ADAPTING TO CLIMATE CHANGE

A STORY OF COMMUNITIES THAT HAVE OVERCOME THEIR VULNERABILITY TO DISASTER ON THE HONDURAN COAST

Schweizerische Eidgenossenschaft
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Adapting to Climate Change:

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Al servicio
de las personas
y las naciones

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I. Introduction

The experience of Santa Rosa de Aguán reflects the challenges of a community with deep territorial and cultural roots that has faced multiple disasters and fragile recuperation processes and has seen how climate change puts pressure on its livelihoods.

This document explains how a Honduran Garifuna community has recalled and renewed its commitment to protect its land and strengthen the collective effort. The women and men of Santa Rosa de Aguán have led a process of awareness and training, linked with the recovery of its dunes and natural reserves, land use planning, and the improvement of water resource management, with the help of the United Nations Development Programme (UNDP) and the Swiss Agency for Development and Cooperation (SDC).

This publication is structured in three parts. The first describes the problems affecting Santa Rosa and other coastal villages due to their vulnerability to climate change, disasters, and reconstruction processes. The second part explains the adaptive actions taken by this community and the lessons learned in this project's framework. The third and final part offers reference information on the main tools and processes being promoted.

The experience of Santa Rosa de Aguán, explained here and in the simultaneously published document titled "For the Love of the Ocean," can be an appropriate benchmark in the design of adaptive strategies in coastal towns in Honduras and other countries in the region and can guide local, national, and international institutions in building human capital in adapting to climate change in this type of community.

Santa Rosa de Aguán dune system

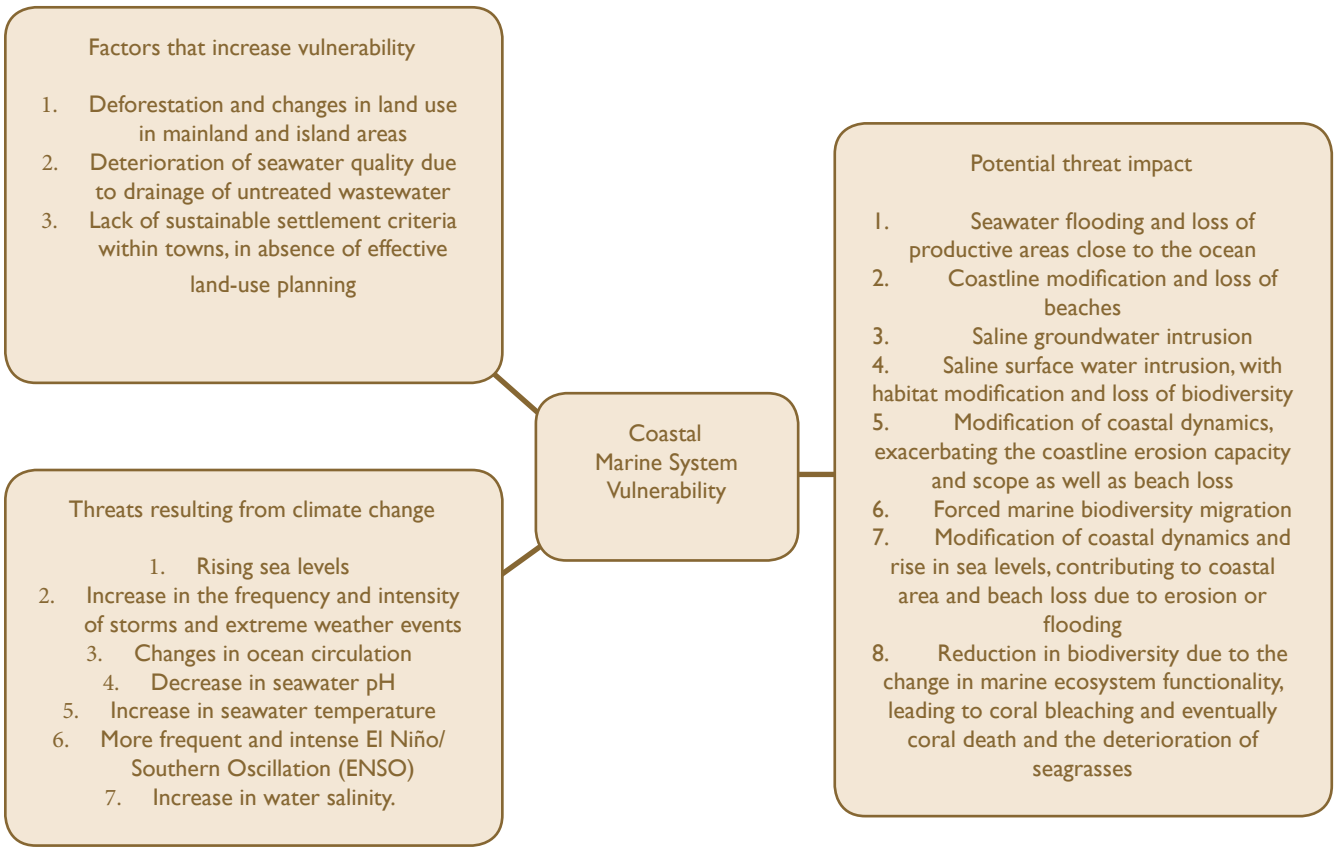
2. The challenges facing coastal villages in regards to climate change and variability

The experience of Santa Rosa de Aguán (SRA) is the story of a community vulnerable to disasters, climate change, and climatic variability, that has begun to organize and take concrete actions on climate adaptation and thus improve its current living conditions and protect itself from new disasters, both sudden and those related to climate change that gradually develop.

The experience of this coastal community reflects the reality facing a large number of coastal communities: throughout Central America, the Caribbean, and South America, the climate change scenarios that have been reported in National Communications on Climate Change (NCCC) present impact levels varying between severe and moderate on coastal resources, many of which are similar to those reported in Honduras' NCCC.

The landscape of coastal marine system vulnerabilities is a reality in Santa Rosa de Aguán, a sensitive environment that has been aggravated by factors such as human occupation, resource consumption, and resource deterioration, sometimes caused by the community itself.

Figure 1. Coastal Marine System Vulnerability



Source: Secretary of Natural Resources and Environment (SERNA) and UNDP (2000). *Segunda Comunicación Nacional del Gobierno de Honduras ante la Convención Marco de las Naciones Unidas sobre Cambio Climático.* Tegucigalpa, Honduras.

Following this National Communication, it is appropriate to quote the "conclusions of the marine-coastal system vulnerability analysis":
"a) The rise in sea level would change coastal dynamics, the coastline and beaches, and the infrastructure associated with these.
The impact of the rise in sea level would be related to coastline regression through beach loss, cliff erosion, and propensity to sea flooding. The magnitude of these impacts will depend on the nature and morphology of the beach and the type of coastal land development. The beaches that are comprised of finer sand and receive larger waves would be the most vulnerable (…).

b) The rise in sea level would affect infrastructure and human settlements in coastal zones.
Transportation, maritime, and tourism infrastructure situated on the coastline would be damaged by the rise in sea level, especially given the occurrence of sea swells and hurricane-force winds. In turn, the combined effect of rise in sea level and the propensity of sea swells and rough seas due to hurricanes or strong winds puts at risk settlements such as Omoa, Puerto Cortés, Tela, La Cieba, Trujillo, Brus Laguna, and Puerto Lempira on the northern coast. The Garífuna and Miskita settlements, as well as the Ladina population located on the Atlantic coastline, would be greatly affected.

c) Intense precipitations would increase the possibility of coastal flooding.
Tropical storms, hurricanes, and more intense coastal precipitation, especially during specific situations of changes in oceanic circulation and atmospheric pressure, would provoke greater winds and waves, exacerbating the frequency and intensity of sea flooding, and increasing the possibility that the high-water mark from sea flooding rises each time. Tropical storms can generate surges of up to 5 meters and a Category 5 hurricane, like Mitch, generated surges of up to 6.5 m.

The most vulnerable areas would be those situated in areas prone to sea flooding, rapid riverine flooding, and/or flooding caused by poor urban drainage, as is the case in the city of La Ceiba. Other human settlements in the coastal region are at similar risk, with an estimate of 7,362 km2 of land that is at some degree of risk of sea flooding.

d) The rise in sea level would affect the saline balance in coastal waters.
The rise in sea level would cause seawater intrusion in freshwater waterways and bodies of water close to the coast, altering the saline balance of estuaries, marshes, deltas, and other coastal habitats; impacting various life forms present in these ecosystems. Additionally, the rise in sea level would cause saltwater intrusion in underground wells that supply water to towns, especially in the aquifers of the Atlantic and Pacific islands, the northwest coastal plain, and the coastal areas of the Gulf of Fonseca (…).

e) The rise in sea level would cause the migration of mangrove swamps and their eventual relocation in other coastal areas.
The rise in sea level would provoke sediment deposits, especially sand, within the mangrove swamp, causing death, defoliation, and stress to the trees; as well as the formation of dikes that would block the ebb and flow of water and would cause damaging increases in interstitial salinity (…).

f) The rise in temperature would reduce mangrove growth rates.
The rise in average ocean temperatures could reduce mangrove development and provoke a decline in growth rates. The increase in temperature and greater evaporation would help to increase water salinity and decrease water availability, thus reinforcing the death rate, especially for the red mangrove [Rhizophora mangle].

g) The rise in sea level would reduce seagrass and coral reef productivity.
The rise in sea level would increase the water column of the substrate in which these species are located, which could reduce available light by 50 percent for phanerograms and seagrass algae and microscopic algae (Zooxanthellae) on coral, causing a 30 to 40 percent reduction in growth. This impact would be more severe in areas affected

by river discharge or other discharges that contain suspended solids or humic material discoloring.

h) Carbon dioxide fertilization will increase photosynthesis productivity in sea grasses, but the rise in temperature could decrease productivity, distribution, and composition.
Higher concentrations of carbon dioxide in sea water would cause higher rates of photosynthesis, but they would be reversed if nutriments, temperature, or light are constraints (…). This would result in changes in the seasonal patterns of spatial composition and distribution of sea grasses (…).

i) The rise in ocean temperature would cause a deterioration in coral reef ecosystems.
Higher water temperature seems to be one of the most probable causes of coral bleaching, causing an acceleration of the coral's metabolic reactions, which damage various cell processes, cause their partial or total death, and cause the destruction of the reef (…).

j) Extreme climatic events would affect marine ecosystems through mechanical impacts and sedimentation.
Intense rain and cyclonic swells would entail sedimentation processes, mechanical aggressions, prolonged emersion, water turbidity, and exposure to contaminants on marine ecosystems, particularly coral reefs and sea grasses. One example of the mechanical impact of Hurricane Mitch's cyclonic swells is found in the outer reef slopes on the southern coasts of Guanaja and Roatán.

k) The rise in ocean temperature would affect ecosystem services in regard to human economic activities.
Ocean warming and the wind regime would provoke changes in superficial ocean circulation, current patterns and consequentially migration patterns, and location and behavior of marines species of commercial importance, especially fishing (…)."

Fishing, one of the main livelihoods in Santa Rosa de Aguán

3. Santa Rosa de Aguán: A coastal town with tremendous vulnerabilities to climate change and climate variability

Santa Rosa de Aguán is located in the Colón Department. It is in Northeast Honduras, bordered to the north by the Caribbean Sea, to the south by the Bonito Oriental municipality, to the east by the Limón municipality, and to the west by the Trujillo municipality.

Within the municipality there is a community called Santa Rosa de Aguán, made up of a Garífuna population, that is currently divided into two sectors. One sector is close to the mouth of the Aguán River (also known as Aguán or Barra de Aguán), on top of the ridge of sand dunes, and the other is 1.22 km away, behind the dunes, and is called La Planada. La Planada arose from the community's relocation process after the losses caused during Hurricane Mitch (Image A).

The zone has an approximate area of 372.34 hectares, from the dune ridge that was formed in the sand bar located at the mouth of the Aguán River to the community of La Planada (Image B).

The main livelihoods in Santa Rosa de Aguán have been agriculture, fishing, livestock herding, cassava and coconut bread preparation, and convenience stores. Due to economic pressure, the population has looked to improve their quality of life by migrating to large cities, both national and international.

Socioeconomic vulnerability

According to the Fund for the Development of Indigenous Peoples of Latin America and the Caribbean (2011),

> "The Garífuna people have occupied the Mesoamerican Caribbean coast for the last 214 years, with 46 communities in Honduras, from Masca to Plaplaya[1], which currently suffer severe consequences of climate change associated with gradual coastal erosion (…).

Imagen 1. Hoja cartográfica de SRA

Imagen 2. Mapa de SRA por setores

Imagen (A) La hoja cartográfica muestra la delimitación del municipio de Santa Rosa de Aguán; (B) imagen de color señalando la comunidad, elipse negra izquierda Santa Rosa de Aguán, elipse derecha La Planada, coordenadas: UTM, SRA (0641299,176335), La Planada (0642899, 1762810).

Fuente: PNUD Honduras, Cruz S.(2011) *Propuesta de Ordenamiento Territorial. Santa Rosa de Aguán, Colón.* Tegucigalpa Honduras

1 Masca is part of the Department of Cortés and Plaplaya to the department of Gracias a Dios.

The destruction of Caribbean fish stocks at the hands of the industrial fishing fleet has been a factor in the Garífuna communities' economic crisis, as they depend on artisanal fishing (…).

The gradual penetration of the market economy imposed by the dominant culture has supplanted the subsistence economy that is now only practiced in certain communities, particularly those that are not electrified. Migration and remittances have had adverse effects on the abandonment of agriculture as the base of the communities' economy.

One important chapter in this community was the death of the coconut as a result of a viral disease known as lethal yellowing of coconut palm, which affects palms.The death of the coconut had a profound impact on the informal Garífuna economy, which revolved around the coconut and its derivatives, with women the most affected and therefore the larger Garífuna family structure. To date, there have not been real attempts at replanting, leaving the beaches bare, increasing the consequences of coastal erosion, and the communities have suffered a drastic decrease in sources of income as well as the loss of one of the fundamental ingredients in the Garífuna diet."

A socio-natural setting of disaster risk

According to the UNDP Early Recovery Needs Assessment in 2010, the principal threats towards the community are floods caused by the Aguán River, tropical storms, hurricanes, hurricane-force winds, and earthquakes. On the other hand, there are also threats from climate change such as the high level of coastal erosion, rise in sea level, extensive dry periods, rise in temperature, and increases in the frequency of hydrometeorological events.

The community has historically been impacted by meteorological events, affecting homes and livelihoods. According to the Honduran National Meteorological Service's registers (2011) from 1870-2010, it is estimated that 25 direct and five indirect hurricanes have affected Santa Rosa de Aguán, as well as 18 direct tropical storms and four indirect tropical storms. Although they were of varying degrees, each has had an impact on the community.

As for the damages suffered by the community at the hands of hydrometeorological phenomena, it is reported that the first tropical storm that affected the entire municipality was in 1935 and the second was in July 1961, leaving people affected, homes destroyed, and crops damaged. The greatest reported losses by the habitants of Santa rosa have been from the hurricane of 1941 and Hurricanes Anna (1961), Fifi (1974), and Mitch (1998). Fifi destroyed 190 homes and caused crop and cattle losses. Mitch is the phenomenon that has caused the most destruction in agricultural crops and homes, leaving a loss of up to 5,000 livestock and 42 people dead. The tropical storms that have caused the most damage have been Katrina (1999), Gama (2005), Beta (2005) and Tropical Storm #16 (2008).

After each one of these events, the townspeople have relocated to safer sites within the same municipality, to nearby communities, to other cities, or abroad. After Mitch, a sizeable part of the town was relocated to Miramontes, Las Lomas, and La Planada, where housing projects were carried out between the Honduran government and international cooperation. La Planada was the only project situated within the original community of Santa Rosa de Aguán and was left over a kilometer away from Santa Rosa.

The productive sector has noticed the effects of climate variability, noting that the dry period has lengthened and precipitation during the rainy season has decreased. It is estimated that twenty years ago, the rainy season began in October and lasted until December, with lighter precipitation between January and March. April through September were considered dry season. Currently, there is little rain in October, with most precipitation falling in November and December. Precipitation between January and March has decreased more than in previous years and dry seasons last from April through part of October. Other climatic variations noticed by producers include the intensity of the heat in the dry season and the increase in tropical storms and hurricanes in recent years.

The effects of climate variability are clear in Santa Rosa de Aguán and it is estimated that these effects will only intensify. According to Stratus Consulting (2006), sea level elevation in a 50 year projection will generate a loss of coastline of about 30 m on the Honduran coast. This estimate indicates that the settlement will be transformed, losing the first houses on the shore and the possible advance of coastal dunes towards the community.

According to the UNDP Early Recovery Needs Assessment in 2010, out of the 83 homes surveyed, 51 are at risk of flooding, especially along the riverbank, 10 are at risk of sea swells, and 14 reported the risk of tsunami. In addition, the entire community faces the risk of hurricanes and tropical storms.

Additionally, the impact from the deviation of the Aguán River puts the ecosystems and production systems in a vulnerable position.

The key factors that have determined the evolution and current status of the area are:

- The inadequate location of the settlement due to spontaneous processes of occupation.
- The concentration of land possession in few owners that have used their land for livestock farming.
- The inadequate use of soil (land degradation) as the biotic and abiotic characteristics of the land are not in line with its form of use, above all with its lack of conservation techniques; this erosion process removes nutrients and chemicals in the soil and contributes to river contamination, permeating the sandy and porous coastal aquifer with the nutrients
- The vulnerability to natural events and climate variability has had negative effects on the production systems. Coastal erosion and hydrometeorological events cause human and material losses.
- The limited economic diversification and low production performance due to the fact that the youth emigrate and do not integrate into the local productive system. There is also low or non-existent investment capital for new initiatives.
- The community's inefficient resource administration by organizations and low impact capacity in the creation of basic services.
- The loss of culture due to low transfer and assimilation of Garifuna traditions and customs.

The degradation of the environmental system in Santa Rosa

Santa Rosa de Aguán is a part of multiple tropical ecosystems rich in biodiversity and sensitive to disturbances. Each one of these ecosystems sustains an indeterminate number of flora and fauna species, including endangered species.

The coastal dunes cover large areas of the Honduran Atlantic coast. The dunes are mounds of sand that are formed by the wind, of various shapes and sizes, creating dune ridges along the entire coast. They are frequently found in areas prone to sediments, strong winds, and vegetation.

In Santa Rosa de Aguán, the dunes are of the parabolic type (an inverted "U" facing windward) and range from 0.5 m to 35 m in height, forming dune ridges. They support the coastal tropical forest, which hosts biological diversity with special abilities to adapt to hostile environments like aridity, high temperatures, high winds, salinity, and humidity.

The community depends on many dune ecosystem services, such as protection from erosion, wood, medicinal plants, sustenance, cultural value, recreation, and tourism, among others. The dunes also function as protective barriers against hydrometeorological events. For example, as Hurricane Mitch made landfall, it was lowered to a Category I hurricane; at this level sea swells reached approximately 4.35 m above sea level. The sea swells destroyed homes below 4 m above sea level and the homes that had a topographic obstacle (coastal dunes) suffered fewer damages or were not affected by the sea swells.

Nature has historically been perceived as a renewable resource. However, the land's capacity to support the development of human activities is increasingly limited, causing ecosystem degradation and even resource scarcity and the deterioration of environmental services.

The Santa Rosa de Aguán community puts direct pressure on the dune system and aquifer. Livelihoods such as farming and livestock farming have expanded inordinately without any organizational plan or sustainable resource management. The majority of the land belongs to few owners, who exploit the properties for livestock farming. Agricultural farming on small plots of land covers the majority of the dune system.

The coastal aquifer is protected by this dune system, creating a lenteja (pond) that stops the salt wedge naturally, but this could be affected by the rise in sea level and could cause the salt water-fresh water interface zone to expand and contaminate the aquifer. Likewise, dune degradation could contribute to the decrease in the lenteja's water levels, provoking the intrusion of the salt wedge. The overexploitation of the aquifer, as well as

severe droughts, could provoke a decrease in freshwater and therefore provoke the salt wedge intrusion.

The Aguán River has changed its course, feeding the majority of its volume into the Chapagua River. This behavior has marked an imbalance in the riverside and aquatic ecosystems, provoking their degradation from the deviation in the Agua Amarilla community to the mouth of the river, altering the livelihoods of the nearby population.

Furthermore, this deviation has prevented the river from breaking the dune, causing it to stagnate. This, combined with the effect of sea swells, the ocean breaches the river and salinizes it and the coastal aquifer of Santa Rosa de Aguán.

Table 1. Problems of the Environmental System

Problem	Cause	Effect
Loss and fragmentation of the coastal tropical forest	Farming expansion Deforestation	Decrease in biodiversity Decrease in environmental services Difficulties in ecosystem regeneration capabilities
Loss of riverbank vegetation	Deforestation Physicochemical change in water due to sea water intrusion Rerouting of the Aguán River	Loss of plant and aquatic species Reduction in land protection
Loss of lake vegetation	Deforestation Physicochemical change in water due to sea water intrusion Rerouting of the Aguán River	Loss of plant and aquatic species Decrease in environmental services
Degradation of dune ecosystem	Felling of trees, burn-off, trampling, animal vagrancy, sand extraction, farming, livestock farming, tourism, coastal erosion, natural events	Degradation in vegetation, morphology, and life forms Reduction in settlement protection
Rerouting of the Aguán River	Human pressure Tropical storms The river's hydraulic behavior	Loss of riverbank ecosystems, aquatic life, farming production Decrease in sedimentary input and flow input
Aquifer contamination	Over-exploitation of the aquifer Coastal erosion Rerouting of the Agúan River	Water scarcity Habitat alteration of the slacks, or lowlands between the dunes
Absence of a baseline of existing plant and animal species	Absence of research projects Indifference in learning the regional biodiversity	Absence of inventories and benchmarks Disregard of taking into account Santa Rosa de Aguán's importance in terms of resources

Source: PNUD Honduras. Cruz, S. (2011). *Propuesta de Ordenamiento Territorial Santa Rosa de Aguán, Colón.* Tegucigalpa, Honduras.

Santa Rosa de Aguán

4. Post-disaster recovery in Santa Rosa de Aguán

As previously explained, Hurricane Mitch was the most severe disaster for Santa Rosa de Aguán. In response, the Honduran government and international aid assisted in the construction of 250 concrete homes with zinc roofs in the La Planada area.

The Santa Rosa de Aguán community has expressed the following weaknesses of this process that range from project´s planning stages to its completion:

- Due community participation was not given in the decision-making process in regards to planning and construction.
- Housing assignments were not based on a participative study on the needs of the community after Mitch.
- The new homes were located on a flood plain.
- The houses were not adapted to the climate.
- The houses are very small, which goes against the Garifuna community and cultural traditions.
- There is no basic aqueduct or sewer system.
- The distance between La Planada and the urban area of Santa Rosa de Aguán is quite large and creates difficulties in accessing services located in SRA. The displacement between both areas is especially difficult for children, the elderly, and those with health problems.
- There is no access to livelihoods.
- The area has since been considered to be at risk in following studies.
- Many families have not occupied the homes that they have in La Planada and the majority of the transfers have been made to only a few members of the family unit.

Climate change awareness campaign

5. The road towards climate change adaptation in the coastal village of Santa Rosa de Aguán

The United Nations Development Programme, together with the Swiss Agency for Development and Cooperation (SDC), initiated a technical support process in the Santa Rosa de Aguán community, under the framework of the project titled "Experts, public institutions, town councils, and communities highly vulnerable to climate change have increased and strengthened their tools and adaptive capacities."

With the support of Social Work student volunteers from the Universidad Autónoma of Honduras, the first steps were taken towards social awareness, with an orientation towards community organization through groups of women, elderly, youth, and students.

Specialists provided simultaneous technical support in the creation of proposals on the integration of climate change in the needs analysis and on the development of frameworks on community-level early recovery, participatory tools on current risks, and climate change, dune ecosystem characterization, and proposals on conservation and rehabilitation.

They then began a participatory analysis directed at adaptation to climate change from the highly vulnerable position of this community and the serious consequences from Hurricane Mitch.

Taking action regarding the dune ecosystem is important because by preserving and rehabilitating the dunes, the ecosystem is strengthened, the services the dunes provide the community remain intact, risks are reduced, and the ability to adapt to climate change is strengthened.

One of the advantages of working with this ecosystem is that once the disturbances caused by humans are eliminated, the ecosystem is capable of regenerating itself geomorphologic and biologically as long as it has sufficient biotic and abiotic resources to develop and tolerate changes.

The project articulates the following processes:

Strategic Processes, investigation of site conditions before defining actions, planning, administrating and managing economic and physical resources to carry out the activities within the project.

Key Processes, sharing investigation results, awareness campaigns, socialization and training, administration capacity building, infrastructure works, and the creation of basic documents to achieve the objectives, such as municipal ordinances.

Support Processes, involving activities related to the purchasing of materials and supplies to develop key processes, coordination between different actors, and hiring of required personnel in all phases of the project.

Figure 2. Map of processes and activities carried out in Santa Rosa de Aguán

Planning and Management

Administration and purchasing

Social awareness on climate change
Training and better us of solid waste
Creation of technical documents
Construction of footbridges, demolition of works, and debris management
Dune reforestation
Rainwater harvesting systems
Hydrochemical study and healthy use of water

Source: Orrego, Juan Carlos. (2013), *Sistematización de Proyecto PNUD-COSUDE.*.

Table 2. Summary of activities implemented by the project

ACTIVITIES	DESCRIPTION - OBSERVATIONS
PROJECT PLANNING WITH THE COMMUNITY AND HUMAN MANAGEMENT	
Meetings with community organizations	The goal was always to convene the entire community. The first meeting had to be separated into two groups due to high attendance.
Meeting with the town council, other community organizations, and the SDC	The goals of the process were defined: to reduce the vulnerability of Santa Rosa de Aguán to climate change.
Formation of Steering Committee	With two representatives of the twelve community organizations, the Climate Change Adaptation Volunteer Committee (CCAVC) was formed.
Organizing and social awareness	Based on the studies conducted on the current conditions of the community, awareness-building strategies were suggested to facilitate the community's understanding and improve the new group's articulation.
Identification of priority actions with technical support	It was jointly determined that it was necessary to spread awareness in the community regarding the environment; without appropriate understanding and commitment in the community, it is not possible to achieve short-term and long-term goals.
Campaign design	An initial awareness campaign on climate change was designed and implemented (2011).
Convening of the Climate Change Adaptation Volunteer Committee	The committee and the community met, linking local youth. This phase included 30 volunteers.
ADMINISTRATION AND PURCHASING	
Administrative control, purchasing, and money management	Capacity building in administration and purchasing. Carried out by the CCAVC with representation from the board of directors
Administrative and accounting processes workshop	Activities such as accounting management, checking, receipts, and basic reports
COMMUNITY AWARENESS ON CLIMATE CHANGE	
Volunteer group awareness talks	CCAVC capacity building to transfer knowledge gained to the community. Talks and trainings on climate change were carried out, teaching how to create flipcharts, bulletins, and sensitization visits to homes.

Creation of posters supporting the awareness process	Posters were designed and displayed in various places with content that spread awareness on dune protection and adaptation to climate change.
Home visits to entire community	Once the volunteer group was created and trained, the first social awareness campaign began with home visits in the Santa Rosa de Aguán town center and in La Planada. The volunteer group displayed a high level of commitment and the Santa Rosa de Aguán community was readily available.
TRAINING AND SOLID WASTE MANAGEMENT	
Workshop on waste management and recycling	The volunteer committee led the sensitizing workshop on this topic to address the high levels of garbage on the beach and its health and environmental consequences (among others, dune deterioration)
Definition of recycled material management proposals	Discarded material on the beach was collected, washed, cleaned, and classified.
Small-scale drawing and construction of mural with recyclable material	A mural of traditional Garifuna activities was created with recyclable materials. The process increased community participation, united multiple groups, revalued the Garifuna identity, and strengthened the project's objectives.
PREPARATION OF TECHNICAL DOCUMENTS	
Meetings and interviews with the community to write adaptation to climate change proposals	With the participation of the community and technical support, timely reports on land-use planning, scenarios and crop adaptation, dune behavior and conservation, and rainwater harvesting systems were published. Additionally, two municipal ordinances were drawn up and approved.
FOOTBRIDGE CONSTRUCTION, DEMOLITION OF STRUCTURES, AND DEBRIS MANAGEMENT	
Analysis, selection, and sensitization on adaptation methods	When the community discovered the function of the dunes, it applied the knowledge gained and debated adaption options. Considering the reality of the community and the projects' costs, three of the five total footbridge options were chosen to be constructed.
Creation and signing of agreement between UNDP and the CCAVC for resource management on the part of the community	The process took approximately five months because the CCAVC lacked legal capacity and had no experience in resource management. After an evaluation, training activities as well as technical and social assistance were offered. This assistance lasted the duration of the agreement's implementation period.
Employment contracts	A person with experience in construction of footbridges and similar projects was hired.

Completion and follow-up of footbridges	Once the carpenter with experience in this type of project was hired, materials were supplied via the Aguán River and later stored, and the community provided assistance in the completion of the project.
Demolition of debris	It was necessary to demolish the debris of the homes affected by Hurricane Mitch in order to preserve the dunes. Authorization from the owners of the remains of the houses was obtained in advance. The committee hired approximately 40 people from the community to complete the demolitions.
Second round of waste removal	A second clean-up for the demolition rubbish was necessary.
Location of remains in authorized areas	It was planned for the remains to be disposed of in an area authorized by the municipality. However, at the request of the community, the majority of the debris was used by the community to improve their homes.
Conclusion and inauguration of the works	Once the works were finished, they were inaugurated with participation from the community, the municipality, and UNDP personnel.
DUNE REFORESTATION	
Meetings covering the selection of priority areas and the promotion of participation by different actors	It was decided to begin the protection and reforestation of the dune system with the area that faces the community, planning the continuation with the help of other actors such as the municipality.
Preparation and maintenance of the seedbed, the nursery, and planting	Natural regeneration strategies have been combined with reforestation of native species produced in seedbeds / community nurseries. The community's working groups have technical assistance throughout the process.
RAINWATER HARVESTING SYSTEMS	
The study "Design of Water Harvesting and Storage Systems for the Santa Rosa de Aguán Community"	UNDP conducted a study to identify the best alternatives for supplying healthy freshwater. The rainwater harvesting system entails the collection, transportation, and storage of rainwater. As it incorporates the appropriate filters, the water can be used for human consumption.
Selection of appropriate harvesting system; collective rain water harvesting station with three month reserve system	The main criteria in choosing the alternative were the ability to adapt to the characteristics of land and the resource's equal distribution through collective systems that are able to supply for groups of approximately three families.

Meetings to disseminate the design and come to an agreement on the distribution of the harvesting systems	The CCAVC disseminated the study's results, including the stations' characteristics, uses, and maintenance. System installation points were chosen in community use areas. Two of these were located in La Planada and another two in the town center of SRA.
Construction of the four rainwater harvesting systems	Qualified laborers were hired, community working groups were organized, and the structures were monitored and completed, and the systems were put into use through the agreement between UNDP and the Fundación San Alonso Rodriguez [FSAR, San Alonso Rodriguez Foundation].
HYDROCHEMICAL STUDY AND THE CREATION OF HEALTHY WATER USE OPTIONS	
"Santa Rosa de Aguán Hydrochemical Study"	With the help of the Universidad Nacional Autónoma de Honduras (UNAH), a study was conducted to analyze the hydrochemistry of SRA's free aquifer and to determine the quality of the water meant for human consumption. The results, in respect to the state of water salinization, determined that the problem is greatest between the Aguán River and the coastal aquifer than between the aquifer and the sea.
Creation of a monitoring system for the salt water-freshwater interface	The system consists of evaluating defined periods: - Indicators of the mixing of salt water with freshwater so that the community can establish a limit of consumption so that the resource is not compromised in quantity nor quality in regard to saline intrusion - Nutrients in wells and the Aguán River - Iron levels. In this case, the system is complementary to a survey of the area and is expected to find the source of (natural) iron that is contaminating the aquifer's water above admissible levels.
Workshops to disseminate the study's results	The UNAH and the FSAR have set up a strategy to disseminate the study's results and search for possible mitigation measures with various community groups.
Meetings on awareness and training regarding monitoring system maintenance and the application of mitigation measures	The designed monitoring system consists of sample collections by the community using multi-parameter equipment. With the assistance of the FSAR and the UNAH, the samples will be analyzed and a trend will be established, which will allow for appropriate early mitigation measures.

CCAVC volunteers

6. Tools for climate adaptation in Santa Rosa de Aguán

The main processes and tools created in Santa Rosa are shown in the following figure. Technical specifications, which summarize this project's community and technical assistance, are attached at the end of the document.

Figure 3. Summary of processes and tools developed in the implementation of the project

Research	Awareness-raising and Training Process	Climate Change Adaptation Volunteer Committee Process
Tool No. 1 Scenario Report on Dune Behavior in Climate Change Framework	Tool No. 2 Crop Adaptation to Salinity	Tool No. 3 Design and construction of footbridges
Tool No. 4 Land-Use Planning Proposal	Tool No. 5 Awareness Campaigns and Training Workshops	Tool No. 6 Demolition and Debris Management
Tool No. 7 Santa Rosa de Aguán Dune Conservation Ordinance and the Unmitigable High Risk Areas Ordinance	Tool No. 8 Design of rainwater harvesting and storage systems	Tool No. 9 Hydrochemical Study and the design of measures for the healthy use of water

Source Orrego, Juan Carlos; Cruz, S. (2013), *Sistematización de Proyecto PNUD-COSUDE.*.

7. Conclusions

7.1. Lessons Learned

- Home visits were a key element. This technique improved outreach to the majority of the population and permitted the adaptation of information and the sensitization of people unable to attend community meetings. This group mainly consists of the elderly and female heads of household.
- The creation of the theater group improved youth integration in this process and the creation and performance of the play was a successful practice in social communication that facilitated community learning in managing early warnings and disasters.
- The community has begun a paradigm shift from the knowledge gained on the use and development of the dunes. The dunes were previously considered to be mounds of sand that bothered the community due to sand intrusion and the lack of ocean views.
- The organization of the committee and other groups in the community can facilitate the development of other projects and the transfer of knowledge.
- Child participation will maintain community knowledge of risk management and environmental awareness.
- It is important to promote jobs for people from the community, which would generate extra income and motivation within certain sectors. In the case of Santa Rosa de Aguán, local hiring was possible for demolitions and debris management.
- Committee members carried out a very important job with great dedication and transparency, motivated by the commitment to improve their community now and in the future.
- The physical works can strengthen the process of change after finishing the project and improve the community's sense of ownership.
- The construction of footbridges has increased the community's pride and self-esteem as they see their environment as nicer and people with reduced mobility can once again access the beach.
- Involving women in this project generated high self-esteem in the group, as by increasing their knowledge and leadership, they understand the value of their point of view. Previously, the majority of projects had been conducted by men and women's opinions had been pushed aside.
- This project has created lessons that may be replicated in other communities such as Tela, Ceiba, Miami, or in other regions of Honduras, where people could organize their Local Emergency Committees [CODELES] and broaden their knowledge on environmental topics, care for the environment, and climate change adaptation strategies.
- The work done is credible due to the fact that all proposals were completed and the work involved the community, generating trust and positive results.
- The community committed itself to the process's development in Santa Rosa de Aguán and La Planada. Its capacity to respond must be valued and reflect on the scarcity of alternative forms of support due to the region's remoteness and the area's insecurity.
- This project was a pioneer in information building and the characterization of its natural resources. The results on dunes, reforestation, and rainwater systems could contribute to future projects.
- The strategy of developing technical and social support as part the community's everyday life and customs generated greater cooperation and credibility in Santa Rosa de Aguán.

- The community has great tourism potential.
- Partnerships between academia and the involved social organizations have been positive for each party. In addition to the direct results on the project, medium-term collaboration opportunities have emerged, which could improve this community's development process.
- Studying and evaluating the social, economic, and biophysical conditions in a participatory way were the basis to define successful actions aimed at risk reduction and climate change adaptation.

7.2. Identified Challenges

- The older population remains reluctant to learn new material
- The majority of young people wants to leave Santa Rosa de Aguán in search of educational and employment opportunities. Additionally, there is a weakening appreciation of their culture.
- The high tendency towards the concentration of land hinders options to develop livelihoods
- Santa Rosa de Aguán remains a high risk zone and its relocation and emergency response should be kept under review. Although the entire community is aware of this risk, its high levels of attachment mean that new resettlement options are not being considered.
- There are no professional teams trained in post-disaster psychological care. In this community there are people with post-Hurricane Mitch trauma.
- A proper conceptualization of phenomena and key territorial components is necessary for the advancement of development processes. In the case of communities with local languages, it is fundamentally important to understand the different meanings new concepts could have. In this case, the word duna [Spanish for "dune"] means "water" in Garifuna and its use was not associated with the mounds of sand.
- It is necessary to consider that project development is usually affected by personal interests. One example in this experience is the refusal of or reluctance towards the demolitions; some people did not want to demolish the remains of the houses due to a lack of knowledge or having other interests in the management of the resources. This issue was successfully addressed with the work that the CCAVC carried out in the community so that the general well-being took precedence over personal matters.
- Weaknesses in local organization still exist and are susceptible to medium-term perspectives
- It is important to strengthen relations between the local government and the community.
- The technical measures developed during the project were established in accordance with the economic, social, land tenure, land use, and attachment limits.

7.3. Some proposals for the development of Santa Rosa de Aguán

- Healthy and efficient water management.
- HIV awareness and training adjusted to this community's HIV mortality rates. There is a lack of knowledge and a lack of protection in handling sexual relations.
- As a result of Hurricane Mitch, four blocks of houses disappeared and are currently in the ocean. The community still harbors fears and trauma caused by this and other disasters, and these issues must be treated.
- Women make up the majority of the population in this community; they possess an entrepreneurial spirit and key roles, but it necessary to work with men and women on matters such as recognition of women's rights, equal opportunities, and gender-based violence. There are a significant number of single mothers.

- It is important to complete the path to La Planada, continue the water harvesting project, and supply the community with water pumps and electric energy to improve the residents' quality of life.
- Redistribution of livestock grazing areas in order to cultivate crops on a sustainable level and allow for the community's food sufficiency and its independence from the cities.

8. Factsheets

Tool 1
Scenario Report on Dune Behavior in Climate Change Framework

Use

For the selection and implantation of climate change adaptation measures in Santa Rosa de Aguán, a technical study was carried out on the background and current state of the dune surface area, coastal erosion, saline intrusion, dune distribution and vegetation, infrastructure, and the main human activities related to the effects of climate change. Part of this study presented future scenarios as well as ecosystem and community adaptation and protection methods.

The content of this study can be found in the document UNDP Honduras. Cruz, S. (2011). Informe Escenario de Comportamiento de Dunas en el Marco de Cambio Climático Santa Rosa de Aguán, Colón, from which the most relevant information has been extracted.

"The settlement of Santa Rosa de Aguán corresponds to spontaneous occupation processes, with community expansion without previous planning, without measuring future natural disaster risks, without balanced development processes, exposing the population to resource shortages and natural disasters. Santa Rosa de Aguán is a vulnerable area that falls along the trajectory of hydrometeorological events, with settlements located along the shore and within the Aguán River flood plain, with ecosystems deteriorated by natural and anthropological factors.

The exposure of a vulnerable area to the effects of climate change further aggravates the negative impacts, limiting the opportunities for progress for its inhabitants. Vulnerability is "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" IPCC (McCarthy et al. 2011). However, it is possible to find elements within an area that contribute to climate change adaptation strategies, such as the case of the dune ecosystem, which provides important environmental services for various purposes. The supply services that provide resources for the community's livelihoods; climate regulating systems such as water quantity and quality conservation, dune forest carbon sequestration and reduction of exposure to hydrometeorological events, and cultural services."

Description

"By means of ecological indicators, resilience, and degradation, the dune ecosystem's past and present were evaluated, and how these vital indicators on dune performance would behave under the context of climate change.

The surface area of the coastal dune ecosystem has been altered, losing soil mainly due to coastal erosion, hydrometeorological events, and changes in land use. Marine transgression has caused the loss of homes, specialized vegetation, and coastal dunes, transforming the landscape. There are traces of seawater intrusion in the aquifer due to the overexploitation of resources, coastal erosion, the aquifer's low capacity to recharge due to the deviation of the Aguán River, and rain deficit.

The dunes are evolving, expanding towards the mouth of the river, where the marine system has clear dominance over the continental system. Dune vegetation is capable of being highly resilient, but this is seriously threatened by changes in land use and logging. The settlement's loss of infrastructure is gradual, losing homes from tropical

storms. Bad practices and poor land management exacerbate the impact of climate change.

The scenarios for 2025 and 2050 are not encouraging for the community or for the dune ecosystem if nothing is done about the matter. The coastal dunes are exposed to erosion and could lose their morphology and sand will reach the community, altering the vegetation gradient and redistributing the dune ridge system. The aquifer will be exposed to saline intrusion, decreasing supply sources for the community and changing the habitats of slacks, causing the disappearance of flora and fauna species, including endangered species.

Plant resources and productive systems will be affected by long periods of drought due to the lack of precipitation and the increase in temperature. An additional factor that will aggravate conditions is the deviation of the Aguán River, which will stop providing the environmental services it had previously provided.

It is expected that storms and hurricanes will intensify and will occur more frequently, affecting the settlements and further degrading the dune ecosystem.

Adaptation measures in the context of the climate scenarios are geared towards dune ecosystem adaptation, including the cushioning of event disturbances, contributing to the evolution of a new ecosystem called "emerging ecosystem." It also provides adaptation to climatic risks that include protecting the community and its livelihoods."

Indicator for Santa Rosa de Aguans´ dune ecosystem
The report draws the following explanatory referenced table:

Indicator	Description	Unit of Measurement	Reference
Dune surface area	Change in the coverage of dune ecosystem	Area (m2, ha, km2)	Current dune surface area / 2001 dune surface area
Geographical distribution and stability of dunes	Change in quantity of dune ridges and change in dune elevations	Number of dune ridges. Height (m)	No. Historical comparison.
	Change in surface area of active dunes to stabilized dunes or vice versa	Number of dune ridges.	No. Historical comparison.
Coastal erosion/ accretion	Change in coastline.	Área (m^2, ha, Km^2) % de pendiente.	Modificación de línea de costa con respecto al año 2010.
Changes in slope of frontal dunes	Area (m2, ha, km2) % of slope	Coastline alteration with respect to 2010.	Comparación de áreas cubiertas con vegetación con respecto 2001
Dune vegetation	Changes in surface area	Area (m2, ha, km2)	Comparison between areas covered with vegetation with respect to 2001.
Saline intrusion	Water salinity in wells that exceed permissible standards for consumption and present high conductivity at shallow levels.	No. From contaminated wells	No historical comparision.
Loss of infrastructure	Loss of infrastructure due to meteorological events and coastal erosion	Number of homes per event.	Beginning in 1998.

"The selection criteria for the indicators shown in the previous table are: existence of information, ability to measure said criteria through a Geographical Information System (GIS) and their sensitivity to climate change, vital ecological functions in the functioning of the ecosystem, ecosystem resilience indicators."

Background and Current State

Dune Surface Area

"To determine the loss or increase of dune ridge areas, aerial photographs between 1992 and 2008 and a topographic survey from 2010, at a scale of 1:15,000, were analyzed."

Calculation of land increases and losses. A: Sand bars with dunes close to the mouth of the river; B: Community; C: Larger dunes between the cemetery and La Planada

"The greatest losses of land occurred between 1992-2001 with -21.52 ha. Homes and coastal dunes were lost due to coastal erosion that may have been caused by the effects of Hurricane Mitch in 1998.

In the period between 2001 and 2008, area A showed greater sediment accumulation, with decreases in sediments in areas B and C. This is a product of coastal erosion influenced by tropical storms. Between 2008 and 2010, an increase in sediments was found to have been concentrated in area A.

The current trend is sediment accumulation in the dune ridges in the sector of the community, causing an increase in dune elevation, coverage in new spaces, and new dune formations on beaches to the west of the community. However, this process is part of the coastal erosion occurring in dune areas to the east of the community where erosion affects primary dunes."

Some of the proposed adaptation measures are as follows:

Measures to Reduce Disturbances

1. "Dune rehabilitation activities after a natural event, such as sea swells, tropical storms, and hurricanes (…).
2. Protect dune ridge formation throughout the community, with special attention to the primary dune ridge (…).
3. Generation of information and monitoring of climate variation at the local level (…)."

Adaptation measures that contribute to dune ecosystem development

"The adaptation measures for coastal dunes are not aimed at preventing or combating climate change with provisions implementing drastic changes such as sediment injection, retention walls, mechanical modeling of dune geomorphology, etc. Rather, they seek respect for the natural changes in the emerging ecosystem, with its new combinations of species and the possibility of changes in the functioning of the ecosystem."

Measures to reduce human pressure

"These must take into account regulations that directly involve local organizations and municipal authorities. Conservation, rehabilitation, and adaptation to climate change must be institutionalized by the municipality's administration and future plan through mechanisms or legal, political, and technical instruments.

This can be obtained through the creation of coastal management plans that include the creation of municipal ordinances, the integration of measures in the municipal development plan or local agenda, taxation plan, land use plan, dialogue and consultation processes with the community, community organizing."

Measures regarding adaptation to climatic risks and livelihoods

1. Strengthen and implement an early warning system.
2. Strengthen Local Emergency Committee and create risk prevention mechanisms.
3. Modernization of and feedback on Municipal Emergency Plan and the creation of a risk management plan that addresses adaptation measures as well as social and environmental productive system recuperation.
4. Management of housing relocation program, with emphasis on homes that are located along the ocean shore and riverbanks.
5. Community meteorological station aimed at gathering and interpreting information and threats to the community.
6. Wind and solar energy circuits at the household level.
7. Search for water abstraction methodology and induced recharge of aquifer for homes, agriculture, and livestock (…).
8. Analysis of productive systems, quality, and performance to guarantee food security, to get a close look at productive challenges and environmental sustainability (…).
9. Crop species resistant to draught and salinity. Crop diversification and even field diversification like ecotourism is possible.
10. Effect of the problematic deviation of the Aguán River.
11. Strengthening of the mangrove system with revegetation respecting the zoning or gradient. Mangrove swamps will contribute as a protection barrier against storms and hurricanes, protecting the aquifer from marine intrusion.
12. Formulation of a plan to follow up and monitor the state of the dune system. The indicators that must be sampled are those that have contributed to understanding the current state of the dune system, permitting comparison over time. Other indicators that could facilitate the evaluation of the state of the dunes can also be included (…).
13. Generation of inputs for investigation like digital terrain models for different years, aerial photographs."

Key Words

Climate change, coastal dune ecosystem, adaptation measures, "emerging ecosystem", saline intrusion, erosion, trend scenarios.

Source:

UNDP Honduras. Cruz, S. (2011). *Informe Escenario de Comportamiento de Dunas en el Marco de Cambio Climático Santa Rosa de Aguán, Colón*. Tegucigalpa, Honduras.

Tool 2
Crop Adaptation to Salinity in Santa Rosa de Aguán

Use

The adaptation to climate change project in SRA allowed the study of the environmental conditions that are negatively affecting production systems. After the selection of a representative survey area, the situation of the livestock farms was characterized and their principal problems and development opportunities were determined.

According to the report *Adaptación de Cultivos a la Salinidad en Santa Rosa de Aguán*, published in 2011 by UNDP Honduras, "the community of Santa Rosa de Aguán is undergoing changes in the coastal ecosystem due to the deviation of the Aguán River and climate variability. These new environmental conditions have negative effects on the production systems in the floodplains.

The consequences of the environmental changes were identified in the community of Santa Rosa de Aguán from the town center to 2.14 km past the La Planada settlement. It was found that those mainly affected are livestock farms, which cover an area of 187.87 hectares.

Principle consequences include the death of livestock by drowning in flooding due to extreme events, inefficient coordination of flood warnings, death due to water and fodder scarcity, livestock poisoning due to consumption of water with a high degree of salinity, death of fodder species intolerant to salinity, flooding of pastures.

Water samples extracted from natural watering places in September 2011 show that livestock located between the community of Santa Rosa de Aguán and La Planada are ingesting excessive salt, contained in the water. This affects the nutrition of the livestock and production rates, generating substantial losses for ranchers.

Possible solutions proposed are aimed at climate change adaptation through the conservation of natural resources and the use of environmentally friendly initiatives. Initiatives include reinforcing riparian vegetation with native species resistant to salinity, fodder resistant to salinity, flooding, and drought, silvopastoral techniques, and alternative sources of water capture in low-lying areas.

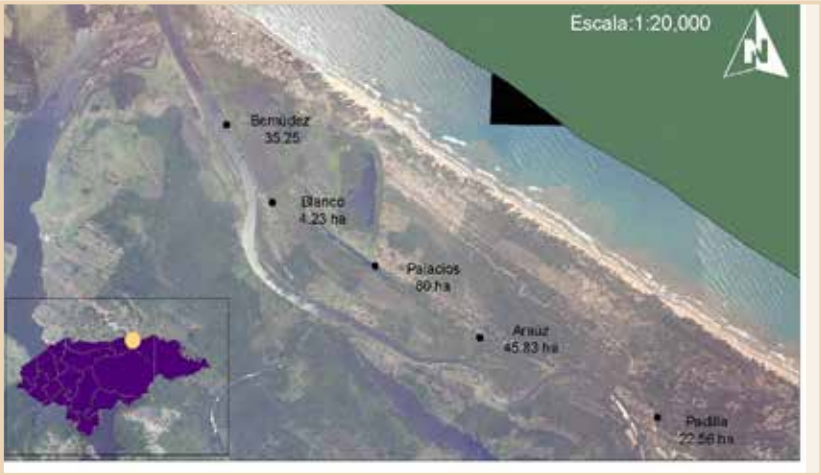
Description.

Study Area

"The study area is located within the limits of the Garifuna community of Santa Rosa de Aguán, Colón. The area is defined from the community pier to 2.14 km east of the settlement called La Planada.

Upon conducting a survey directed at agricultural and livestock producers potentially affected by changes in the salinity of the Aguán River, five cattle ranches have shown problems due to changes in the river's salinity.

There are 187.87 ha of livestock land in this region and they are concentrated along the banks of the Aguán River, as this is the principle source of water in this sector. Farms are grouped in areas closer to the beach, are relatively small, depend on rainwater for their production, and do not show problems related to salinity."



Aerial photograph (2008, PMDM), showing location and hectarage of cattle ranches located along the banks of the Aguán RiverAguán.

Problems in the cattle ranches

"The Aguán River has changes its course, feeding the majority of its volume into the Chapagua River. It is estimated that this event took place in 2008 as a result of strong precipitation caused by Tropical Storm #16. This behavior has marked an imbalance in the riverside and aquatic ecosystems, provoking the degradation of these ecosystems from the deviation in the Agua Amarilla community to the mouth of the river.

Other consequences of this deviation include the closure of the mouth of the river during the dry season. As the river does not have enough water flow, sediments carried by waves accumulate into a sandbar. The river, unable to pass the sandbar, begins to flood the ranches along the riverbanks.

The critical seasons for the farms are the droughts between April and August and the season of heavy rainfall in November and December. After Hurricane Mitch, these ranches recorded losses of 70-100 livestock or more. In Hurricane Katrina (1999), three livestock were lost; with Tropical Depression #16 in 2008, approximately 30 animals were lost. This has limited this sector's progress and ranchers are currently vigilant about possible flooding in order to move the cattle to higher ground, although they are not always successful as sometimes they take action after flooding has already begun and are unable to remove the cattle on time."

In the following table, this same report shows the main problems that have been detected, their causes, and their consequences.

Problems in the cattle ranches

Problem	Cause	Consequence
Death of livestock	Riverbank flooding Livestock concentrated along riverbank as it is their principal source of water Extreme events Closure of mouth of river Lack of riverbank protection	Loss of investment Decrease in production Decrease in availability of dairy products in the Santa Rosa de Aguán community

Death of fodder species	Deviation of Aguán River Increase in salinity during dry season Closure of mouth of river Long periods of drought	Lack of fodder Poor livestock nutrition Low milk production rates
Water source unsafe for livestock	Deviation of Aguán River Increase in salinity during dry season Long periods of drought	Poisoning of livestock Poor nutrition Death of livestock Low milk production rates
Death of riverbank species	Deforestation Deviation of Aguán River Increase in salinity during dry season	Flooding

Producers' needs and development opportunities

"In the absence of good quality and production rates in dairy products, producers make an effort to maintain their cattle, improve nutrition, and make improvements to their ranches in order to increase profits. Nevertheless, these improvements involve financial investment they are not able to take on."

Some needs identified by the producers include: "expand pasture to higher areas of their properties, materials to improve ranch infrastructure and organization, supplies to control weeds, obtain additional sources of water, improve quantity and quality of fodder, an effective alert system to move livestock to higher ground, investment funds for livestock care and ranch maintenance, technical assistance, modification of the sector and inclusion of organic crops as means of subsistence, funds to invest in irrigation for pastures in high areas."

"One of the advantages the ranchers have is that they hold land in high areas that has been previously worked, but due to a lack of money, the land has not been used to sow grasses or fodder. These lands can be rotated as pastures during critical periods.

Another opportunity is the demand for dairy products in Santa Rosa de Aguán, as there is little competition and it is a fixed market."

Possible solutions

1. Strengthening the riverbank with native species resistant to salinity

"In previous years, the riverbank has been covered with vegetation valued for its ability to adapt to this environment and its ecological functions in ecosystem functioning. According to Gonzáles and García (2001), the vegetation's presence on the riverbank improves soil cohesion through its root system, and significantly increases resistance to erosion due to the force of the current. Additionally, the strengthening of the riverbank helps to create greater resistance and to limit flooding; their roots or grasses assist in slowing floods.

In the case of mangrove swamps, it has been found that they serve as an important barrier that limits flooding thanks to their complex and flexible roots, in particular those of the Rizophora mangle. Mangrove forests decrease the current's impact as they act as sinks for suspended solids. According to Kathiresan and Rajendran (2005), mangrove swamps can prevent seawater from coming inland and thus protect groundwater systems in addition to drastically reducing groundwater salinity.

Therefore, a beneficial measure is the strengthening of riverbank vegetation with native species resistant to salinity that have disappeared due to logging as well as tropical storms and hurricanes.

In accordance with the information provided by the community, red (Rhizophora mangle) and black (Avicennia germinans) mangroves previously grew between the mouth of the river and two kilometers upstream. Currently, parts of the riverbank are colonized by southern cattails (Typha dominguensis), which, like the mangrove, adapts to salinity. Additionally, according to Villamil (2003), the southern cattail contributes to the dispersion and establishment of mangrove propagules by acting as a physical barrier that offers protection from the sun, which aids mangrove growth.

Other riverbank species which can strengthen the riverbank and can adapt to freshwater include the purple coraltree (Erythrina glauca), bloodwoods, willows (Salix chilensis, Salix humboldtiana, Salix spox), ceibón (Ceiba pentranda), among others."

2. Use of fodder species tolerant to salinity and drought

"The goal is to have a variety of fodder species that adapt best to salinity, flood areas, and drought, so that each may be used in different areas of the ranches.

Rotating pastures according to dry and rainy seasons is extremely important. During the rainy season, grasses can be used in flood areas and in turn are resistant to salinity. In times of drought and excessive buildup of salts, it is recommended to use grasses resistant to drought and in non-flood zones."

The report proposes various grasses adaptable to salinity (Pangola, Transvala or Swazi, Aleman, Pinto Peanut, Brazilian jackbean, etc.) and to drought (African star, Andropogon, Dictyoneura, Signalgrass, Guinea, King, Napier or South African pigeon, Mombasa guinea, etc.)

3. Silvopastoral systems as alternative fodder supply

"Silvopastoral systems are an option to adaptation to climate variability as they offer fodder availability during critical seasons. Fodder trees are able to produce high quality and quantity fodder, which improves livestock nutrition and reduces the pressure of grazing, which degrades pastures in dry and rainy seasons.

Silvopastoral systems are a supplementary feed option to pastures during the dry season and provide shade, decreasing heat stress in the livestock. During the rainy season, these systems offer greater soil stability, preventing erosion, and contribute to rainwater capture as they increase seepage, which aids aquifer recharge.

Other benefits include the increase in biodiversity, carbon capture, and improvement in soil fertility. According to the Tropical Agricultural Research and Higher Education Center (CATIE, 2009), pastures with tree coverage between 20% and 30% offer economic and ecological benefits as compared to degraded pastures."

Some of the "tree species for fodder appropriate for the wet and tropical system of Santa Rosa de Aguán are:" Guácima, Guapinol, Ice cream bean, Avocado, Plum, Pito, Pitón, Wild Cashew, Jicaro, Supa, Almond, etc.

4. Rainwater harvesting in seasons of drought

"Santa Rosa de Aguán is part of the country's rainy ecosystems, with over 2,400 mm of precipitation (…). Rainwater harvesting is an option for supplying water for animals and humans. In this case, the objective of the rainwater harvesting is directed towards livestock.

In accordance with the area's characteristics, rainwater harvesting systems with roofs, ponds lined with polyethylene or black plastic, or trenches lined with black plastic were proposed."

Rainwater capture by roof catchment (Anaya and Martínez, 2007)

Example of a pond lined with black plastic (CATIE, 2006)

Key Words

Adaptation to climate change, coastal ecosystem, conservation of natural resources, livestock production system, salinization, native plant species, forage species, silvopastoral systems, rainwater, Santa Rosa de Aguán community

Source

UNDP Honduras. Cruz, S. (2011). *Adaptación de Cultivos a la Salinidad en Santa Rosa de Aguán.* Tegucigalpa, Honduras

Tool 3
Design and construction of footbridges

Use

After a community socialization process, three footbridges were built to prevent foot traffic on the dunes and protect the dunes. The design and construction of the footbridges were carried out according to the report UNDP Honduras. Cruz, S. (2011). *Diseño Participativo y Supervisión de Obras de Conservación de Sistema Dunar en Santa Rosa de Aguán.*

This document characterizes the dunes and proposes footbridges, including necessary information on construction materials, activities, and applicable prevention and mitigation environmental measures. This fact sheet offers the most relevant information from this report.

The construction of footbridges in Santa Rosa de Aguán "aims to contribute to the conservation and rehabilitation of coastal dunes through spatial organization, easy access to the beach from homes, prevention of damage to geomorphology and vegetation due to foot traffic, as well as the removal of obstacles that are not part of the ecosystem in order for the dunes to regenerate naturally."

"Selection of paths was done avoiding areas sensitive to dune erosion, such as arms and crests. Areas with high levels of pedestrian circulation were also taken into account.

With the support of the Santa Rosa de Aguán Climate Change Adaptation Volunteer Committee, a short list of paths was created for consultation by the community. On August 13, 2011, the community held meeting on socialization, consensus, prioritization of paths, and the signing of an agreement. The following paths were selected and prioritized as a result of the consensus."

Proposed sections for footbridge construction.

Description

Design description

"The proposed designs consist of wooden footbridges adapted to the topography, sand transport dynamics, and vegetation.

The elevated walkway located at the school, or Section 1, is 132.45 m in length and 2 m in width, with heights between 1 and 5 m. This structure combines designs for a flexible footbridge linked by nylon rope 0.5 inch thick for areas with lower incline. Ramps with a 7.5% incline were used, with railings 1.10 m high to facilitate access and provide support. Between ramps, steps 0.40 m wide were placed, with landings (…). The aim of flexible footbridges is that they adapt to the changing geomorphology of the dunes and that they minimize as much as possible the alteration of the direction of the sand transported by the wind (…).

Section 2 is 37.50 m in length and 2 m in width, with railings of 1.10 m that vary between 1 – 1.50 m. The supports closest to the beach were buried at a depth of 1.50 in order to provide further resistance against erosion, with the rest of the supports at a depth of 1 meter.

Section 3 is 48.91 m in length and 2 m in width, without railings as the footbridge's height ranges from 1-1.5 m. The structure begins with a flexible walkway, followed by a ramp, and ending with a flexible walkway.

Section 4 is 40.21 m in length and 2 m in width, with height ranging from 1-1.5 m. The structure is a ramp that ends in a flexible walkway.

Section 5 is 43.41 m in length and 2 m in width, with height ranging from 0.5-1m with a railing of 1.10 m. The structure consists of a ramp that leads to steps."

Construction material characteristics

"The type of wood that will be used is pinewood previously treated against outdoor elements that can withstand exposure to sun, rain, salt, and wind. The wood must pass through pressure, vacuum, drying, and planning processes and was rounded at the corners.

Assembly was carried out with metal reinforcements for the wood. Reinforcements like bolts were galvanized.

In order to purchase the wood, documents certifying that it has been legally extracted must be presented (…)"

Accompanying Activities

"The work to be carried out is part of the conservation and coastal dune rehabilitation measures. Considering that they are structures that are not part of the dune system, they present advantages as well as disadvantages. On the other hand, the location could have potentially negative impacts that can be prevented and others that must be compensated for.

ADVANTAGES	DISADVANTAGES
• The materials and design used are in harmony with the surroundings and therefore have less impact on the landscape. • They aid community organization, which is vital for dune conservation. • Increases attractiveness for tourism. • The footbridge gradients are designed for use by the elderly and those with physical disabilities. • The elevation of the walkways permits sand circulation and plant growth.	• Footbridge possibly buried by sand. It must be maintained through sand removal. • Change in typical sand transportation behavior in dune formation, although this has been minimized by the proposed designs. • In the event of sea swells, these sites do not provide a barrier. • Fewer walkways have a smaller impact on the dune system.

Plant species are important to dune stability and must not be cut or unnecessarily damaged.

Herbaceous and bush species must be cultivated in the areas surrounding the project."

The previously mentioned report provides the following explanatory table:

Prevention and mitigation environmental measures regarding construction of wooden footbridges

Environment Affected	Activities	Impacts	Recommendations
Soil	Soil excavation	Subsoil instability Erosion	Do not exceed the location's limits
	Compression	Change in natural sand transport. Change in dune formation.	Only compress areas when strictly necessary.
	Wood residues	Contamination from solid waste. Obstacles for dune formation.	Pile wood in one single site and give it to the community for reuse.
	Hired personnel activities	Dune compaction due to trampling.	Use paths with soil stabilized by abundant vegetation. Avoid walking in areas with instable subsoil.
		Soil contamination from solid waste (organic and inorganic)	Keep containers for waste. Remove, transfer, and dispose of waste in authorized locations assigned by the municipality.
Air	Combustion of transport and construction equipment fuels.	Emission of pollutant gasses such as CO_2 and NO_2.	Control truck and/or equipment emissions and build-up.
Vegetation	Ground clearing	Loss of dune vegetation species. Subsoil instability.	Do not exceed the location's limits. Cut shrub vegetation and grasses only as necessary. Do not cut trees or bushes over 1 m in height. Plant shrub or tree species once the project is finished.
	Hired personnel activities	Removal of vegetation due to trampling.	Avoid trampling dune vegetation, above all grasses, herbaceous plants, and small shrubs.

Photos

Key Words

Climate change, coastal dune ecosystem, flexible footbridges, sections, conservation works.

Source:

UNDP Honduras. Cruz, S. (2011). *Diseño Participativo y Supervisión de Obras de Conservación de Sistema Dunar en Santa Rosa de Aguán.* Tegucigalpa, Honduras.

Tool 4
Land-Use Planning Proposal

Use

Among the climate change adaption measures fostered by this project is the creation of a land-use planning proposal. A community characterization of the SRA community was done from a participatory approach, including administrative, biophysical, social, and economic systems and facilitated a diagnosis of the territory and the resulting land-use planning options. Its content can be found in the report UNDP Honduras. Cruz, S. (2011). *Propuesta de Ordenamiento Territorial*. Santa Rosa de Aguán, Colón, which is the source of this factsheet.

"Santa Rosa de Aguán is one of the most vulnerable coastal communities in the country, with high levels of poverty, far from development poles, which has created a dependency on the ecosystem services that have sustained their needs in the long-term. The degradation of natural resources due to poor practices has put the community in a vulnerable state, which, together with other crucial factors like spontaneous land occupation, hydrometeorological events, and a volatile economy, have created a need for territory management capable of confronting the effects of climate change.

This publication shows a land-use proposal, taking into account the criteria of the community, the resources offered by the Land Use Planning Law, ecosystem conservation, and technical criteria. The ordinances are at the community level and the methodology used is simple enough for analysis by the community."

Description

Study Area

"In 2007, the Fundación San Alonso Rodríguez [San Alonso Rodríguez Foundation, FSAR], with extensive experience in community work in this area, took the initiative to create a Diagnosis and Community Action Plan which consisted of obtaining information about the territory, identification of problems and needs, and a plan with actions selected by the community as the way towards resolving their problems and territorial needs. Zoning was also done according to the needs that were found.

The implemented phases were as follows:

1. Preparation and promotion
2. Territorial Diagnosis: Diagnosis, Territorial Vision, Community Approval, and Action Plan
3. Territory Zoning

With this work complete, the project continued in a participatory manner with the analysis of the current state of the territory, territorial perspective, and spatial planning options, forming a land-use planning collaboration scheme as follows:

1. 1. Preparation and promotion.
2. 2. Territorial characterization: administrative, social, economic, environmental systems, threats and risks.
3. 3. Diagnosis and analysis of current state of territory.
4. 4. Territorial perspective.
5. 5. Spatial planning options.

To begin, the valuable work done by FSAR was analyzed (…). The territorial characterization was complemented by and updated with new information in the study area, and was approved by the community. It was organized

in accordance with the systems that form the territory (administrative, social, economic, and environmental, as well as threats and risks), with threats and risks included under the climate change framework as a precondition of the territory.

In the Diagnosis and analysis of the current state of the land, the approval and incorporation of new issues have been included, such as the causes and consequences for each sector, so that we can identify the potential for each. The territory's key actors were recognized, classified according to their influence and importance. Exercises to understand territorial identity were also conducted.

Next, the current state of the land was analyzed and a map of current land use was created. After determining the degree of conflict in land use, landscape units were defined on a very general scale, given that these units provide information on vegetation, terrain, and soil type (...).

Finally, the key factors that have contributed to the transformation of the land and have hindered its development were detailed.

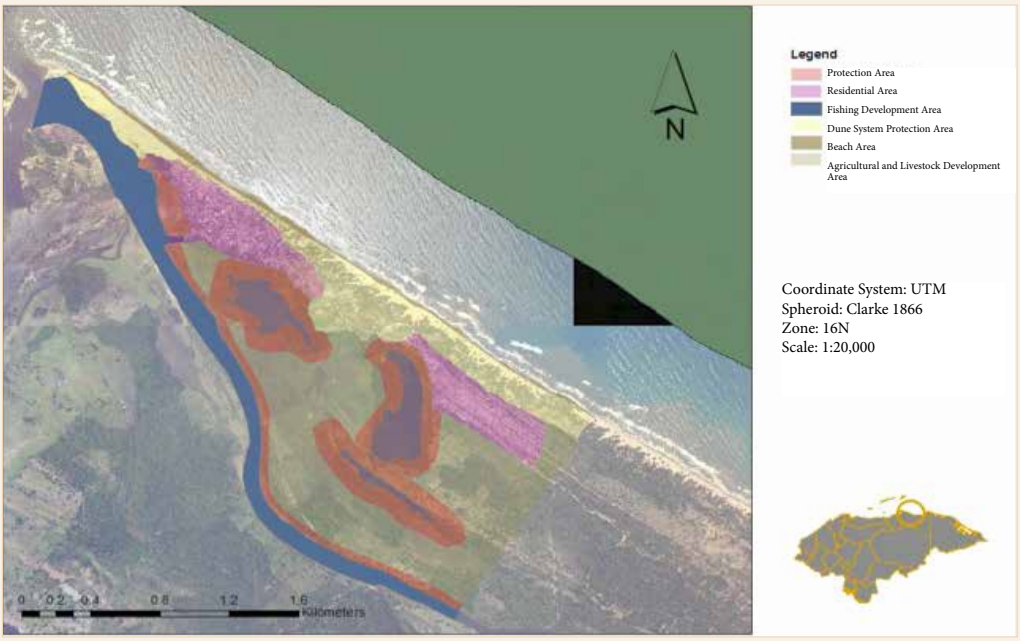
In the analysis phase, key variables, which have determined space, time, and behavior trends, were used. These variables are comprehensive, classified by the sectors or systems that comprise the territory. Each variable's behavior was visualized over a span of 10 years, comparing each to a Trend Scenario (...), Optimal Scenario (...), Cooperation Scenario (...). Based on this, transformative territorial demands or initiatives arose.

Spatial planning was the last phase, where each category or territorial zone was updated, including increases in meteorological events and climate variability in the context of climate change. Finally, se pasó a transformative action plan for the territory."

SPATIAL PLANNING – ORDINANCE CATEGORIES

"There is a total of five ordinance categories which were defined on the bases of the Land Use Planning Law and its regulations, as well as the interests and needs of the community: A) Agricultural and Livestock Development Area, B) Residential Area, C) Forest Conservation Area, D) Dune System Protection Area, E) Fishing Development Area, and F) Beach Area."

Land-Use Planning Map
Santa Rosa de Aguán, Colón



Given that the community will not be relocated and that land use will remain the same, zoning is proposed. "The differences in land use with the new zoning proposal lie primarily in the 5.49% increase in the Dune Protection Area. This preserves perennial and annual species in flat areas and areas far from primary dunes, using agroforestry and soil conservation techniques. It is not appropriate for agriculture to be within this ecosystem, it is not recommended, but due to the land tenure system, it seems to be one of the spaces in which the community is able to grow crops (...).

Secondly, the livestock sector, encompassing 63% of the land, has been divided, with 26.01% going towards a forest protection area, leaving 36.79% of the land for potential livestock breeding and agricultural use. The Forest Law states that lake and riverside areas must be protected. However, in areas already occupied, conservation practices must be agreed upon with landowners. These practices can be silvopastoral.

One constraint in land use is the unequal land distribution, where the largest areas are owned by cattle farmers and the majority of the community does not have land to cultivate. The combination of coastal dune conservation, forest protection areas close to bodies of water, the use of fodder banks through silvopastoral techniques, agroforestry, and ecological tourism, will allow for land use that is more environmentally friendly and adapted to natural events and climatic variability."

LAND USE PLANNING ACTION PLAN

"Land management is the process that establishes and carries out the development of land use by man, which must maintain balance between ecology and socio-economics, managing the land in a sustainable and multifunctional manner. The proposed actions are born from the demands of the community, which are important for community development, given the lack of social, home, and productive services, as well as environmental problems and high vulnerability. Therefore, these actions are directed towards meeting the needs and climate change adaptation measures."

The following chart, included in the report previously mentioned, summarizes "land-use planning actions".

SECTOR-ACTION	IMPACTO
Administration	
Strengthening relations between the municipality and local organizations through participation, coordination of actions, and fund management.	Mejor gestión del territorio.
Social	
Improving and equipping the elementary school, high school, and kindergarten facilities.	Better prepared students.
Organization to improve quality of education, foster bilingual education.	Better prepared students.
Strengthening Garifuna teaching and traditions involving the youth.	Improved territorial identity.
Promotion and dissemination of community development actions, involving youth, women, and the elderly.	Increase in social participation in community development.
Basic sanitation training.	Cleaner community.
Water and sanitation project management.	Water supply and sanitation services.
Improving the road from Aguán to La Planada	Better communication between towns.
Improving electricity service.	Better access to electricity.
Improve bus and boat transportation service and regulate services' costs.	Easy access.
Management of position for a permanent doctor and auxiliary.	Improvement in the community's health.
Supply of medical equipment and drugs.	Improvement in the community's health.
Training and seed capital management for projects.	Higher incomes.
Investigation on state of land tenure.	Distribution of clearly defined lands.

Economic	
Management of investment capital or help with materials.	Improved product quality and quantity. Higher incomes.
Take action to return the Aguán River to its original riverbed.	Improved product quality and quantity. Higher incomes.
Training and organization of tourist attractions.	Higher incomes.
Apply fishing ban ordinances and vigilance.	Higher incomes. Increase in fish resource.
Reforestation along lakes, rivers, and dunes.	Better protection for the community. Protected forest resources.
Water storage and search for water capture sources.	Sufficient water quantity and quality for tasks to be performed
Dune protection via creation of access paths and infrastructure demolition.	Less vulnerable settlements.
Ordinances to control logging, burning-off, and animal vagrancy, and to control agrochemicals.	Improved state of dune ecosystem and forestry plantations.
Warehouse and food management.	Improved assistance in the event of a disaster.
Equipping the CODEL.	Improved assistance in the event of a disaster.
Apply no housing construction ordinance in high-risk sites.	Decreased vulnerability.
Strengthening of early warning system.	Decreased vulnerability.
Planting of drought-resistant and saline-resistant crops.	Greater resistance to climatic variability.
Training and application of soil conservation and crop improvement techniques.	Improved product quality and quantity. Higher incomes.

Key Words
Coastal dune ecosystem, land-use planning, soil conservation, high risk areas, vulnerability, key actor mapping, territorial identity, participation, territorial perspective, ecosystem conservation.

Source:
UNDP Honduras. Cruz, S. (2011). *Propuesta de Ordenamiento Territorial. Santa Rosa de Aguán, Colón.* Tegucigalpa, Honduras.

Tool 5
Awareness campaigns and training workshops on climate change adaptation in Santa Rosa de Aguán

Use

Santa Rosa de Aguán is one of the most vulnerable coastal communities in Honduras. Its ecosystem diversity is being degraded by climate change and human practices. However, its inhabitants can gradually expand their capacity to create a development process based on risk reduction and adaptation to climate change.

Three dissemination campaigns and a training workshop were organized to further this process. As a result, the residents of Santa Rosa de Aguán have increased their understanding of climate change, adaptation and natural resource conservation measures, early warning systems, and development planning from a risk management perspective.

Following a participatory methodology, the community became involved in identifying climate change adaptation needs, gave feedback on the campaigns' and workshops' contents, and through the CCAVC, took the lead to implement conservation measures for this territory's typical dune system.

The campaigns began in March 2011 and concluded in June 2012.

Description

The campaigns and workshops maintained a flexible dynamic suited to the community's needs and forms of organization. Their logic was structured in the following manner:

"Informing Myself on Adaptation to Climate Change" Campaign. With this campaign, the community committed to adaptation to climate change and decided to create the CCAVC. The committee's volunteers "trained themselves to train" the community, in communication skills and techniques and on topics specific to climate change and natural resource conservation.

This process of awareness and training included five workshops with theoretical activities and exercises in relation to the climate change situation in SRA and the possible adaptation options. Additionally, a workshop was held on gender and promoting female participation.

A total of 37 people attended these workshops. The average attendance was at least three workshops per participant and five people attended every workshop.

Knowledge transfer was done through home visits, which was chosen as a way to reach every resident of Santa Rosa de Aguán. The people who ran the workshops organized themselves and voluntarily visited 237 homes (of which 63 were located in La Planada), using self-made materials in Garifuna and Spanish.

Despite the family responsibilities of the women of SRA, these women participated most in the campaign, indicating a stronger commitment to development in their community.

In general, the people visited expressed their concern towards degradation factors affecting SRA and the lack of institutional support to face this situation.

Awareness Campaign on Early Warning Systems (EWS). From a preventative rather than emergency approach, the

campaign addressed risk management and community organization, early warning systems, and the measures and actions to cope with emergencies. Theoretical training and practice, focused on the CODEL and the CCAVC, was disseminated via a community play and discussions in neighborhoods and at the school.

The play was performed by the townspeople of SRA after designing and rehearsing with the collaboration of a volunteer group of artists, graduates of the National School of Dramatic Arts of Honduras. The play's success was due to the fact that it was based on the socio-cultural Garifuna reality and was performed in various locations, bringing together the community by neighborhood. Thus, the community was able to reflect upon and easily understand the risks posed by natural phenomena, early warning systems, and the importance of prevention.

This campaign included three workshops with an average attendance of 23 people. 20 students in fourth, fifth, and sixth grade, upon seeing the play and discussions, participated in a drawing contest.

Awareness Campaign on Climate Change and Adaptation Measures. Following the analysis of the local reality, a model of community development was promoted, linked to adaptation to climate change situation and the availability of the community's own resources, from the expansion of the community's abilities. Some of the adaptation measures introduced included the reutilization of rubbish, the creation of compost, etc.

Training was done in two sessions with the participation of 21 people. After educating the committee volunteers on specific topics on climate change and adaptation and social communication skills, they once again made home visits to disseminate and train the community.

The volunteers were organized into pairs and visited 244 homes in the town center and La Planada.

Workshops on Climate Change, Adaptation to Climate Change and Development Planning with a Focus on Gender, Risk Reduction and Adaptation to Climate Change.

These workshops were aimed at training representatives of local organizations, relevant actors in the community, and municipal technicians to promote a participatory land-use planning process with the mentioned focuses.

The contents of the workshops were: development, environment, natural risks and climate change, land-use planning and early recovery, tools to incorporate gender, risk reduction and adaptation to climate change in development planning.

In the three sessions held, the average attendance was 21 people.

Results

The Santa Rosa de Aguán community became involved in needs identification and in the self-management of resources for adaptation to climate change and reducing its vulnerability.

These campaigns caused a synergistic effect between the increase in the community's social capabilities, physical capabilities, and environmental capabilities; the strengthening of the local organization facilitated the study, the selection, and the implementation of measures to protect the dunes and reduce vulnerability. At the same time, the planning process and execution of works, based on the proactive role of the civil society, promoted new local governance practices.

Knowledge of different territorial capitals and the analysis of the main disasters (for example, Hurricane Mitch) were key in the dissemination of land-use planning strategies with a preventative focus and the improvement of

emergency plans. Since many of the campaigns' contents were new to the community, reinforcement will be necessary in order to consolidate the reinterpretation of reality in the long term.

Photos

Key Words
Awareness, Abilities, Volunteer, Adaptation to Climate Change, Risk Reduction, Early Warning, Gender, Wulu-Duna, Prevention, Emergency, Planning, Development.

Fuente:

UNDP Honduras. Cruz, S. (2011). *Informe Campaña "Sensibilizándome a la adaptación al Cambio Climático". Santa Rosa de Aguán, Colón.* Tegucigalpa, Honduras.

UNDP Honduras. Cruz, S. (2012). *Informe Campaña de Sensibilización sobre Sistemas de Alerta Temprana (SAT). Santa Rosa de Aguán, Colón.* Tegucigalpa, Honduras.

UNDP Honduras. Cruz, S. (2012). *Informe Campaña de Sensibilización sobre Cambio Climático y Medidas de Adaptación. Santa Rosa de Aguán, Colón.* Tegucigalpa, Honduras.

UNDP Honduras. Cruz, S. (2012). *Talleres sobre Cambio Climático, Adaptación al Cambio Climático y Planificación para el Desarrollo con Enfoque de Género, Reducción del Riesgo de Desastres y Adaptación al Cambio Climático. Santa Rosa de Aguán, Colón.* Tegucigalpa, Honduras.

Tool 6
Demolition and Debris Management in Santa Rosa de Aguán

Use

The demolition and adequate debris management was done with the involvement of the community under the leadership of the CCAVC. Before the demolition of the structures, the community had to understand that the remains of the homes destroyed by Mitch were affecting the recovery of the dunes. Only after a social awareness process and after receiving permission by the owners could the demolition and proper use of the debris proceed.

Eleven structures were demolished. The debris was deposited in areas previously authorized and was later used in small construction and home improvement projects.

According to *El Primer y Segundo Informe de Supervisión de Obras,* by UNDP Honduras. Cruz, S., "As part of the intervention measures to rehabilitate the frontal coastal dunes, it has been suggested to demolish the concrete structures, which are remains of homes destroyed by Hurricane Mitch and which restrict dune formation as they prevent the spread of native vegetation and impede the geomorphological formation of the dune, thus affecting the dune ecosystem."

The following explanatory images have been taken from these reports:

Photos of some demolitions
to be done

Description

The reports mentioned explain the steps taken for the demolitions and debris management.

1. Demolition supervision

"In regard to the demolitions, a field visit was made with the help of the CCAVC (…) [a UNDP adviser and the contractor], with a list of demolitions identified by owner's name and photographs. During this visit, they explained the scope of the demolitions and the principle of not damaging the dunes or the specialized vegetation (…).

The demolitions were scheduled for three weeks, from Wednesday, June 27 to July 18. The team finished earlier as they worked double shifts, demolishing the homes efficiently and ahead of schedule. The foundations were left intact as removing them would damage sea grape plants (…).

The hauling of debris was completed over the course of two weeks, placing the remains in the sports field close to the pier, having been authorized by the mayor (…). A recommendation was made to collect all remains without

leaving any behind among the plants as this would cause visual pollution and affect vegetation growth. The debris collection crew was made up of two groups of 20 people who worked one or double shifts.

It was also suggested that the remains be stored in an organized manner. Posters were displayed in public areas to notify those who need construction materials such as concrete bricks or concrete remains as fillers for home improvement that these materials were free to take."

2. Demolitions and Debris Hauling

The hauling of debris left by the demolition of the remains of homes destroyed by Hurricane Mitch was completed in two phases. Care was taken to not leave any remains as they could leave a negative impact through visual pollution and remains and could affect the natural regeneration of dune vegetation species.

Accumulation of home demolition debris, impeding the dune dynamic.

Part of a destroyed home.

State of the dune after removing the obstacle.

Accompanying Activities

"To the extent that demolitions were done, it was necessary to install sand collectors to avoid sand intrusion in the community. The collectors were created with dried palm leaves, dry branches, and the leftover lumber from the footbridges.

One key accompanying measure is the planting or transplanting of Coccoloba uvifera [sea grape] in the areas where structures have been removed."

Prevention and mitigation environmental measures regarding the demolition of concrete structures

According to the report *Diseño Participativo y Supervisón de Obras de Conservación de Sistema Dunar en Santa Rosa de Aguán:*

Demolitions

Environment Affected	Activities	Impacts	Recommendations
Soil	Land excavation	Instability of subsoil Erosion	Do not exceed demolition site's limits. Reincorporate sand in the same area from where it was extracted.
	Manual demolition of structures	Contamination by solid waste	Classification of rubbish that can be useful and that which is not. Removal of waste from dune area. Avoid leaving concrete debris.
	Hauling of debris	Sand compacting	Indicate transit routes, avoid trampling on the dunes.
	Final disposition of debris	Contamination by solid waste	Debris must be left in dumps or sites assigned by the municipality for its later use. Debris must not be left along the dunes, shore, or riverbank.
	Hired personnel activities	Dune compacting due to trampling. Soil contamination from solid waste (organic and inorganic)	Use paths with soil stabilized by abundant vegetation. Avoid walking in areas where the subsoil is instable. Use the same access paths, avoid walking in different directions. Maintain waste containers. Remove, transport, and dispose of debris in authorized areas assigned by the municipality.
Air	Manual demolition of structures	Emission of pollutant gasses such as CO2 and NO2.	Control truck and/or equipment emissions and build-up.
Vegetation	Hired personnel activities	Loss of dune vegetation species. Instability of subsoil.	Do not exceed the site's limits. Cut shrub vegetation and grasses only as necessary. Do not cut trees once the project is completed.
	Actividades del personal contratado	Removal of vegetation due to trampling.	Avoid trampling dune vegetation, above all grasses, herbaceous plants, and small shrubs.

Key Words

Demolitions, remnants, debris hauling, sand compacting, dunes.

Soure:

UNDP Honduras. Cruz, S. (2011). *Primer y Segundo Informe de Supervisión de Obras. Santa Rosa de Aguán, Colón.* Tegucigalpa, Honduras.

UNDP Honduras. Cruz, S. (2011). *Diseño Participativo y Supervisión de Obras de Conservación de Sistema Dunar en Santa Rosa de Aguán.* Tegucigalpa, Honduras.

Tool 7
Santa Rosa de Aguán Municipal Ordinances: Dune Conservation and Unmitigable High Risk Areas

Use
The creation and approval of municipal ordinances linked to risk management and adaptation to climate change were measures geared towards land-use planning in SRA, which was achieved with the participation of various community actors during June and July 2012.

The drafts were disseminated in different announcements and passed with the help of 121 people, including various local leaders, both male and female. Following this process, the ordinances were presented and approved in the SRA municipality. In addition to their legal form, the community saw the need to raise social awareness to enforce the ordinances.

Description
The following ordinances were signed on July 18, 2012, by the mayor of Santa Rosa de Aguán, Pablo Castro.

1. Santa Rosa de Aguán Dune Conservation Ordinance

The Santa Rosa de Aguán Dune Conservation Ordinance recognizes the ecological value of the dunes and the causes for their degradation in the following terms:

ECOLOGICAL VALUE OF THE COUNTRY'S DUNE ECOSYSTEMS
Provide services and environmental goods like water reserve and purification
Act as a barrier against marine intrusion
Serve as a support for the coastal tropical forests
Permit conservation of cultural traditions
Protect human settlements against hydrometeorological events
Possess recreational value
Are a source of sediments
Are a habitat home to biological diversity
Provide regulatory action against climate change
Act as topographical barriers that prevent the destruction of homes

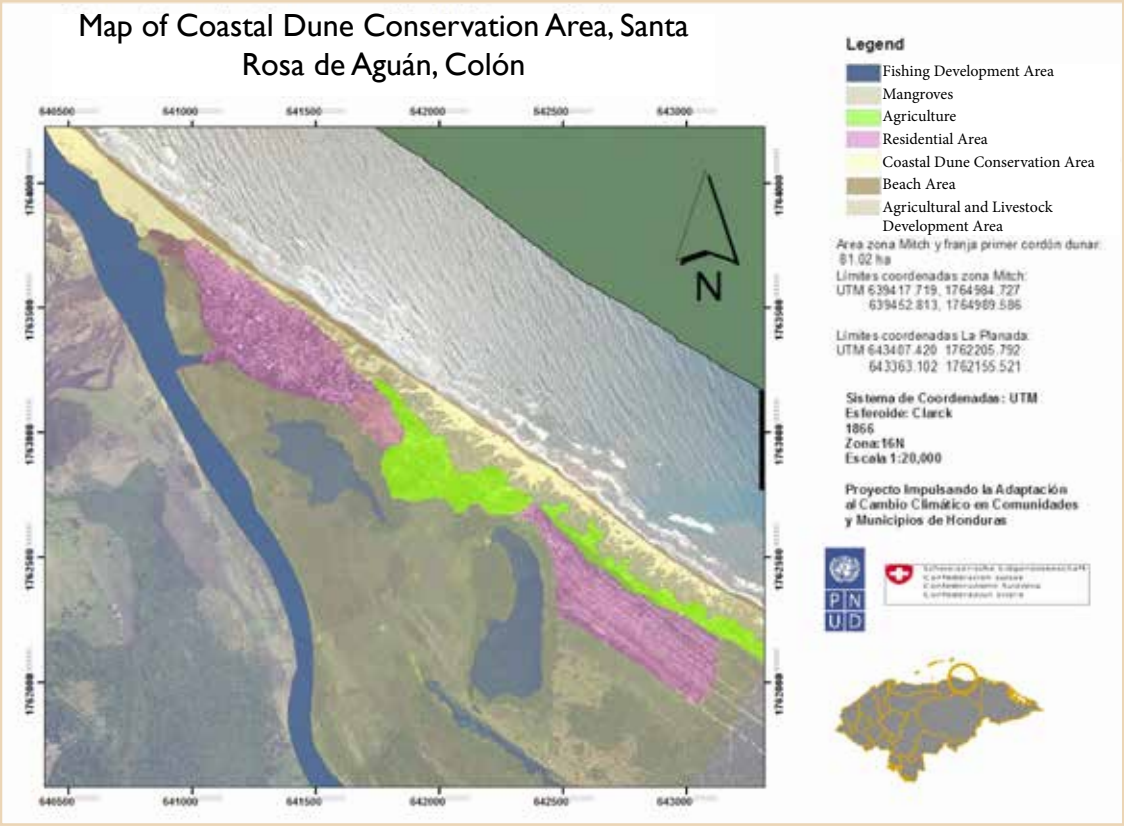
NATURAL CAUSES OF DEGRADATION OF COASTAL DUNES
Hydrometeorological events
Anthropogenic causes such as lack of land-use planning
Constructions on dunes
Creation and use of footpaths
Solid waste disposal
Crops on dune slops and on primary dunes, livestock grazing
Animal vagrancy
Tourism-related activities
Deforestation and burn-off, among others

"First. The declaration of CONSERVATION AREA of the dune ecosystem in the region called "Mitch" to the west of the community, where the coastal dune ecosystem is currently in the process of rehabilitation. This area is located on the map, which is an integral part of this ordinance.

Second. The declaration of CONSERVATION AREA of the primary dunes or frontal dunes from the urban area of Santa Rosa de Aguán to the sector known as "La Planada". This area is located on the map that is shown below.

Third. PROHIBITING any activity that causes short-term or long-term negative impacts in the primary dunes or frontal dunes and the area known as "Mitch". PROHIBITED activities include the following:

a. a. Logging, burn-off, uprooting or disturbing any type of vegetation.
b. b. Construction of any form of infrastructure.
c. c. Crops on the slopes and crests of primary dunes, nor in the area known as "Mitch".
d. d. Animal/livestock grazing or vagrancy on the dunes.
e. e. Dumping, burning, or burying garbage (solid or liquid waste) on the dunes.
f. f. Creation of new beach access paths.
g. g. Recreational and tourist activities that affect the dunes.
h. h. Extraction of sand from the dunes."



2. High Risk Unmitigable Area Ordinance

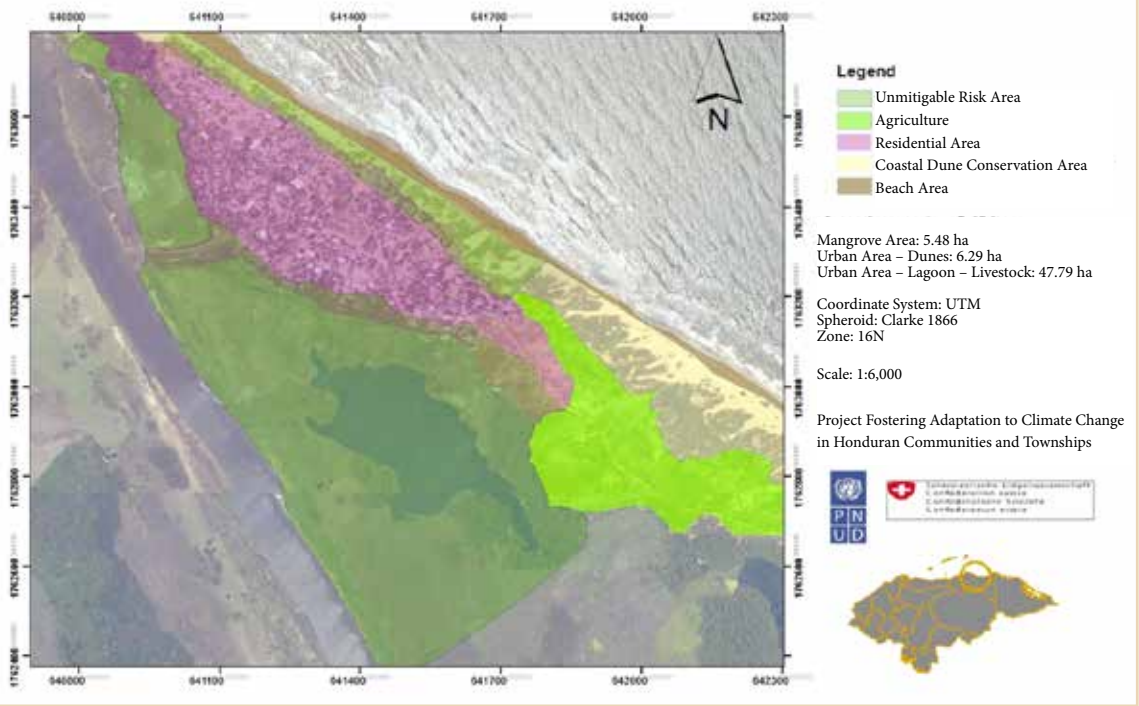
"Considering: that the community of Santa Rosa de Aguán is a product of a spontaneous occupation process in an area identified as high risk, which puts the human life and property of the community in grave danger.

Considering: that the high risk condition has been determined due to the location of part of the Santa Rosa de Aguán community on a sandbar of deltaic deposits next to the mouth of the Aguán River and due to being located within the flood plain of the Aguán River (…).

Thus, it is decreed:
First: The ocean shore, riverbank, coastal sandbar, and the banks of coastal lagoons are declared UNINHABITABLE AREA. This area is located on the map which is part of this ordinance.

Second: Any form of infrastructure construction along the ocean shore, the right side of the Aguán River, and coastal lagoons is PROHIBITED regardless of construction material or intended use (business, home, tourism, production, public use, etc.), as according to the ordinance map."

Map of High Risk Unmitigable Area, Santa Rosa de Aguán, Colón



Key Words

Climate change, municipal ordinance, hydrometeorological, dune conservation, high risk unmitigable areas, municipal corporation, community participation, disaster risk reduction, early recovery.

Source:

UNDP Honduras. Cruz, S. (2012). *Ordenanzas Municipales en Santa Rosa de Aguán – Conservación de Dunas y Zonas de Alto Riesgo no Mitigable*. Tegucigalpa, Honduras.

Tool 8
Design of rainwater harvesting and storage systems for the Santa Rosa de Aguán community

Use

The limitations in access to water fit for human consumption detected in Santa Rosa de Aguán motivated the study of more appropriate options to meet this need and the later design and installation of rainwater harvesting and storage demonstration systems. AS a result, the community has four rainwater harvesting systems distributed equally between the urban center of SRA and La Planada. Each of these systems provides water storage for an estimated average of four families.

The technical information behind this adaptation measure is found in the document UNDP Honduras. Cruz, S. (2012). Diseño de Sistemas de Captación y Almacenamiento de Agua para la Comunidad de Santa Rosa de Aguán. Tegucigalpa, Honduras. Its most relevant contents are presented in this factsheet.

"Freshwater is fundamental for life and development. It is a natural resource that has social, economic, cultural, and environmental dimensions that are complementary and interdependent. The limited access to water, both in terms of quality and quantity, is a problem that negatively impacts all aspects of development.

Uneven population growth and human activities have contaminated surface water and groundwater sources and have also caused environmental degradation, affecting water availability.

It is for these reasons that various options have been developed that maximize this vital resource, one of these options is the collection and storage of rainwater.

Santa Rosa de Aguán is a community that depends on groundwater and has problems with water quality and water access. The La Planada sector has access problems and has five manual extraction pumps for 70 families. In the case of the town center, they have easier access, but water quality is affected by salinity and in the rainy season, the water becomes cloudy with bad taste. This happens most frequently in the areas closest to the beach.

The rainwater system was identified as a widely accepted mechanism in the community and is a new option that would cover water quantity and quality needs and would improve family's water access.

Two types of rainwater harvesting designs were proposed for April, May, and June, the driest months. One of the designs is conventional for homes and the second design is a harvesting station meant to be shared between three or four families."

Description

Rainwater harvesting systems

"A rainwater harvesting system is defined as the collection, transport, and storage of rainwater that falls on a natural or manmade surface. The surfaces that harvest water in cities can be roofs of homes and buildings, store roofs, etc. Stored water can be used for any purpose, so long as the appropriate filters are used each time (Rainwater capture for urban centers manual, PNUMA, 2008.)

Rainwater harvesting system, in their most basic form, are composed of the following elements: a) capture; b) collection and conveyance; c) interceptor; and d) storage.

The harvesting system in Santa Rosa de Aguán represents a healthy alternative for freshwater storage and is a

form of water resource development in sites where water access is difficult and water quality is not suitable for consumption. It is also a way to apply less pressure on the aquifer."

Methodology

1. Review of literature "on rainwater harvesting systems and information on projects related to rainwater capture in coastal areas."

2. Creation of "simple surveys directed at 30% of the 178 families in the town center, and 22% of the approximately 70 families in the La Planada area. The survey collects the following data: water usage per day for the calculation of allowances, access to water sources, types of water sources, identification of problems related to water quality and access, housing materials, level of acceptance of a rainwater harvesting project."

3. Review information regarding the design of the "precipitation system provided by the Honduran National Meteorological Service between 2002 and 2009 at the weather station in Trujillo. This information was quite limited, given that information was not generated for the Santa Rosa de Aguán area and ideally 15 years or more of precipitation data is required (...)."

4. Creation of design using "models of rainwater capture systems from UNAT-SABAR (2001), CIDECALLI-CP (2007):

    e. Determine demand for water
    f. Calculate net rainfall
    g. Calculate area of rainwater capture
    h. Design harvested water conveyance system (rainwater canal)
    i. Design drainpipes for harvested rainwater
    j. Design harvested rainwater storage tank
    k. Cleaning interceptors for first rains."

Design description

"One of the main criteria for designing the rainwater harvesting systems was the conflict caused by sharing or equally distributing the resource with community tanks, due to the community's idiosyncrasies, the cost of creating a water administration entity, conveyance systems, among others (...).

Consequently, two options were proposed (...) in which a conventional rainwater harvesting system would be built for the homes in La Planada with a reserve for April, May, and June, which can be adapted to harvest water for one month and can also be adapted (...) to the homes in the urban center with only the cost of the pipes.

On the other hand, a rainwater harvesting station was proposed, with a three month reserve system that can be modified to store water for less time or can function as collective stations for three or more families that do not have access to water. This design can be attached to a house or be placed in patios and was proposed in response to the high costs one would have in changing their roof.

The rainwater harvest system on roofs is composed of the following elements:

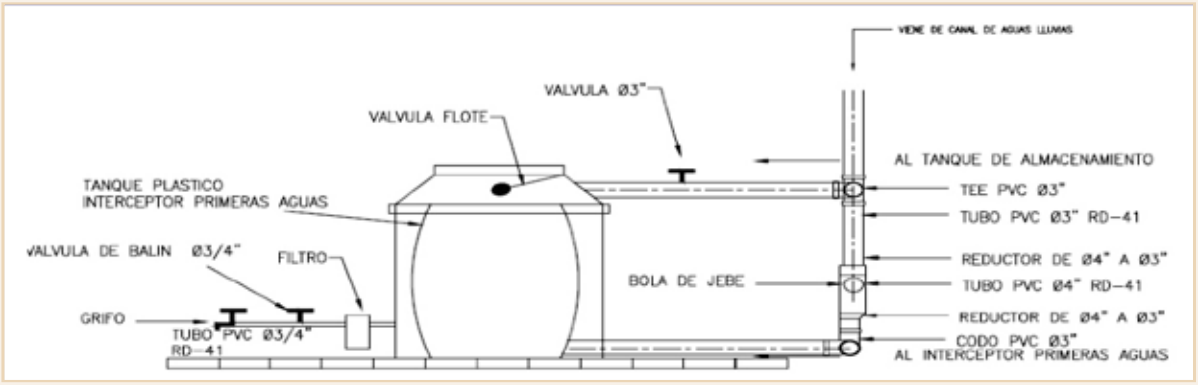
a. Capture: The capture is made up of the aluzinc roof in the La Planada home. In the case of the urban center, the only homes able to be used are those with aluzinc roofs; asbestos and aluminum are not recommended due to their contaminants. The rainwater harvesting station is made up of the aluzinc roof over galvanized gutters, supported by four PVC pillars filled with rods and cement with their respective foundations (...)
b. Collection and Conveyance: This consists of the gutters that are along the lowest borders of the roof where

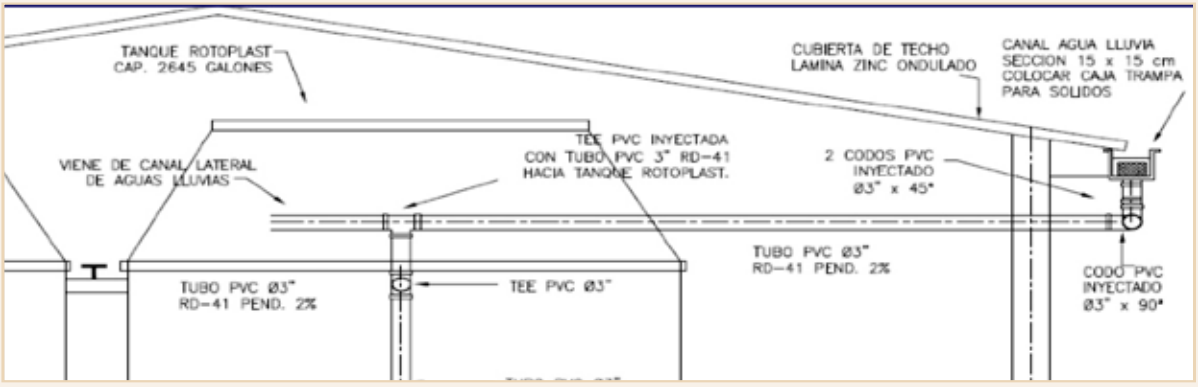
the water tends to accumulate before falling to the ground. PVC is suggested for the gutters, drainpipes, and connections, as it is light, water resistant, and easy to join together, reducing water leaks (...).

c. Interceptor: Also known as a pressure relief device for the first water from the roof, which contains all the materials that were washed away with the first rains.
d. This device prevents unwanted materials from entering the storage tank and thus minimizes contamination of stored water and water to be stored later. A plastic barrel receptacle is recommended, placed on the floor so that the water can be used for irrigation (...).
e. Storage: This is the project designed to store the volume of rainwater necessary for daily consumption, especially during periods of drought.

In regards to the storage tanks' support base, in this case it is recommended to use wooden planks as a foundation would be more costly due to the sandy soil and the heavy tank (...)."

According to the previously referenced report, the first graphic corresponds to the first rainfall interceptor system and the second graphic corresponds to the storage tank system.





Conditions that must be met by the beneficiaries

"As a community rainwater harvesting system is not feasible, a dissemination process must be carried out to select beneficiaries and must have selection criteria for beneficiaries, which can be as follows:

The homes closest to the beach and La Planada have greatest priority.

- Families without access to water who invest great amounts of time in hauling water; families with poor water quality
- Large families
- The most impoverished families.
- Families associated with other families for the use of shared systems in clear agreement on the distribution of water.
- Families with aluzinc roofs in good condition as this will lower costs by only installing gutters, an interceptor, and a storage tank."

Key Words

Water for human consumption, climate change, water harvesting and storage system, rainwater reserves.

Source:

UNDP Honduras. Cruz, S. (2012). *Diseño de Sistemas de Captación y Almacenamiento de Agua para la Comunidad de Santa Rosa de Aguán.* Tegucigalpa, Honduras.

Tool 9
Santa Rosa de Aguán Hydrochemical Study

Use

To implement measures regarding appropriate use of water resources, UNDP Honduras and the Universidad Nacional Autónoma of Honduras began a hydrochemical study in Santa Rosa de Aguán in 2012.

According to the residents of SRA, "the water from their traditional wells is increasingly "harder/saltier", which can be attributed to a possible seawater intrusion in the aquifer." As a result, it was suggested "to analyze the hydrochemistry of the free aquifer in SRA, determining the water quality for human consumption/use."

Description

"For Santa Rosa de Aguán, access to water for consumption is not a problem, with over 2000 mm/year in precipitation and a moderately productive aquifer with easy access (...), the problem stems from the quality of the aquifer and that is where short-term efforts must be focused."

Concept definition

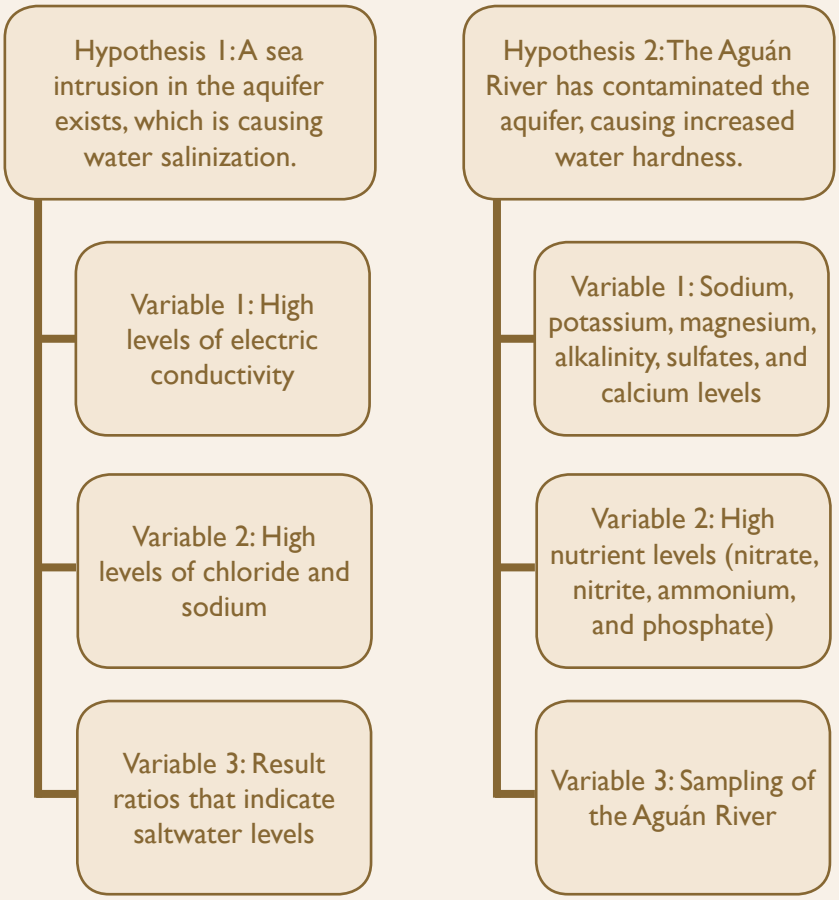
"In groundwater hydrology, an aquifer is considered the strata or geological formation that permits the movement of water through its pores and cracks so that man can use it in economically significant quantities to meet his needs (...)[1]

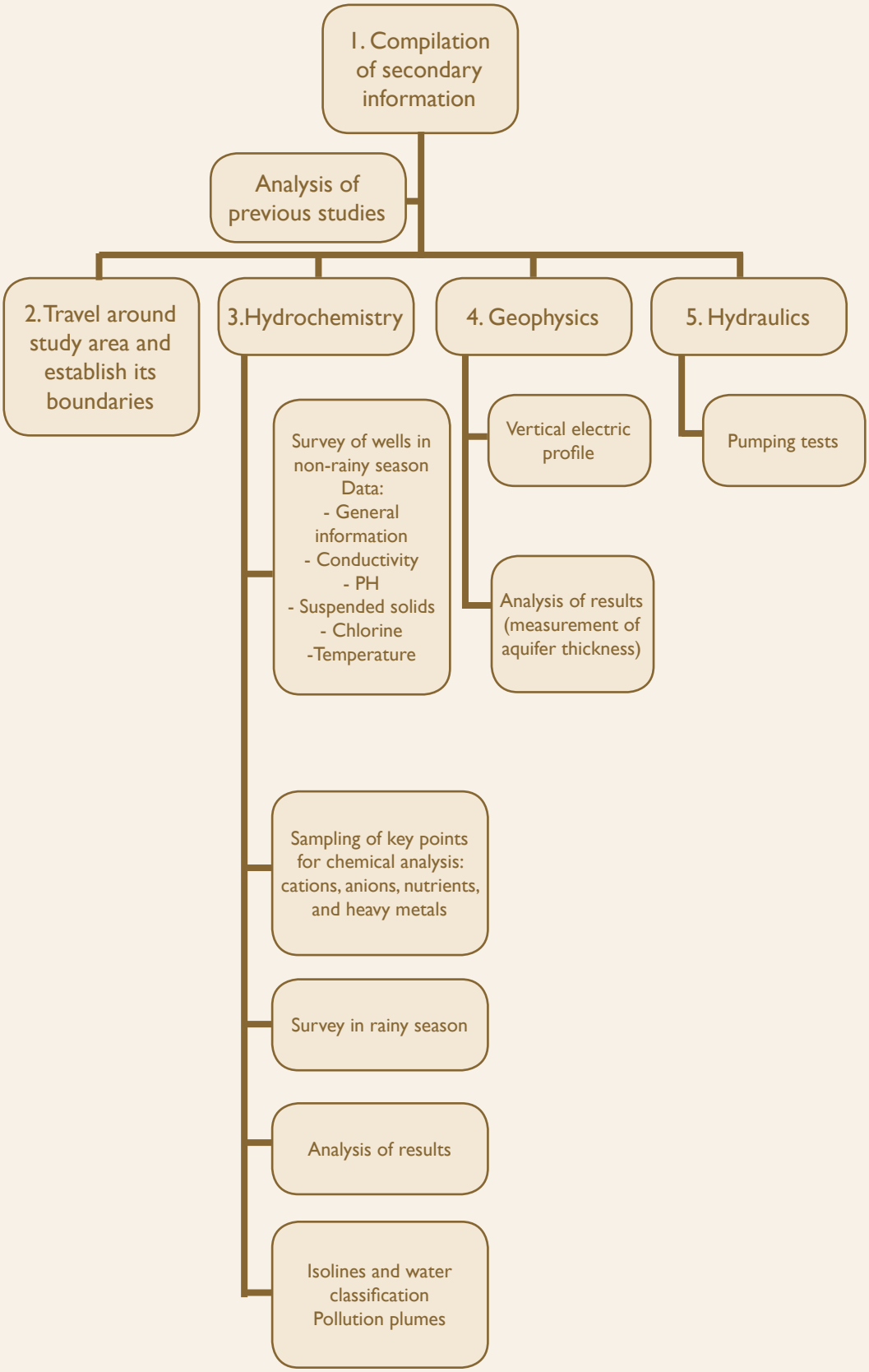
These can be free (or unconfined) or captive/confined; for the effects of this study, the SRA aquifer to be studied is the free aquifer."

"Salt water or body of salt water refers to water with chloride content equal to or close to that of seawater, for example 19,000 ppm (...). Water abstracted in a coastal aquifer is contaminated (salinizes) when an active portion of the abstraction is affected by the salt water-fresh water interface zone, or by salt water itself. However, this is not the only form of salinization as if abstraction takes place in an underground body of freshwater over saltwater, causing the salt to ascend and form a cone. In other cases, contamination can come from other contaminated aquifers or from saltwater flooding (sea swells and /or tsunamis) or from storms (…)."

1 Llamas Manuel Ramón, Hidrología subterránea/Sección 5 - Conceptos básicos y definiciones.

Methodology




1. Compilation of secondary information
Analysis of previous studies
2. Travel around study area and establish its boundaries
3.Hydrochemistry
4. Geophysics
5. Hydraulics
Survey of wells in non-rainy season
Data:
- General information
- Conductivity
- PH
- Suspended solids
- Chlorine
-Temperature
Vertical electric profile
Analysis of results (measurement of aquifer thickness)
Pumping tests
Sampling of key points for chemical analysis: cations, anions, nutrients, and heavy metals
Survey in rainy season
Analysis of results
Isolines and water classification
Pollution plumes

Conclusions

1. "The hypothesis on possible saline intrusion contaminating the wells has been dismissed for the moment, as hydrogeochemical indicators for this phenomenon have come back negative. However, the threat of well salinization has not been ruled out and therefore, a saline intrusion monitoring system has been proposed, which will be developed with the help of the San Alonso Foundation and members of the community. This will tell us the thresholds in which salinization processes can occur and thus allow for timely corrective action.

2. As part of the monitoring system, nutrients (nitrate and ammonium) will also be evaluated, in both wells and in the river, to avoid possible complications.

3. A fact-finding tour of the area will be undertaken to determine the source of the iron that is contaminating the Santa Rosa de Aguán aquifer as well aquifers of neighboring communities. The monitoring of iron levels in the study area is also recommended."

Key Words

Water for human consumption, wells, aquifer, hard-salty water, saline intrusion.

Source:

UNDP Honduras y Universidad Nacional Autónoma de Honduras. UNAH – IHCIT. (2012). *Estudio Hidroquímico Santa Rosa de Aguán.* Tegucigalpa, Honduras.

Mural made out of bottle caps, tiles, and other recycled materials.

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