemical substances. In 1992, the Research Center for Inland Waters of Nicaragua, (CIRA/UNAN), affiliated to the National Autonomous University of Nicaragua, at request of the Ministry of Environment and Natural Resources (MARENA), carried out a sampling program on waters, benthic organisms and sediments of the San Juan River. The results, showing high concentrations of pesticides used in banana plantations, were sent by MARENA Minister to the Chancellor's office and a verbal note of protest was presented by Nicaragua to the Costa Rican Government. Consequently, a meeting of the Central American Commission of Environment and Development (CCAD) requested support to OAS and UNDP to initiate a research program to establish the severity of the problem.

In October 1994, UNEP and OAS signed an Agreement in which both organizations agreed to support Costa Rica and Nicaragua in carrying out the Project for Environmental Management and Sustainable Development of the San Juan River basin. UNEP agreed that the OAS would be the executing organization with respect to technical cooperation. The project's technical activities were initiated in June 1995.

The project's main objectives were defined as those relating to human development and the preservation of natural resources and ecosystems. The following aspects were given priority:

- Management and preservation of shared basins and water resources;
- Management of protected areas and preservation of biodiversity;
- Incentives for the development of sustainable economic activities;
- Overcoming the population's conditions of poverty, and attention to indigenous groups; and,
- Institutional strengthening and legislation which would reconcile key issues at the border and Central American level.

Due to their characteristics, the Central American border areas, and especially the Project areas, are key elements in the structuring of any alternative directed towards protecting the environment, combating poverty, and creating a favorable atmosphere for the countries' sustainable development. Likewise, the border areas favor the possibility of creating biological corridors which would permit the most effective preservation of biodiversity, avoiding fragmentation of the natural ecosystems.

## 2. State of the Lake and Basin Environment

As noted before, the basin includes three well-differentiated sectors: the Lake Xolotlán (Managua) basin, the Lake Cocibolca (Nicaragua) basin, and the San Juan River basin (Figure 1). Since Lake Xolotlán occasionally connects with Lake Cocibolca through the Tipitapa River, it has not been considered in PROCUENCA Project. However, the basins of the Indio and Maíz Rivers in Nicaragua and the Tortuguero River in Costa Rica (these are not depicted in Figure 1) have been included because they share environmental conditions similar to those of the lower San Juan River basin.

### 2.1 Sediments in Lake Cocibolca and the San Juan River

Sediments originate in the upper and middle parts of the basins and are the result of strong rains, the fragility of many volcanic soils, the deforestation to which the area has been subjected, and agricultural/livestock development. In Nicaragua, agricultural activity and deforestation have caused erosion problems and, as a result, floods and the diversion of watercourses.

Lake Cocibolca is the depository for sediments carried by its tributaries. It also receives runoff and subsurface drainage which carry dissolved or suspended fertilizers and pesticides used in the area. There is almost no knowledge about the volume of sediment arriving at Lake Cocibolca. This information is essential to appreciate the seriousness of the problem and to implement the conservation practices, requirements that would allow for the preservation of lake.

At the Terrón station on the San Carlos River in Costa Rica, the contribution of sediment was calculated at 817 metric tons/km<sup>2</sup>/yr; at Peñas Blancas, 700 metric tons/km<sup>2</sup>/yr;

at Punta Viejo and Veracruz on the Sarapiquí River, it was calculated at 216 metric tons/km<sup>2</sup>/yr. At the Guatuso station on the Frío River, a contribution of 298 metric tons/km<sup>2</sup>/yr was calculated.

Periodic samples of suspended sediments transported by the rivers have not been taken at key stations; however, the sedimentation can be verified visually. Already in 1868, Thomas Belt, an English mining engineer and naturalist, noted the sand banks development along the San Juan River due to deforestation. Sediment has caused some riverbeds to be filled in, with the consequent problems of overflow, floods, and the formation of new beds. This especially affects the San Juan River delta and, therefore, the animal habitat of the seacoast.

## 2.2 Presence of Pesticide Residues in Sediments of Lake Cocibolca

The agriculture on the basin relies on heavy usage of agrochemicals. Table 6 shows crops raised in both sides of the basin, and the different substances employed. Lack of control of both substances and concentrations applied remains as a major challenge to meet.

In 1994, 1997, 2002 and 2003, the Research Center for Inland Waters of Nicaragua (CIRA/UNAN) carried out sampling campaigns surveying organisms (phytoplankton, zooplankton, fish, benthic organisms), water and sediments. The most striking results are those of pesticide residues contents of the sediments. Organochlorine pesticides, (pp-DDT, lindane, dieldrin, heptachlore), and organophosphorous (methyl parathion) were found in all 49 sampled sites, at concentrations of health concern both for people and the environment. For example, the pp-DDE concentration was found to be as high as 790 pg/g in the sediment at one station (CIRA/UNAN 1992-2003).

## 2.3 Biological Diversity

The confluence of the bio-geographical regions of North and South America has given the San Juan River basin a varied and rich biological diversity. In addition, the largest tropical rain forest north of the Amazon region is also found here. However, the basin area has been irreversibly changed, despite the fact that nature reserves are maintained and appropriate areas are identified to serve as buffer zones and for environmental restoration. Some of these areas have a very high representation of ecosystem types, which affords them a high potential for use in non-extractive activities. These activities could generate resources to partially finance their protection and development activities.

A total of 51 protected areas, varying in type and size, have been identified in the basin. Thirty-three of these have been established in Costa Rica and 18 in Nicaragua. The main types of protected areas found in the basin are biological reserves, national parks, wildlife refuges, protected areas, and nature reserves.

The main terrestrial threats to the preservation of biodiversity of the basin have been identified as:

- Lumber exploitation and deforestation;
- Recurrent burning of pastureland;
- Mining activities;
- Damming or redirecting of surface waters;
- Unplanned colonization and ramshackle settlements;
- Contamination by agrochemicals and other products;
- Erosion and soil loss;
- Problems regarding land possession; and,
- Lack of a unified conceptual framework between the two countries with respect to the management of protected areas.

**Table 6. Crops and Pesticides Used in the Watershed Area.**

Crops	Insecticide	Nematicide	Fungicide	Anti-bacterial/viral	Herbicide	Molluskicide
Rice	✓	✓	✓		✓	
Beans	✓	✓	✓	✓	✓	✓
Corn	✓	✓	✓			
Roots and Tubers	✓	✓	✓	✓	✓	
Oranges	✓	✓	✓	✓		
Bananas	✓	✓	✓		✓	
Coffee		✓	✓			
Pineapples	✓	✓	✓		✓	
Sugar cane	✓		✓	✓		
Cotton	✓			✓		
Peanuts	✓	✓	✓	✓	✓	
Vegetables	✓	✓	✓	✓		

Source: PROCUENA San Juan project.

In conclusion, it should be pointed out that in both countries, alternatives for the preservation and sustainable management of biodiversity exist. The alternatives include:

- defining buffer zones to temper the pressures on protected areas;
- implementing biological corridors which aid the preservation of species of fauna or for environmental restoration; and,
- fostering greater understanding and abilities with respect to preservation of the protected areas. In all cases, these alternatives are subject to a clear definition of objectives and methodologies which will help prioritize consistent with the aspirations, motivations, and opportunities afforded to local societies.

### **3. Economic Activities in the Basin Based on Natural Resources**

At different times, the section of the basin belonging to each country was affected by strong growth in agricultural and livestock activities. These activities have generally expanded both in suitable areas and in areas where the capacity for use under current conditions is for forests. As a result, there has been indiscriminate deforestation. In the case of Costa Rica, the forests that existed in the low lands, lands with lesser slopes, and non-floodable lands in the basin have practically disappeared; and in the case of Nicaragua, the remaining natural forests have deteriorated up to the very boundaries of the most significant biological reserves. The process has been generated by the destructive use of forest resources and the advance of shifting agriculture and livestock production. For this reason, significant areas have been exposed to erosion generated by high-intensity tropical rains, with the loss of soil which is then reflected in increased levels of water turbidity. Agricultural production technologies, which are in many cases inappropriate, and the intensive use of agrochemicals on certain crops have adversely impacted the quality of water resources, a factor that has only had limited studies to date.

In the Nicaraguan sector, the agricultural frontier is expanding, in many cases on ground of low productive capacity. This constitutes one of the causes of deforestation and of the great pressure on protected natural areas. It is estimated that 8.5% of the Nicaraguan sector and 8% of the Costa Rican sector is occupied by primary and secondary forests.

In the case of Costa Rica, the productive incorporation of these territories has already occurred and the need for land is now directly pressuring the protected areas. In Nicaragua, the agricultural frontier is still rapidly expanding eastward, in a new drive, without having achieved its consolidation and is threatening the Great Indio-Maíz Biological Reserve. The causes of this process are found in a combination of factors: it is linked to subsistence agricultural production, inefficient use of natural resources, and migration to new lands. These lands

lose their fertility and are abandoned after a few years, making way for pastures and stockbreeding; thus the elimination of the forest is consolidated. At different times, this process has been encouraged by means of national incentives for stockbreeding, based on direct or indirect subsidies.

The indiscriminate extraction of lumber has been an additional factor in deforestation. The options for discouraging the destruction of the forest do not seem simple. They require the implementation of mechanisms which intensify and permanently settle agricultural production. This would require the adoption of new practices by the producers, as well as a change in their attitude with respect to the use of natural resources. Forest production requires, in its turn, new approaches which revert the extractive concept of forest exploitation. In addition, it would require a change to a productive activity with longer cycles, one which offers economic conditions that would permit it to compete with other alternative lands uses.

The area for agricultural uses covers 60% of the territory. In Nicaragua, the basin produces 26% of the national bean crop, almost 21% of the sorghum, and slightly more than 16% of the corn and sugar cane. In the Costa Rican sector, the basin produces 54% of the beans, 11% of the sugar cane, 6% of the corn and banana production, and 90% of the production of tubers and roots.

Agriculture in the Lake Cocibolca-San Juan River basin reveals marked asymmetries with respect to the number of producers and available land areas. Commercial producers represent 11% of the total and occupy 55% of the land, and small and subsistence producers represent 88% and occupy 49% of the total area.

In the Nicaraguan and Costa Rican sectors of the basin, stockbreeding has a fundamental role because nearly 20% of the national herd is found in the project area. In Nicaragua, the breeds are generally dual purpose. In Costa Rica, on the other hand, there is a tendency toward specialization in accordance with the type of production, meat or milk. Management of stockbreeding activities should improve at the global level in order to increase production instead of increasing land areas devoted to this activity. Improvement of the herds is a priority, as are planning and management of the fodder base, development of breeding services, and improvement of sanitation for livestock.

Some industries associated with the primary production activities are located in the area. There are a total of 70 sawmills in operation, 10 in the Nicaraguan sector and 60 in the Costa Rican one. Under the heading of agroindustries, the following stand out: in Costa Rica, the presence of four banana companies located in Pococí Canton, one citrus fruit processing plant in Los Chiles, three sugar mills, a milk producers cooperative located in Quesada City, San Carlos Canton, and numerous coffee processing plants. In the Nicaraguan sector, the agro-industrial activities are associated with the sugar



mills located in Rivas Department, one tomato processor in Nandaime Municipality, one palm oil extractor in El Castillo Municipality, and several coffee processing plants.

#### 4. Framework of Legal and Institutional Work

Both countries have made progress with respect to the definition of a legal framework which considers, both in a sectoral and integrated manner, the factors which create environmental management in national areas and in international relations. These instruments have two types of limitations: on the one hand, institutional and organizational capacity to implement them is weak, and on the other, there are gaps and overlapping areas which make it difficult to use them adequately. It is not by coincidence that in both countries, changes have occurred in the legal instruments which are conducive to improving the unity and coherence which reality demands. The creation of the Ministry of Energy, Resources, and Mines (MINAE) and the Ministry of Environment and Natural Resources (MARENA) as organizations responsible for environmental management and management of natural resources in Costa Rica and Nicaragua, respectively, are two examples. Also, in both countries there are numerous institutions which directly or indirectly have authority over the environment and various natural resources, including water, which makes it difficult to clearly establish their jurisdictional boundaries, their responsibilities, and the control which each exercises in practice. This multiplicity of jurisdictions and superposition of functions caused by the various activities that are carried out both in and outside of the basin, impacts negatively on the evaluation and control of the environmental impacts.

In short, the existing constitutional mandates, institutional mandates, laws, and international agreements suggest that there is a sufficient regulatory framework to direct environmental management actions, biodiversity preservation, and sustainable development. The major limitations are associated with the institutional, technical, and organizational capacity to enforce compliance with this regulatory framework and the lack of public awareness which facilitates legal action in every country. Although the instruments which regulate binational relations with respect to the boundaries and the laws of the countries associated with the San Juan River do exist, the regulation of environmental issues where water resources are key, and the intent to jointly develop the territories around the basin lack the legal framework that promotes binational cooperative efforts. The national initiatives have concentrated on a few agreements regarding specific work. For example, the Proyecto de Areas Protegidas para la Paz (Protected Areas for Peace Project, SI-A-PAZ) with regards to the efforts undertaken by the Presidents and Chancelleries of both countries, through which the Binational Commission has been, in recent years, revitalized to deal with border issues of common interest.

Costa Rica and Nicaragua define their borders in accordance with the provisions of the Cañas-Jerez Treaty of April 15, 1858, ratified by the Cleveland Decision of March 22, 1888. The State of Costa Rica, in its Constitution, Article 121, specifies that

natural richness and biodiversity, among others, are a benefit belonging to the nation; the same is stipulated by Article 89 with respect to natural beauty. The Constitution of Nicaragua refers specifically to the environment and natural resources in two articles: 60 Cn, which establishes the right of Nicaraguans to live in a healthy environment; and 102 Cn, which stipulates that natural resources are the national heritage.

#### 5. Situation Assessment

The GEF Operational Strategy lists four major areas of concern relating to international waters:

- degradation of the quality of water resources;
- physical habitat degradation of coastal and near-shore marine areas, lakes and watercourses;
- the introduction of exotic species that disrupt aquatic and land ecosystems; and,
- excessive and/or inappropriate exploitation of resources due to inadequate management and control measures.

These issues were identified as part of an earlier study, carried out jointly by UNEP and the OAS, that pointed to a number of current and emerging problems that threaten the sustainability of development in the San Juan River basin and ultimately the quality of life of the people who live there. These transboundary environmental problems often have common roots and manifest themselves both individually and collectively. They are closely interrelated, but in the interest of seeking solutions they have been broken down as follows.

##### 5.1 The Accelerating Degradation of Transboundary Ecosystems

In the traditional uses of the main ecosystems of the area, human activities have exerted pressures on the environment and resulted in conflicts among the various groups involved, with negative consequences for the quality of water resources. These consequences include inadequate urban, industrial, and agroindustrial wastewater treatment systems; migratory agriculture, extensive grazing and the consequent extension of the agricultural frontier; widespread cutting of trees for timber, unregulated ecotourism, non-conservationist farming practices, the introduction of aggressive exotic species such as *Tilapia spp.*; and uncontrolled fires in the drier forests and of grassland. An emerging problem is the growing use of small and very small hydropower plants to tap the considerable hydroelectric potential of the region.

##### 5.2 Overexploitation of Valuable Natural Resources

The problems here are related to poor land use, especially the farming of hillside areas and wetlands, the construction of poorly designed roads, unregulated fishing, and excessive exploitation of valuable moist tropical forest species and the

destruction of plant cover in fragile areas, causing erosion and land degradation. The result is a loss of potential income from agriculture, fishing and tourism, a threat to biodiversity and the natural productivity of the ecosystem, and a change in coastal and inland waterway dynamics. There are signs that three marine and freshwater species are being over exploited: *Carcharhinus leucas*, locally called “bull shark” or “freshwater shark” because of its unique behavior of migrating between the Caribbean Sea and Lake Cocibolca; *Pristis perotteti* or big sawfish; and *Pristis pectinatus* or fine-toothed sawfish.

### 5.3 Soil Degradation and Increasing Sedimentation

Part of the sedimentation of the San Juan River and its coastal zone is produced as a result of natural processes, according to historic documents. Nevertheless, road construction, the advancing agricultural frontier and its associated deforestation, and hillside farming without adequate soil-conservation techniques exacerbate sedimentation problems, as well the emerging problems arising from open-pit mining and the extraction of construction materials.

### 5.4 Pollution of Water Bodies

The main causes of water pollution are the indiscriminate use of pesticides and fertilizers, especially where intensive farming practices are used, and urban, industrial, and agro-industrial waste discharges. The water bodies being affected in Nicaragua are Lake Cocibolca, the San Juan River and its coastal zone, the wetlands to the south of Lake Cocibolca. In Costa Rica the Caño Negro wetlands, the Colorado River, and the Tortuguero canals are suffering the consequences of degraded water quality. Sporadic die-offs of aquatic fauna and flora give evidence of such degradation, as do small-scale and occasional studies of water quality that have been carried out in some parts of the Lake Cocibolca-San Juan River Basin.

### 5.5 High Vulnerability to Natural Hazards

This is apparent in the devastating impact of hurricanes and tropical storms on the region’s ill-housed populations, on its infrastructure, and on crops grown in areas where the forest has been cleared and the soil is fragile (areas exposed to landslides caused by hurricanes, tropical storms, and seismic or volcanic activity). Natural hazards can have a drastic and dramatic effect on the watercourses of the region.

### 5.6 Inadequate Planning and Management

Although MINAE and MARENA are both trying to promote integrated watershed management using the legal mechanisms provided within each country through their own environmental legislation, there is no watershed planning and administration capacity in place. There have been no mechanisms for coordinating management and control across the international border and, thus, no ongoing institutional approach to water resources management in the Lake Cocibolca-San Juan River basin. The lack of comprehensive up-to-date data on the Lake

Cocibolca-San Juan River basin—how it is structured, how it works, what its socioeconomic dynamics are, how information is managed at the local level—makes it impossible to proceed with the minimum certainty needed.

### 5.7 Weak Institutions

Although both countries have quite comprehensive legislation on environmental management and the sustainable use of natural resources that could be implemented locally, a paucity of financial and human resources on the local level and the poverty in which most of the population lives makes compliance difficult.

### 5.8 Insufficient Human and Institutional Capacity

Natural resource management is inefficient and it will not be possible to strengthen environmental command-and-control mechanisms without first creating local economic foundations and training people.

### 5.9 Limited Stakeholder Participation

There is currently limited participation by stakeholders in sustainable development due to centralization of decision-making, which the governments are currently trying to change. This situation, added to reductions in the overall size of government, has hampered local action. This organization recognizes the need to promote and strengthen civil society organizations, increase the participation of women, and involve more people in decision-making on the sustainable development of the Lake Cocibolca-San Juan River basin. The initial steps toward enhancing stakeholder participation have been already taken during the execution of the GEF supported Block B program and through other actions of MINAE and MARENA. These steps now need to be reinforced and further developed through programs to educate people about sustainable development and adopting sustainable production practices and lifestyles within a comprehensive watershed management approach that does not yet exist.

### 5.10 Extreme Poverty

Extreme poverty, combined with high population growth, low incomes and a subsistence economy, poor sanitation conditions, and a relative imbalance in employment and income-generating opportunities between the two countries, characterizes the current level of economic development in the Lake Cocibolca-San Juan River basin. Uncontrolled migration exacerbates the situation, by exceeding the capacity of existing institutions to meet all the sanitation, health, and educational needs created. The economic conditions force the inhabitants to move to the mountainsides and practice slash-and-burn agriculture just to survive. These reactions contribute to the environmental degradation being experienced in the Lake Cocibolca-San Juan River basin, but can be addressed, in part, through building institutional capacities and creating

economic instruments, neither now existing, to address such problems.

## 6. The PROCUENCA Project

### 6.1 Components

Thus far, the PROCUENCA Project has been the only activity that has devised a comprehensive initiative, including critical policy, legislative and institutional framework for long term basin management. It is comprised in the following components.

**Component 1:** Formulation of the Strategic Action Plan (SAP). Development of the SAP is the core task to be completed by the Technical Units in close consultation with UNEP and the OAS pursuant to the implementation arrangements.

**Component 2:** Lake Cocibolca-San Juan River Basin Information System. The objective of this Component is to enhance the capabilities of existing infrastructure in the decision-making process at all levels of government, and to encourage technical cooperation at the national level, by contributing and disseminating information among stakeholders, while, in the first instance, specifically facilitate data acquisition and sharing through an improved system.

**Component 3:** Strategic Actions with Stakeholder Involvement. Strategic planning and management will depend on integrating basic research with a series of activities and investment projects carried out within the identified geographic and subject areas to be targeted for development. Historically, such projects have lacked effective stakeholder involvement as a result of the institutional and human resource issues identified above. As an integral part of the process of formulating the SAP for the Lake Cocibolca-San Juan River basin, a series of demonstration activities illustrative of ways and means for promoting sustainable agriculture production and the conservation restoration of land and water ecosystems will be conducted, providing both an assessment of cost and feasibility, and specific examples to local communities of alternative means of production and land and water resource management. Economic mechanisms contributing to the sustainable management of natural resources and to meeting the demand of the inhabitants for improved living conditions, and to solve the conflicts that can arise over plans and decisions affecting resource use will be specifically identified and developed. This component will facilitate interaction between the GEF-funded activities and those of on-going development projects.

**Component 4:** Public Participation. This component will foster and support the participation of all stakeholders, including the general public, in the development and implementation of the activities carried out under the Lake Cocibolca-San Juan River basin project, and complement the activities proposed under Component 3 (above). Success is dependent on identifying and motivating stakeholders and giving them an opportunity to participate, including, where necessary, through financial

contributions. National and binational workshops will be organized to give stakeholders the opportunity to become involved, to engage their commitment and facilitate SAP implementation. The project team will strive to assure gender balance in these activities. To establish a broad base of participation and learn the capacity of organizations to carry out actions, the four demonstration projects in various natural areas within the Lake Cocibolca-San Juan River basin are envisioned. These activities are to be more broadly-based and inclusive of the general public and public-at-large than those to be conducted under Component 3 (above), and will contribute to inclusion of public inputs beyond those considered from an economic perspective.

**Component 5:** Local, national and bi-national level institutional arrangements. This component is designed to correct problems identified in the transboundary diagnostic analysis (TDA) regarding the shortcomings in institutions working at the local and national levels, and to encourage enhancement of binational coordination between institutions within the Lake Cocibolca-San Juan River basin as well as to ensure that the prescribed actions of the SAP are incorporated into national policies. Technical meetings bringing together MINAE and MARENA personnel and cooperative research efforts between universities and other institutions of both countries will be promoted. Current institutional arrangements and the role they play in the management of the San Juan River basin will be reviewed. This component is complementary to Component 6 (below).

**Component 6:** Capacity building and institutional strengthening. This component will foster the formation of basin councils in critical sub-basins and encourage the participation of such councils within the municipal sustainable development councils existing within the Lake Cocibolca-San Juan River basin. The Federation of Local Border Governments will be strengthened through specific activities with clearly defined goals in order to promote the strengthening and further development of coordination mechanisms at the local level. A proposal to strengthen institutions will be drafted with measures for: (a) building sustainable development planning and management capacities; (b) improving infrastructure; (c) equipping institutions; and (d) designing mechanisms to increase the incomes of local and regional institutions. These activities will be supported by two demonstration projects establishing costs and feasibility of achieving integrated management as well as assessment of specific paradigms to be developed at specific sites within the Lake Cocibolca-San Juan River basin.

**Component 7:** Education and training in conservation and the sustainable use of natural resources. This component has been designed to provide the building blocks of an education and training Program that will make the inhabitants of the Lake Cocibolca-San Juan River basin more aware of the important role that water resources play in society, in the economy, and in nature. It will be especially geared to students and young people, who generally are more willing to change their habits

and production practices, and who have been shown to be effective conduits by which such habits and practices can be transferred into individual households to the benefit of entire communities. Best sustainable production practices will be identified. The information will be disseminated in both countries and knowledge will be furthered through training for various kinds of local organizations working in the fields of development and environmental conservation. Workshops, seminars, and technical meetings will be held in conjunction with the preparation of the SAP. Materials for environmental education will be collected, designed, and implemented in three demonstration projects, which will be evaluated to aid in the design of the implementation Program.

## 6.2 Initiatives from Municipalities

Local governments have a crucial role to play in the development of the afore-mentioned processes. In parallel with the work carried out by PROCUENCA, the municipalities around Lake Cocibolca organized in an Association of Municipalities of the Great Lake (AMUGRAN), which consists of 32 municipalities. The Association has agreed on a Declaration of Policies for Uses of the Lake Cocibolca and its basin, and on their Conservation. This historic declaration sets a reference framework so stakeholders in the municipalities are helping to define both the course of the economic development and the protection of the basin resources.

## 7. Lessons Learned and Recommended Initiatives

For a long time, state agencies from the Central Government of Nicaragua have not been able to coordinate development efforts on the basin of the Lake Cocibolca-San Juan River system. As a consequence, many of the undesirable effects already presented above have resulted in degradation of the basin and loss of resources and development opportunities. Information now available from a major effort done through PROCUENCA sheds light on how stakeholders involved in conception and development of plans, programs, and projects can help to improve the general situation. Public awareness of the losses of environment assets seen as both economic and social opportunities losses, leads public opinion into national attention.

Lack of reliable scientific data has been a major drawback and must be taken into account for any Strategic Action Plan to be devised.

The interest of the Mayors of the Municipalities associated in AMUGRAN can drive the SAP and help the Central Government to initiate needed actions at the local level. In this aspect, the request that AMUGRAN presented both to the President of the Republic and to the National Assembly on June 4 and 5, 2003, to have a Law which would declare Corridor of Sustainable Development for the Municipalities contained in the Lake Cocibolca-San Juan River basin. This initiative would integrate the many protected areas, Ramsar sites, archeological and

cultural monuments, and would help the proposed nomination of the Lake Cocibolca as a UNESCO world natural heritage site, requested by the Nicaraguan government.

## 8. References

This document draws heavily from materials available on the PROCUENCA San Juan project website (<http://www.oas.org/sanjuan/>) including:

OAS (Organization of American States) and UNDP (United Nations Development Programme). 1997. *Diagnostic Study of the San Juan River Basin and Guidelines for an Action Plan: Executive summary*. (Available at <http://www.oas.org/sanjuan/english/documents/diagnostic.html>).

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