Coastal Resilience to Climate Change in Cuba through Ecosystem Based Adaptation – "MI COSTA"

Feasibility Study

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Abbreviations/Acronyms

Abbreviation/Acronym	Definition
AMA	Environment Agency of CITMA
AMP	Marine Protected Areas
ANAP	National Association of Small Farmers
APPP	Provincial Assemblies of People's Power
BASAL	Project Environmental Bases for Local Food Sustainability
CAP	Provincial Administration Councils
CBA	Community Based Adaptation
CBC	Capacity Building Centers for Integrated Coastal Management
CC	Climate Change
CCA	Climate Change Adaptation
CBCS	Capacity Building Centers and Knowledge Management for Adaptation
CCS	Cooperative of Credits and Services
CES	Centers for Environmental Studies
CGB	Forest Guard Corps
CGRR	Center for Risk Management
CIEC	Center for Coastal Ecosystem Research. Cayo Coco. Ciego de Ávila
CIMAC	Center for Environmental Research, Camagüey
CIP	Climate Information Products
CISAT	Center for Research and Environmental and Technological Services. Holguin
CITMA	Ministry of Technology, Sciences and Environment
CM	Multidisciplinary Commission
CPA	Cooperative of Agricultural Production
CPAP	Country Program Action Plan from UNDP NIM
CPP	Country Partnership Program
CRI	Coastal Resilience Index
DIM	Direct Implementation Modality
DNFFFS	Forest Directorate Flora and Fauna
EBA	Ecosystem Based Adaptation
ECIT	Entities of Science, and Technological Innovation
ECOVIDA	Center for Research and Environmental Services Pinar del Río
EIRR	Economic Internal Rate of Return
FMC	Federation of Cuban Women
FONADEF	National Fund for Forest Development
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information Systems
GoC	Government of Cuba
GPPP	Municipal Assemblies of People's Power
IAS	Invasive Alien Species
ICIMAR	Institute of Marine Sciences
ICM	Integrated Coastal Management
ICZM	Integral Coastal Zone Management
INAF	Institute of Agroforestry Research
INRH	National Institute for Hydrological Resources
INSMET	Institute of Meteorology
IAS	Invasive Alien Species
IRC	Coastal Resilience Index (By its acronym in Spanish)
IPCC	Intergovernmental Panel on Climate Change
IPF	Institute of Physical Planning
IRR	Internal Rate of Economic Performance
MINAG	Ministry of Agriculture
MINAL	Ministry of the Food Industry
MININT	Ministry of the Interior

Abbreviation/Acronym	Definition
MINSAP	Ministry of Public Health
MPA	Marine Protected Areas
MTSS	Ministry of Labor and Social Security
NGO'S	Non-Governmental Organizations
NIM	National Implementation Modality
NPV	Net Present Value
OACE	Organism of the Central Administration of the State
ONEI	National Office of Statistics and Information
PAs	Protected Areas
PMF	Performance Measurement Framework
PVR	PVR – Hazard, Vulnerability and Risk
SAT	Early Warning System
SCAT	Community Early Warning Systems
SDG	Sustainable Development Goals
SEF	State Forest Service
SIDS	Small Island Developing States
SIEC	Complementary Statistical Information System
SIEN	National Statistical Information System
SIET	Territorial Statistical Information System
SLM	Sustainable Land Management
SLR	Sea-Level Rise
TNC	The Nature Conservancy
UBPC	Basic Unit of Cooperative Production
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America

Executive summary

This feasibility study supports the Funding Proposal document of the project "Coastal Resilience to Climate Change in Cuba through Ecosystem Based Adaptation". The Project responds to the coastal adaptation needs of Cuba due to the increasing frequency of extreme weather (hurricanes and tropical storms) as well as rising sea levels. These impacts derived from climate change will result in coastal retreat, increased coastal flooding during storms and extreme tides that will be felt through increased losses and damages from flooding and increased saline intrusion to coastal aquifers.

Cuba lies in one of the most active parts of the Atlantic/Caribbean hurricane region. The percentage of hurricanes affecting the country classified as intense (category 4 & 5) has risen from a historical average of 26% to 78% in the past 10 years. This trend is likely to intensify in a changing climate, as seen through the increase in intense storms observed across the Atlantic and related to the high temperatures observed in the Caribbean since 1998. Data from the National Office of Statistics and Information (ONEI) and cited within Cuba's Nationally Determined Contributions have shown that hurricanes and extreme weather events in Cuba have a great economic impact. Losses from 16 hurricanes dating from 1998-2008 have been calculated to be at USD 20.564 billion.

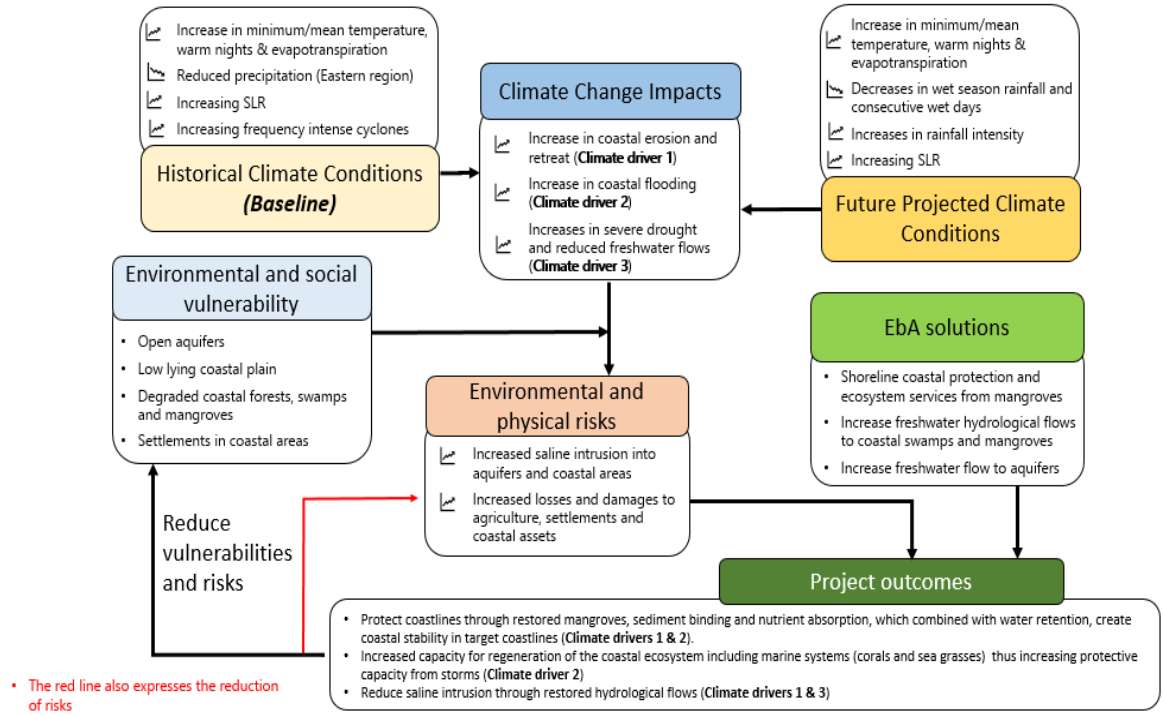
Under IPCC scenarios sea levels in Cuba are expected to rise by .015 m in 2030 and 0.29 m by the year 2050 (see Section 1 of the FS). Combining increasing storm surges and projected SLR, flooding of up to 19,935 km² (CC + Category 5 hurricane) and 2,445 km² (CC + normal conditions) can be expected by the year 2050 affecting over 220 coastal settlements.

Impacts from these climate drivers are a matter of national security for a small-island state and pose an existential threat to coastal settlements and communities. Projections show that if no intervention is made by 2100, up to 21 coastal communities will disappear with a further 98 being severely affected by climate related threats (flooding, coastal erosion and saline intrusion).

Cuban coastal seascapes and landscapes are a succession of ecosystems that have coevolved under normal climatic condition, including extreme events. The progression of coral reefs, seagrass meadows, beaches, coastal mangroves and forest or grassland swamps represents an equilibrium that confers resilience to each ecosystem separately but also to the coast as a whole in an integrated manner. Healthy ecosystems can be a natural defense barrier against wind, waves and extreme events by reducing coastal erosion, flooding and salt intrusion risks. However, the degradation of ecosystems has diminished their capacity to perform climate protective functions. While actions are being taken nationally to address ongoing anthropogenic pressures, additional resources are needed to restore and ensure their function as a protective service against climate change threats to Cuba's coast.

The proposed project looks to enhance adaptive capacity to such threats by rehabilitating coastal wetlands and, protecting and reducing anthropic pressures to submerged coastal ecosystems. It will also strengthen coastal governments and communities´ adaptation capacity by building capacity on ecosystem-based adaptation (EBA) solutions while enhancing information flows between coastal stakeholders and ensuring their continuity through time and through the mainstreaming of EBA in relevant planning instruments. Figure 1 summarizes the climate change rationale for the project, demonstrating how both observed historical and projected changes in climate (section 1.3.1 and 1.3.2) lead to impacts on erosion, flooding and freshwater flows (section 1.3.3), which increase the risks of saline intrusion and losses and damages to infrastructure and livelihoods. It further demonstrates how the proposed EbA solutions (mangrove regeneration and improved freshwater flows) will lead to outcomes (coastal stability, protection and reduced saline intrusion) which reduce environmental and social vulnerabilities to climate change impacts.

Figure 1 – Climate change impacts, vulnerabilities, risks and their reduction through EbA solutions and project outcomes



The project will focus on actions along Cuba's Southern Coast that has been selected due its high vulnerability to climate change (open aquifers, low lying coastal plain, degraded ecosystems and concentration of settlements), particularly to storms, drought and sea level rise, which result in coastal flooding and saline intrusion.

This Project will respond to CC-related threats that are increasingly affecting the coastal zones of Cuba, focusing specifically on two key outputs:

Output 1: Rehabilitated Ecosystems to enhance coastal resilience to climate change and,

Output 2: Increased CC adaptation capacity to CC in coastal communities, governments and economic sectors

1,300 km of coastline, 24 communities and 1,324,114 people will benefit from the project implementation (444,793 indirect and 879, 321 indirect). 11,427 ha of mangroves, 3,088 ha of swamp forest and 928 ha of grass swamp will be restored, which in turn will improve the health of 9,287 ha of seagrass beds and 134 km coral reefs crests.

CCA and EBA training thought as training of trainers will target national and local decision makers, teachers, economic sector leaders and local communities. Climate data and information, as well as that generated during the restoration process will be available and distributed through a knowledge platform, to ensure the strengthening of regulatory frameworks and continuous feedback to and from the communities to technical organizations and government.

These project interventions demonstrate a new paradigm from past national approaches to climate change adaptation and disasters risk reduction, achieved by positioning ecosystems integration into disasters risk reduction and climate adaptation strategies and policies as the best alternative for integrated coastal zone management in a changing climate. To change such paradigm, information needs to be available, ecosystems need to be protected and restored and communities and institutions' adaptation knowledge strengthened.

The project complements and in some cases sets the baseline for the enactment of the GoC's State Plan to Face Climate Change y ("Tarea Vida"), providing a platform for national upscale. Through its interventions, the project proposes direct solutions to national priorities outlined in "Tarea Vida" and in Cuba's Nationally Determined Contributions (NDCs), enabling a transformation in how the GoC will manage climate change impacts and generate information for implementing a similar approach in the Caribbean region.

The project will build on baseline successful experiences and knowledge in ecosystem rehabilitation to support an integrated EBA approach within a coastal ecosystem landscape including both inland

and coastal marine areas. It will also ensure the knowledge is disseminated through relevant information products and managed through enhanced adaptation capacities and actions (from territorial planning, to understanding the impacts of CC and managing its response). By training local communities and authorities, the project will enhance ownership at the local level, and by promoting information exchange and including local communities in an active role within the monitoring and information management process, the project is enhancing ownership of the decision-making process thus envesting coastal communities with the capacities for active adaptation. Increasing the understanding of the risks and solutions among planners and communities will allow and promote more effective adaptation actions within the territorial development plans- as they apply to climate resilient coastal management, while favoring a bottom up regulatory approach that will be nested within national technical norms and scientific information on ecosystem and adaptation needs.

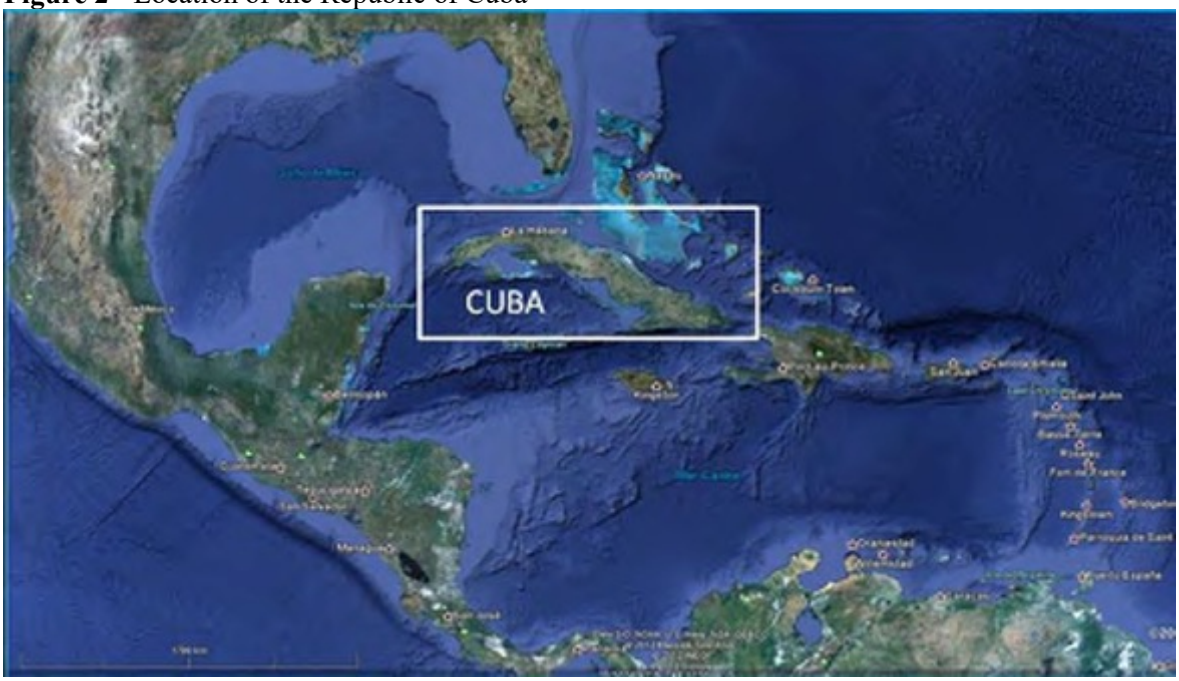
The project foresees an estimated total investment of USD 44.3 million of which 23.93 million will come from GCF resources and 20.37 million will correspond to counterparts of the Cuban Government. The project will be led by Cuba's Ministry of Science Technology and Environment (CITMA) through its Environmental Management Agency (AMA) as the institution in charge of leading national action on environmental issues including the collection and monitoring of data on climate and natural systems. Co-financing and support will be provided from the Ministry of Agriculture (MINAG) as the organization responsible for management and actions on agriculture, livestock and forestry, including mangrove forest and from the National Institute for Water Resources (INRH) as the institution in charge of managing and monitoring the country's water resources. The project will be managed, under CITMA leadership, and will in turn promote an inter-sectoral and integrated and proactive national approach that will be unique to the country.

I. Cuba's Climate Risk Profile.

1.1 Geographic Characteristics of Cuba

1. The Republic of Cuba is located in the Caribbean Sea, at the entry of the Gulf of Mexico at a distance of 140km from the Bahamas, 180km from Florida, 210km from Cancun, 77km from Haiti and 146km from Jamaica (Figure 1). Its total surface area is 109,886.19km², made up of the Island of Cuba (107,466.92km²), the Island of Youth (2,419.27km²) and almost 1,600 other islands, islets and cays totaling 3,126.43km².

Figure 2 - Location of the Republic of Cuba



2. The country is divided into 15 provinces (Figure 2) and 168 municipalities (including the special municipality of the Island of Youth), of which 96 have coastline (Figure 2).

3. Cuba's geography is a long, narrow island measuring 1,250 km from its most western end (Cape Santo Antonio), to its most eastern point (Punta de Maisi); in its widest part it measures 191 km and in the narrowest 31 km[1].

4. Cuba has a varied relief, with four mountainous systems that occupy 19,594 km^2, equivalent to 18% of the total area of the country. Thes include, the Guaniguanico mountain range, in the west; the Guamuhaya mountain range in the center; the Nipe-Sagua-Baracoa massif; and the Sierra Maestra both in the east of the country. Plains represent 82% of the total area of the country, these includide typical coastal and river plains; the lowest zones correspond to marshes and coastal marshes.

5. The coastal zone of Cuba comprises virtually the entire archipelago: the total length of the coast is 5,746km (3,209km on the North coast and 2,357km on the South coast) (Furrazola and Núñez, eds., 997). The coastline is very irregular and diverse, including steep cliffs, sandy beaches, extensive low lying and swampy coastal plains, fringing coral reefs, marine terraces, inlets, deltas and bays.

6. Cuba's insular platform extends for approximately 67,832 km^2. The North coast has a length of 3209 km, and the South coast of 2537 km, for a total of approximately 5746 km of coastline. The 5,746 km of coastline encompass a total of 262 coastal settlements (excluding la Habana) (IPF, 1998).

7. Cuba has a diversity of soils, which by their genesis are classified into 10 groups, among the most widespread are ferralitic, brown, alluvial, fersialitic and humic, where agricultural and forestry activities are developed, depending on local potential.

1 ONEI, 2017. Anuario estadístico de Cuba 2016.

8. The geographical characteristics of the archipelago determine the direct relation between fresh and salty waters. Of particular significance for the management of water resources is the existence of a watershed boundary that runs through the main island's longitudinal axis. This watershed fosters the formation of small basins with karst being predominant in deep aquifers; in many of them the karst develops from the surface of limestone massifs under which these aquifers lie. Karst processes are present in 67% of the national territory.

9. The island's form and orientation (from east to west), does not allow the existence of long and flowing rivers. Surface drainage is divided into two watersheds (one that drains to the North and the other to the South Superficial and are of quick discharge to the sea. Water sources are mainly provided through the underground aquifers to which the country is largely dependent, these are sedimatry rocks and karstic stone. Aquifers in their majority stand at or below sea level with most water from these flowing into the sea thus making them highly susceptible to saline intrusion, particularly during long periods of drought and as a result of ground water over exploitation.

10. The country has 3 fundamentally fishing areas: the estuarine coastline measuring 8,500km^2, seagrass and coral reef areas measuring 45,000km^2 and ocean waters.

1.2 The socioeconomic context.

1.2.1 Cuban Population and Distribution

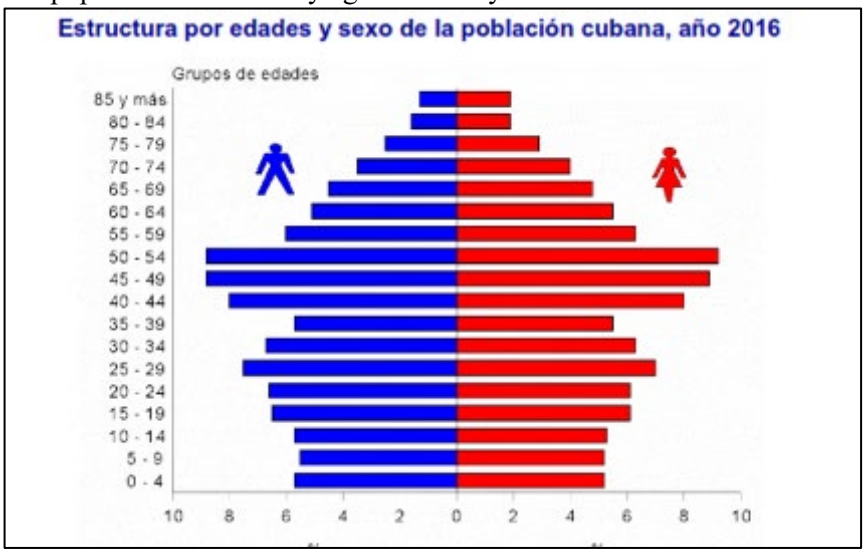
11. The total population of Cuba is 11,239,114 million [2] distributed in 15 provinces and 168 municipalities (Figure 2). Of the total population, 5,599, 279 (49.8%) are men and 5,639,835 (50.2%) are women (Figure 3).

Figure 3 - Political and Administrative division of Cuba in provinces.

Source (ONEI, 2010)

2 ONEI.2017. http://www.one.cu

Figure 4 - Cuban population structure by age and sex by 2016.



Source; ONEI. Panorama Económico y Social. Abril 2017

12. There are 7,014 human settlements (ONE, 2012) in Cuba, of which 6,417 (91.4%) are rural and 597 (8.6%) urban. The country has 12 major cities as provincial capitals. In addition, there are 29 other medium cities with population between 20.0 and 99.0 thousand, which account for 1,213,084 million people, 10.86% of the total population. In other 403 settlements over 2.3 million people live in the municipal cities (20.8% of the national population), of which 24% live in smaller settlements or in dispersed form. The distribution system of the population influences the levels of coverage of basic or specialized services like education, culture and health, among others, that contribute to the quality of life of its inhabitants. Therefore, access to services in urban areas that imply greater capacity and social resilience has increased compared to disperse rural communities.

13. Water supply pipelines serve the concentrated population, both in rural and urban settlements of various categories, through an aqueduct network estimated at 21,315 km of conductors, which provide coverage to 92.4% of the resident population (INRH, 2008) with potable and treated water. Sanitation services reaches 98.9% of the urban population and 88.5% of the rural population.

14. Cities generate around 80% of urban-industrial wastewater; that is, more than 60 million m^3 and a large part of these are incorporated into surface currents without prior treatment; despite the fact that sewerage coverage in urban areas cover over 50% of households. Storm drains while present, do not cover the full needs of the cities, this has an unfavorable impact during events such as summer rains, hurricanes, etc. which generate flood problems in inhabited areas.

15. Human settlements most vulnerable to these are those located next to river banks and in low-lying coastal areas with very weak relief, poor drainage and where they are also exposed to penetrations of the sea. To mitigate potential impact, this situation is monitored, by early warning systems and preventive evacuation plans, coordinated by Civil Defense and contemplated in the corresponding contingency plans.

1.2.2. Forms of Employment in Cuba and Educational Level

16. The Constitution of the Republic (2019) establishes that access to a job is a right and a duty for every citizen. The body that governs employment policies in Cuba is the Ministry of Labor and Social Security (MTSS). There is a policy to ensure employment for disadvantaged groups such as people with disabilities, young people leaving the military, and prisoners leaving prison.

17. Beginning in the 1990s, with the approval of the introduction of foreign capital and autonomous work by national actors, new forms of employment appear in the Cuban context that coexist with state employment, the only employment system that existed until that moment.

18. The main sources of employment in Cuba include muncipial, provincial and national governmental entities, state owned enterprises and cooperatives and, the private sector. Currently 70% of employees are contracted under governmental entities while 30% is employed in the non-state sector (private sector). (ONEI, 2017)

19. Under the governmental sector there are also research centers, teaching institutions as well as regulatory and policy offices that will support the achievement of the project objectives, both nationally and locally.

20. The cooperative sector includes Cooperatives for Agricultural Production (CPA), Basic Units of Cooperative Production (UBPC), Credit and Services Cooperatives (CCS) and Non-Agricultural Cooperatives (CNA).

21. The private sector is another important source of employment, which includes, farmers, craftsmen, restaurant owners, and skill-workers which provides many different services.

22. The sectors with the greatest number of workers in Cuba are agriculture, livestock and forestry, which together represent 17.8% of the economically active population, followed by education (11%) and public health/ social assistance (10.7%). The employed female population is more significant the sectors of Public Health, Social Assistance and Education.

23. It should be noted that 73% of the working population has an educational level between Middle Higher and Higher (ONEI, 2017)[3]. Hence communities in general and economic sectors (even those that are rural based) are made up of highly qualified and educated personal that serves as a key asset to the country.

V 1.3 Climate Analysis

1.3.1 Climate Conditions in Cuba

24. The climate of Cuba is seasonally wet tropical, with semi-continental characteristics and marine influence. Cuban climatic conditions present high but very seasonal levels of rainfall and generally high temperatures. Rainy season ranges from May-October followed by a dry season from November-April. Precipitation seasonality is highly associated to atmospheric conditions and its variations.

25. Climatic conditions are determined by the geographic location of the archipelago, at a latitude very close to the Tropic of Cancer. It receives high levels of solar radiation throughout the year, which results in high temperatures, while its proximity to the tropics exposes it to the seasonal effects of tropical and non-tropical atmospheric circulations.

26. Between May and October, the weather is determined by the location and intensity of the North Atlantic (Azores-Bermuda) anti-cyclone: there is little variation in meteorological conditions, which are only interrupted by the passage of tropical disturbances (barometric waves from the east and tropical cyclones), resulting in increases in rainfall levels.

27. Between November and April, by contrast, the weather is much more variable, in accordance with predominant processes and phenomena of extra-tropical circulation. Cold fronts result in lower temperatures, although there are still frequent hot days in the warmer periods between these fronts. These phenomena predominantly affect the western part of the country. The presence of extra-tropical low-pressure systems to the north of the country precedes the entry of cold fronts and generates strong, dry and hot winds from the south (termed "sures"), which can affect crops.

28. Physical and geographic conditions also affect the climate. Despite the generally flat or rolling nature of its relief, the location and height of the main mountain systems, coupled with local patterns of atmospheric circulation, result in a transition from the tropical wet and dry climate that predominates in the country (Aw according to the Köppen Climate Classification System) to other types and subtypes in certain areas, namely:

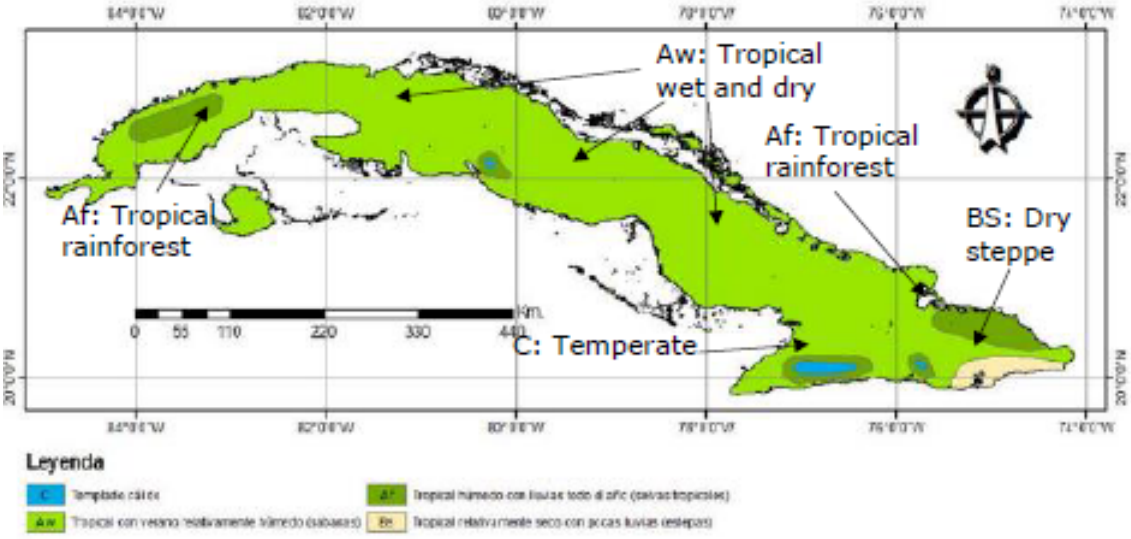
- Tropical rainforest climate (*Af*), with average precipitation of at least 60mm (2.4in) in every month: principally found in the windward side of the Nipe-Sagua-Baracoa mountain group, on the north-eastern slopes of the eastern part of the country; total annual rainfall exceeds 3,000mm (118in), with greatest amounts between November and April, in contrast to the rest of the country.
- Dry steppe climate (BS), with annual rainfall of not more than 600mm (24in): principally in the southern coastal belt of the provinces of Santiago de Cuba and Guantánamo.

3 Oficina Nacional de Estadística e Información (ONEI). Anuario Estadístico de Cuba, 2017. Capítulo 7: "Empleo y Salarios". Indicador 7.7. "Nivel educacional de los ocupados por sexo". La Habana, 2018. 19pp

- Temperate climate (C), of medium latitudes and greater altitude, with rainy season between May and October. There are two variants: monsoon-influenced humid subtropical climate (Cwa) in Guamuhaya and the eastern mountains, and Subtropical highland climate or temperate oceanic climate with dry winters (Cwb) in the highest peaks of the Sierra Maestra and the Nipe-Sagua-Baracoa Group.

29. Other geographic factors, such as marine currents and distance from the sea, play important roles in determining climatic conditions in the country. The Gulf Stream guarantees high surface seawater temperatures, and permits a rainy climate at latitude otherwise dominated by deserts. The long, narrow configuration of the country, meanwhile, ensures that no part of the country is very far from the sea, which buffers climatic variations.

Figure 5 - Climate types in Cuba (modified Köppen classification).



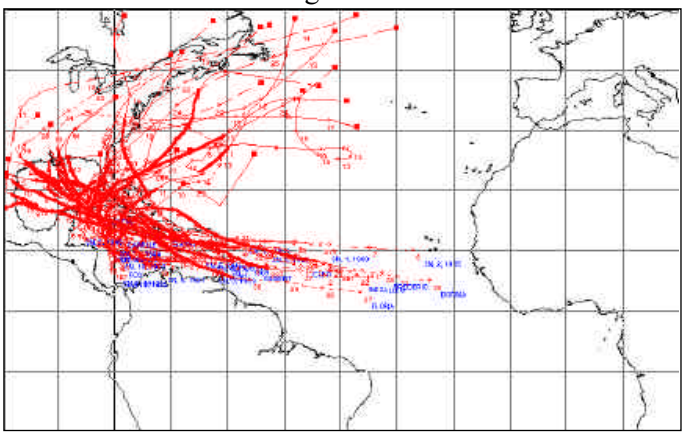
30. Median annual temperatures range from 24°C on the plains to 26°C or more on the eastern coasts, and less than 20°C in high parts of the Sierra Maestra. There is some seasonal variation in temperatures, with the July-August period being warmest and January-February the coolest. Daily temperature variation is greater than annual variation.

31. The largest rainfall amounts are associated with tropical cyclone cold fronts, local storms and tropical waves. Median annual rainfall across the country is 1,335mm (53in), although drought events do occur that sometimes last for several years.

32. The highest risks of damage arise from meteorological phenomena such as tropical cyclones and severe localized storms (with tornadoes, hailstorms, waterspouts and high winds). The cyclone season lasts from July 1st to November 30th and the most intense cyclones typically occur in October. The annual frequency of cyclones ranges from 0 to 4, with an average of one per year. The most affected region is the West part of the country. Severe local storms occur throughout the year, but most frequently between March and October, and in the afternoon.

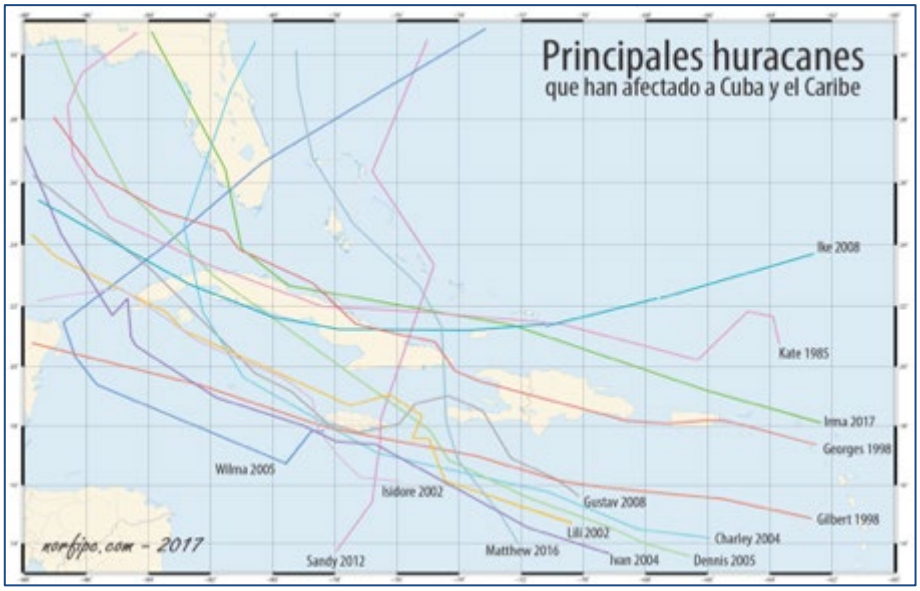
33. The island of Cuba is in a geographic position between the Caribbean Sea and the Atlantic Ocean near the Gulf of Mexico, so it is between two areas of high and low pressure. This difference in pressure happens particularly during periods of increased radiation that match the hurricane season. This situation explains the high frequency of hurricanes in the Caribbean (Figure 5), which often affects the island of Cuba. Figure 6 shows some major hurricanes in the island between 1985 and 2017.

Figure 6- Category 4 and 5 Hurricanes affecting Cuba between 1890 and 1995.



Source: PRODOC Manglar Vivo project

Figure 7- Map with paths impact on the island of Cuba of the major hurricanes that have arrived between 1985 and 2017**.**



34. In the Cuban archipelago, rain is the main source of hydrological resources. The average annual rainfall, updated for the period 1961-2000, is 1335 mm. This means that the country has a number lower than the 38,100 million m^3 reported in the past based on an average annual rainfall of 1375 mm. The exploitable hydrological resources are estimated at around 24 km^3 per year, 75% of which correspond to surface water and 25% to groundwater.

35. With the objective of counteracting the long droughts and floods caused by the hurricanes, since 1963 a process of hydrological infrastructure has been invested in by the GoC. To date, Cuba has 241 dams (which store more than 9 km^3 and can provide 78% of the water requirements), 730 reservoirs smaller than $3hm^3$, 60 secondary channels ("diverters"), 780 km of main channels and 8 large pumping stations to decant, 1,300 km of dams, and 1,010 km of channels (against floods).

36. These hydrological works supply the water for the country, with $13.7km^3$ yearly of available water ($1,220m^3$ per person). This represents 57% of the hydrological exploitable resources, which has a positive socio-economic impact. Nonetheless, these reservoirs have created some problems in terms of the fragmentation of terrestrial ecosystems, increased levels of evaporation from the reservoir surfaces, the damming of surface currents and the consequence decrease in the nutrients necessary for maintaining ecosystem services.

37. Salt-water intrusion has been identified as a main threat to water availability, particularly affecting coastal communities. As most underground aquifers are open to the sea, sea level rise has led to sheets of saltwater intruding into these aquifers, resulting in water that may become too saline for human consumption and that can result in increased salinization of fields. This impact is also aggravated by the over pumping of water from underwater aquifers for local use.

38. According to the Vulnerability and Climate Change Adaptation Index in the Latin America and Caribbean region, Cuba is classified as a "high risk" country[4]. Observations show that the country's climate has been changing, and studies conducted under the Second National Communication to the UNFCCC (2015) indicate the occurrence of: i) increased temperatures; ii) erratic seasonal rains; iii) greater frequency of long and severe droughts; iv) increased frequency and severity of cyclone activity; and v) moderate and severe coastal flooding[5].

1.3.2 Climate Change in Cuba

39. The Second Evaluation of Climate Variations and Change[6,] carried out within the framework of the Second National Communication of Cuba to the UNFCCC, indicated that the climate of Cuba has in fact reached a state similar to that evaluated by the IPCC for an intensified greenhouse effect in the terrestrial atmosphere.

40. Ample evidence has been generated by Cuban institutions and others regarding climate change and variability to date, and the corresponding vulnerability of human populations. Studies of circulation patterns in the Caribbean suggest that the structure and influence of the Azores/Bermuda High Pressure System on the region have undergone changes at a multi- decade scale (Naranjo y Centella, 1997). A significant warming of the lower troposphere of the region was detected in the 1970s, which is consistent with overall climate change and is in accordance with the significant patterns detected in circulation patterns in the Pacific/North American sector (Trenberth and Shea, 1997).

41. Climate projections in Cuba have been based on both the full ensemble of CMIP5 GCMs, as well as a dynamical downscaling of two state of the art GCMs including a multi-parameterisation to quantify uncertainty due to parameterization of key processes. The dynamical downscaling was performed on the following model configurations:

- QUMP: selection of 6 versions of the Hadley Center (HadCM3) atmospheric model, which differ in a set of physical parameters or have a different parameterization. QUMP is the English acronym for Quantifying Uncertainty in Model Projections.
- ECHAM5: is a climate model by the Hamburg Centre adapted from the global climate models developed by the European Center for Medium-Range Weather Forecast (ECMWF) in the United Kingdom.
- HadGEM-ES: one of the latest models developed by the Hadley Center within the Earth System models, which incorporates a larger number of components and interactions of the climate system (eg. the biosphere, the biogeochemistry and the chemistry of atmospheric components.)

42. The results of the QUMP and ECHAM5 models were based on the SRESA1B emissions scenario, while for the HadGEM-ES model representative RCP2.6, RCP4.5 and RCP8.5 concentration scenarios were used. All changes were projected for the years 2030 (2021-2040), 2050 (2041-2060) and 2070 (2061-2080) in reference to the 1961-1990 period, and a dynamic scale reduction method was used by means of the Regional Climate Model PRECIS to obtain a grid of future climate estimations for Cuba with a 25 km resolution.

43. **Temperature:** An evaluation of climatic variation and change in Cuba, carried out by the Meteorological Institute of CITMA (R. Pérez et al. 2009), provides observation-based evidence which clearly indicates that the climate in Cuba has become warmer. Figure 8 shows the trends in mean daily temperatures over Cuba between 1961 and 2015, with all regions demonstrating statistically significant (at the 95% confidence level) positive trends.

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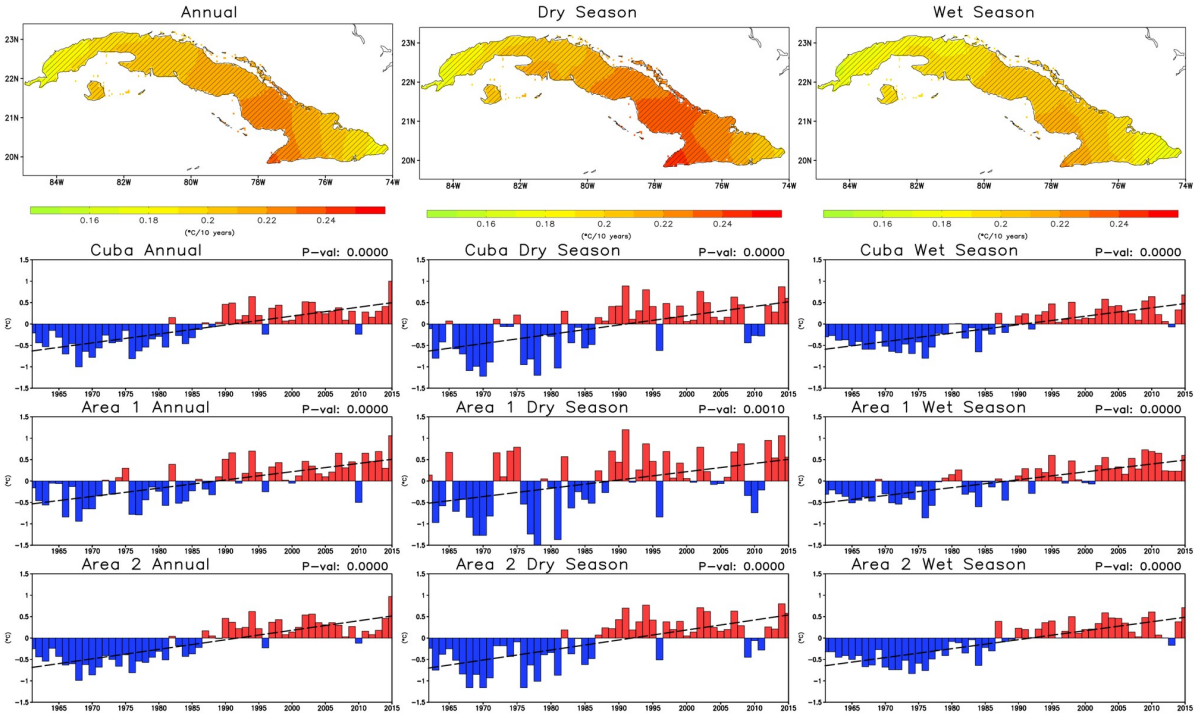
[4] Corporación Andina de Fomento, 2014. Índice de vulnerabilidad y adaptación al cambio climático en la región de América Latina y el Caribe.

[5] Second National Communication to the UNFCCC. 2015. Havana: Republic of Cuba https://unfccc.int/sites/default/files/resource/cubnc2.pdf

6 Pérez R., C. Fonseca, B. Lapinel, C. González, E. Planos, V. Cutié, M. Ballester, M. Limia, and R. Vega (2011): "Segunda evaluación de las variaciones y tendencias del clima de Cuba", in II International Congress of CC of the VIII International Convention of Environment and Development. ISBN 978-959-300-018-5.

Figure 8- Trends in mean daily temperature[7] . Annual (left), dry season (middle) and wet season (right). Spatial trend top row (hatching indicates trend statistically significant at 95% confidence level). Cuba 2nd row. Area 1 (western region) 3rd row. Area 2 (eastern region) 4th row



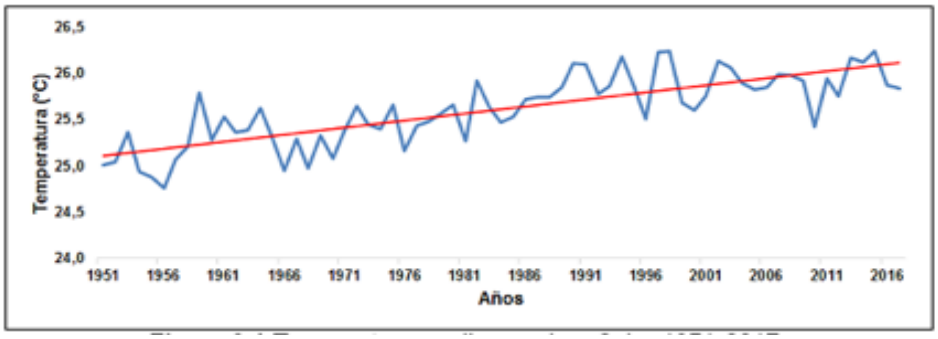
44. Furthermore mean annual temperature has increased by 1.0°C and mean annual minimum temperature, by 2.0°C in the 1951-2017 period. Each of the past three decades has been warmer than all of the past. Trends can be summarized as:

- Mean annual temperature in Cuba: 1.0°C increase in the 1951-2017 period (Figure 7). Difference between the mean value in the last 10 years (2008 - 2017) and that of the 1951-1960 decade: 0.8°C
- Temperature increase: More pronounced in the December-February quarter (1.4°C) than in the June-August quarter (0.9°C). Each of the past three decades has been warmer than all of the past since 1951, with the 10-year period from 2008 to 2017 being warmer than in previous decades.
- Mean annual minimum temperature: A 2.0°C increase in the 1951-2017 period. Difference between the mean value in the last 10 years (2008 - 2017) and that of the 1951-1960 decade: 1.6°C. Increase in the December-February quarter: 2.6°C. Increase in the June-August period: 1.8°C.
- No trend has been observed in mean annual maximum temperature between 1951 and 2017. However, an increase of 0.8°C was recorded in the 1978-2017 period and an increase of 0.5°C, in the June-August quarter.

Figure 9- Trends in annual mean temperature in Cuba1951-2017[8] .

[7] http://www.climatologylab.org/terraclimate.html

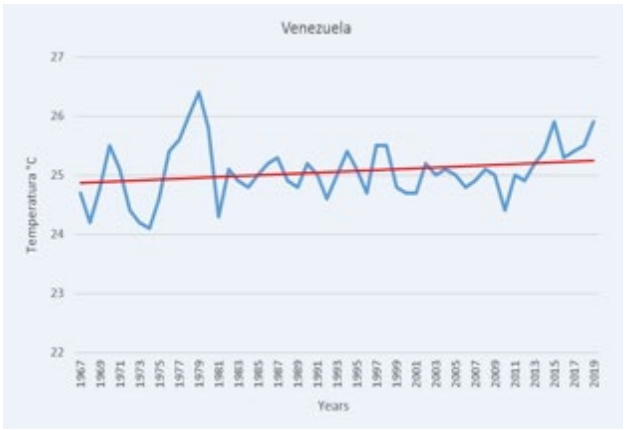
[8] Information derived from a group of 11 high quality meteorological stations along the Cuban territory with long-term records



45. Since the middle of the last century, the median annual temperature has increased by almost .9°C. The last two decades stand out as the hottest registered to date. Associated with this trend, there has been a very marked increase in mínimum temperatures, the monthly average values of which have increased by around 1.9°C. There have been no corresponding statistically significant trends in maximum temperatures, meaning that median daily diurnal temperature range has reduced by almost 2°C.

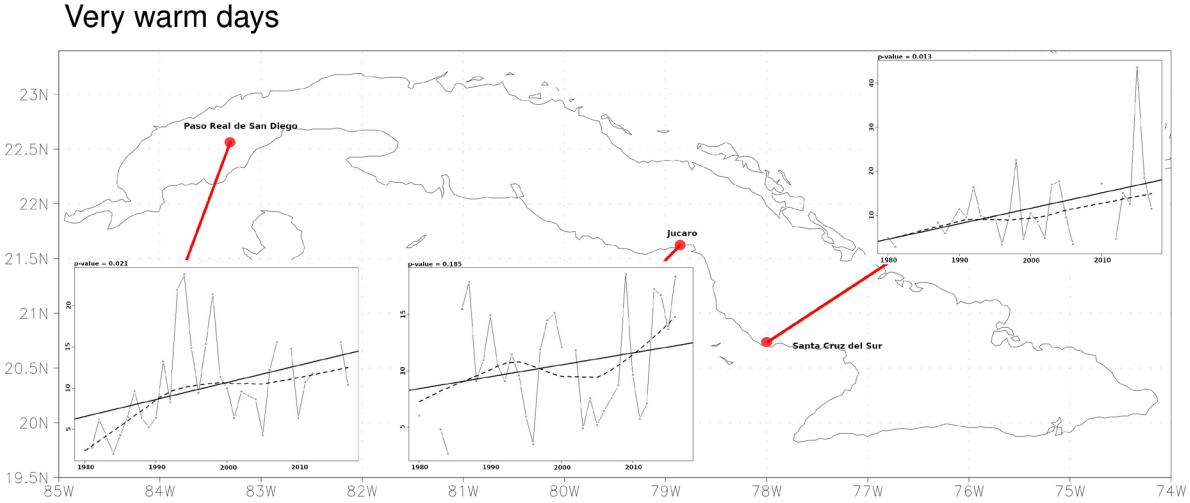
46. This tendency has also been indentified within Cuba's coastal areas as can be seen annual averages from local weather stations (Figure 10).

Figure 10- Trends in annual mean temperature in a) Santa Cruz del Sur b) San Juan Martinez c) Venezuela 1970-2018.



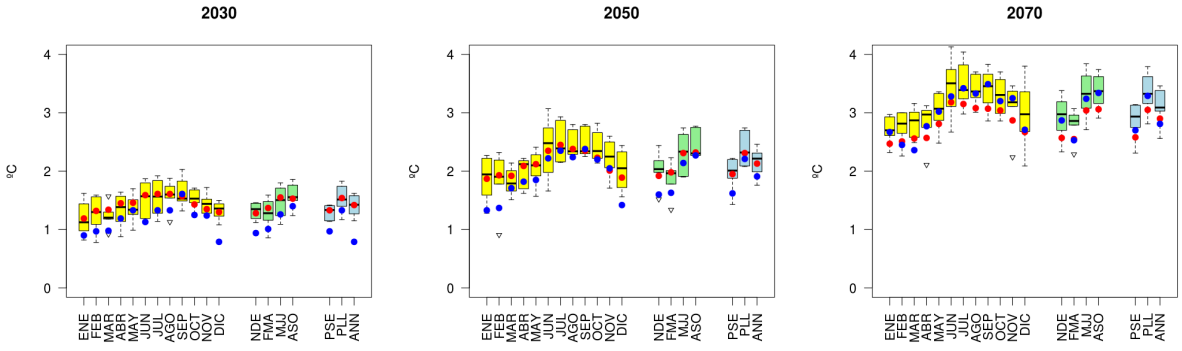
47. These increases in average temperatures have lead to increasing significant trends in very warm days (90th percentile maximum daily temperatures) between 1980 and 2016 at stations along Cuba's southern coast (Figure 11).

Figure 11- Trends in number of days > 90th percentile maximum daily temperature along southern coast (1980-2016).



48. Regional Climate Modeling, including the use of a large multi-parameter ensemble[9], suggests that by the end of the 21st century, the climate in Cuba will be warmer with temperatures increasing by 1.0 °C and 3.5 °C for the periods 2030 and 2070, respectively, with an uncertainty of approximately 0.5 ~ 0.6 °C, and largest monthly increases during summer and autumn (Figure 12).

Figure 12- Temperature projection for 2030, 2050, 2070. Boxes is for QUMP. Red points QUMP mean. Blue points ECHAM5 mean. In yellow the annual temperature distribution. In green quarterly averages (NDE – November, December, January; FMA – February, March, April; MJJ – May, June, July; ASO – August, September, October. In light blue PSE (dry season); PLL (rainy season); ANN (Annual))[10]



49. Figure 13 further shows that the model ensemble projects steady increases (between 1960 and 2100) in the percentage of time when very warm days (>95th percentile of daily maximum

9 Using the simple MAGICC-SCENGEN model and the regional PRECIS model, with a number of global climatic models, within the framework of the Second National Communication to the IPCC: Centella A., A. Bezanilla and K. Leslie (2008): A Study of the Uncertainty in Future Caribbean Climate Using the PRECIS Regional Climate Model. Technical Report, Community Caribbean CC Center, Belmopan, 16 pp.

10 Climate projections in Cuba have been based on the estimations of the following three global climate models: QUMP: selection of 6 versions of the Hadley Center (HadCM3) atmospheric model, which differ in a set of physical parameters or have a different parameterization. QUMP is the English acronym for Quantifying Uncertainty in Model Projections.ECHAM5: is a climate model by the Hamburg Centre adapted from the global climate models developed by the European Center for Medium-Range Weather Forecast (ECMWF) in the United Kingdom. HadGEM-ES: one of the latest models developed by the Hadley Center within the Earth System models, which incorporates a larger number of components and interactions of the climate system (eg. the biosphere, the biogeochemistry and the chemistry of atmospheric components.) The results of the QUMP and ECHAM5 models were based on the SRESA1B emissions scenario, while for the HadGEM-ES model representative RCP2.6, RCP4.5 and RCP8.5 concentration scenarios were used.
A dynamic scale reduction method was used by means of the Regional Climate Model PRECIS to obtain a grid of future climate estimations for Cuba with a 25 km resolution

temperatures) and warm nights (>90th percentile daily minimum temperatures) occur over eastern and western regions of southern coast. The increases are accompanied by increases in annual, dry and wet season temperatures over the eastern and western regions of the south coast (Figure 14).

Figure 13: Projections of percentage of time when very warm days (>95th percentile of daily maximum temperatures) and warm nights (>90th percentile daily minimum temperatures) occur over eastern and western regions of southern coast between 1960 and 2100.

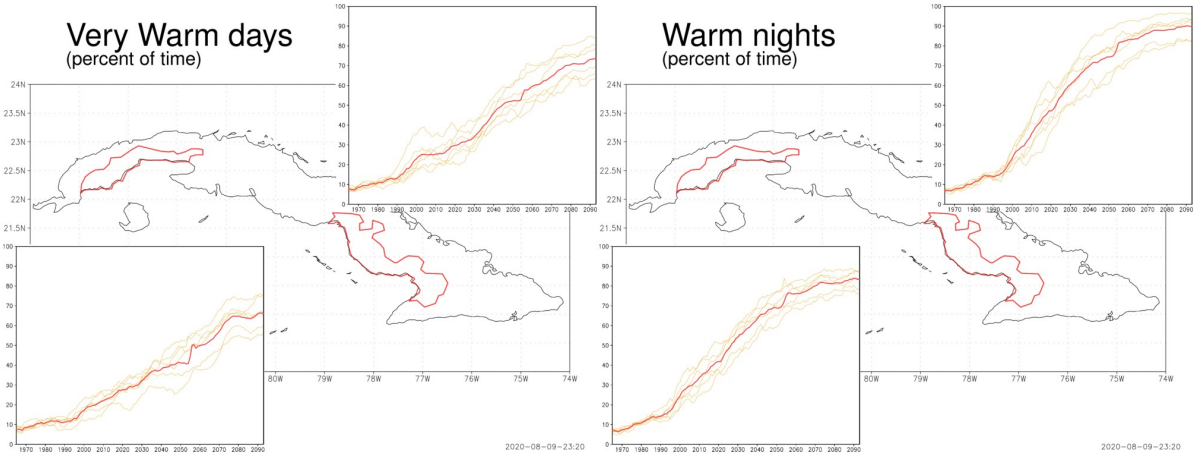
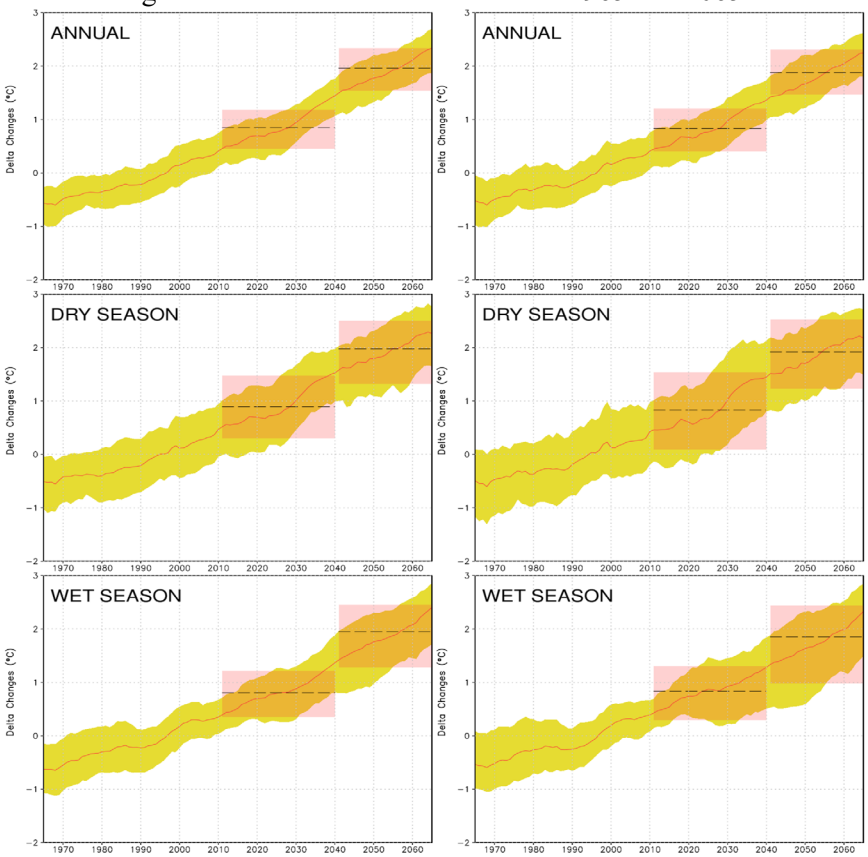
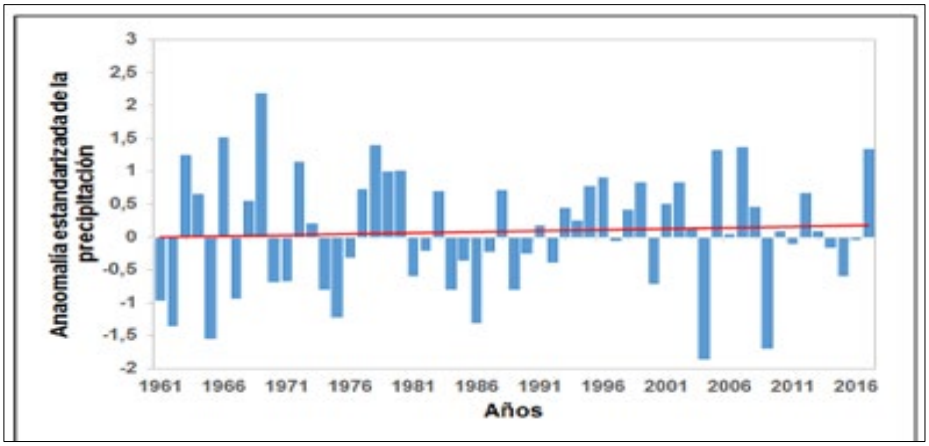


Figure 14- Projections of annual, dry and wet season temperature changes over eastern and western regions of the southern coast between 1965 and 2065.



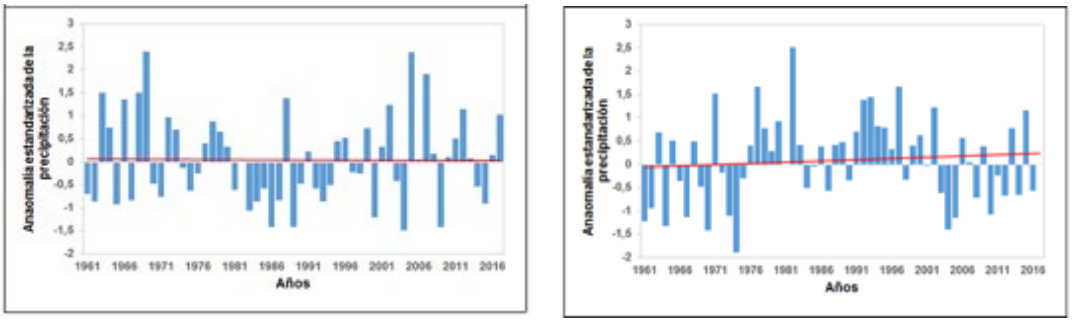
50. **Precipitation:** Precipitation has remained relatively stable over Cuba as a whole in recent decades (Figure 12). Positive anomalies indicate that precipitation was greater than average precipitation in the 1970–1999 period, while a negative anomaly indicates that the precipitation observed was less than the average precipitation between 1970 and 1999. Although the positive trend of annual precipitation observed for Cuba between 1961 and 2017 is not statistically significant, positive anomalies have tended to be more frequent since the 1990s (Figure 15).

Figure 15- Multi-year variation of standardized annual precipitation anomalies for whole of Cuba between 1961 and 2017.



51. With respect to the dry season (Figure 16b), despite the predominance of negative anomalies in recent years, a slight increasing trend is observed since 1961, but it is not statistically significant. The rainy season distribution of precipitation anomalies over the whole of Cuba, however, reveals a change in average values during recent decades, but contrary to the trend described for the non-rainy period, there is no discernable trend (Figure 16a).

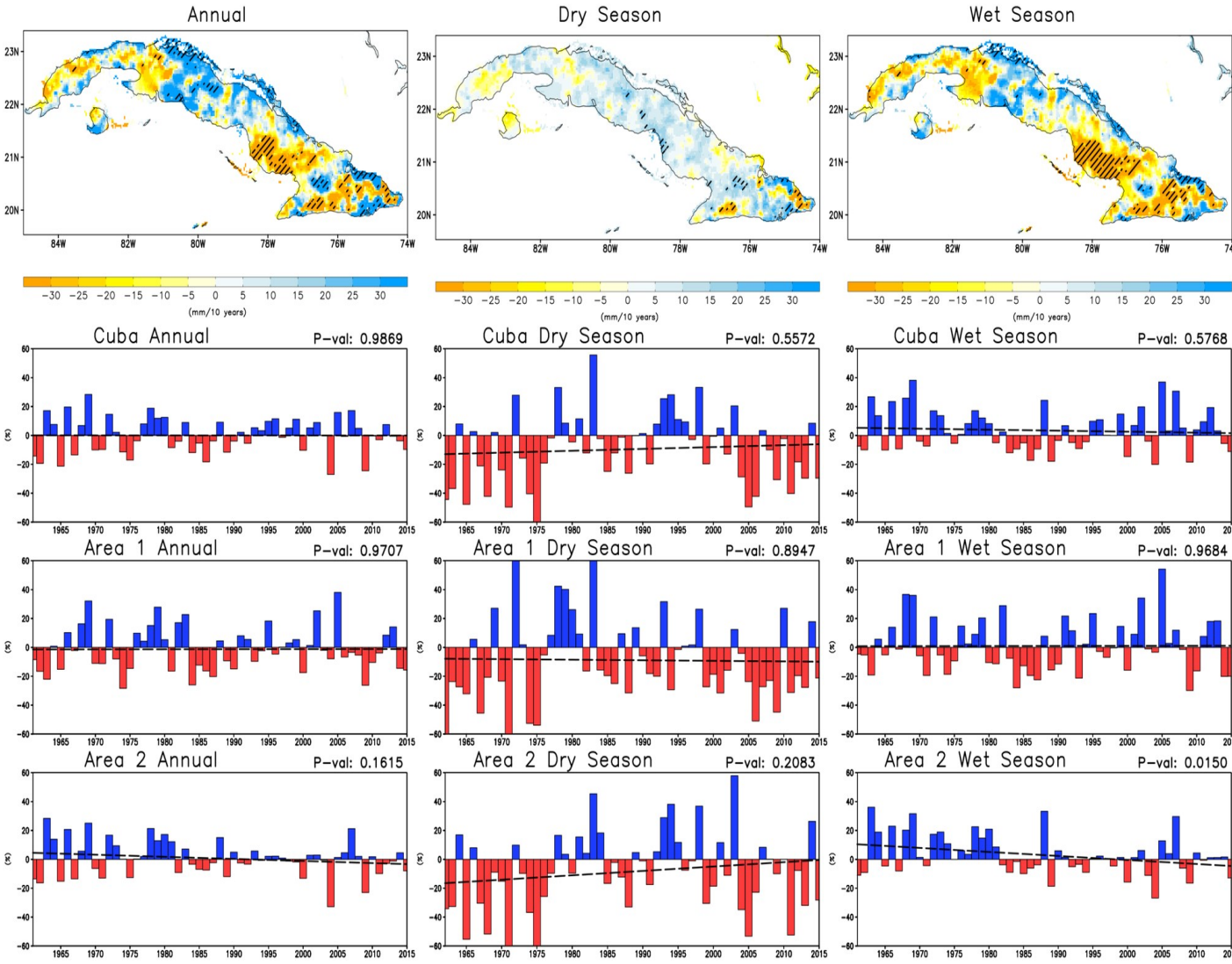
Figure 16- Multi-year variation of standardized precipitation anomalies for rainy (a) and dry (b) seasons



(a) (b)

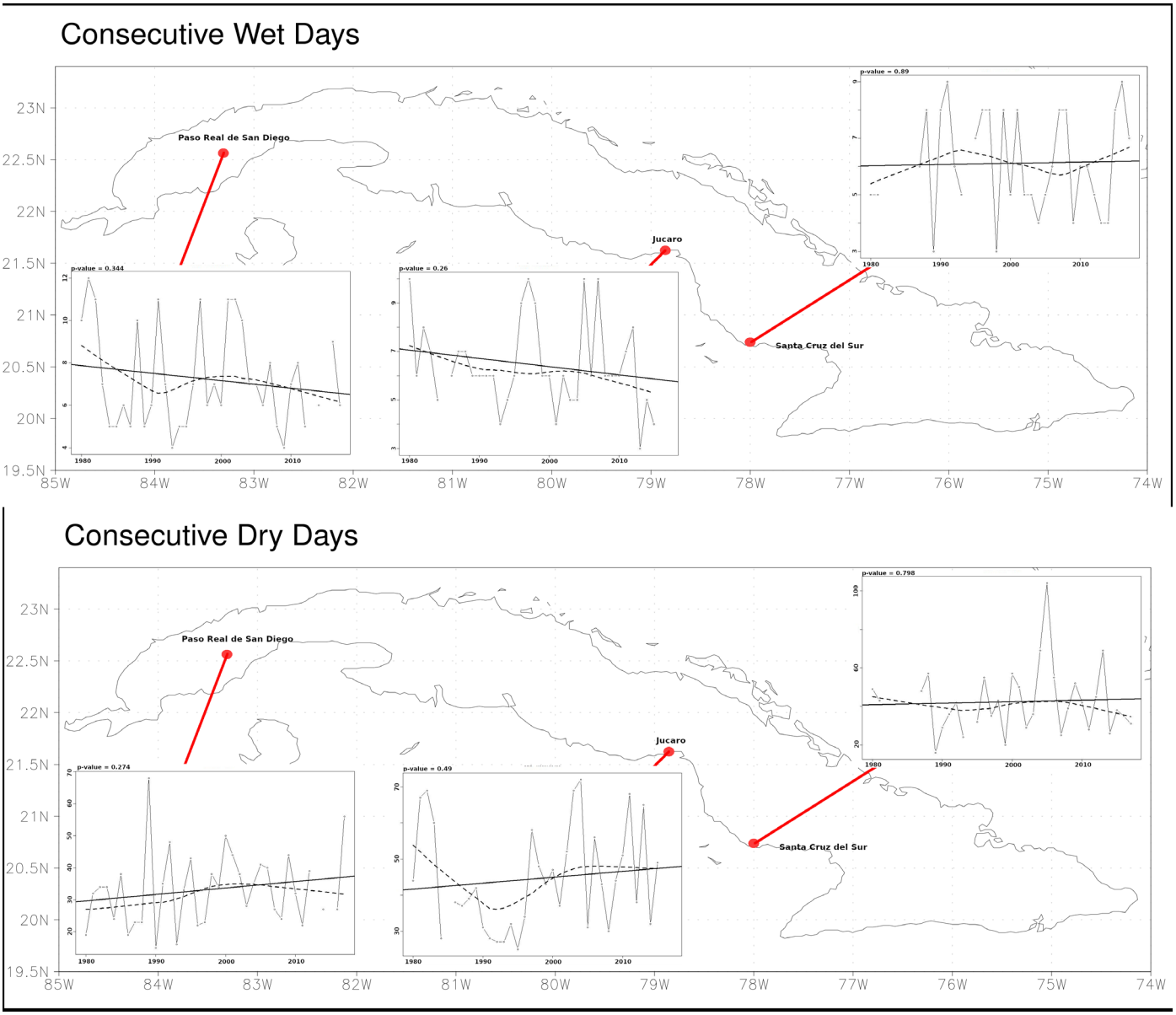
52. These observed trends in rainfall for the whole of Cuba, do however mask regional differences in trends between the dry and rainy seasons, as well as their significance. Figure 17 therefore shows these spatial differences for both the dry (November to April) and wet season (May to October) indicating that negative annual trends between 1961 and 2015 are mostly located over the far western and southeast of the country, largely reflecting the trends seen during the wet season, with the negative trends over the southeast statistically significant at the 95% confidence level (see Figure 17). Increases in rainfall are mostly along the north coast, reflecting the increased influence of extratropical cyclones during the wet season.

Figure 17- Annual precipitation trends in mm/decades 1961-2015. Annual (left), dry season (middle) and wet season (right). Spatial trend top row (hatching indicates trend statistically significant at 95% confidence level). Cuba 2nd row. Area 1 (western region) 3rd row. Area 2 (eastern region) 4th row



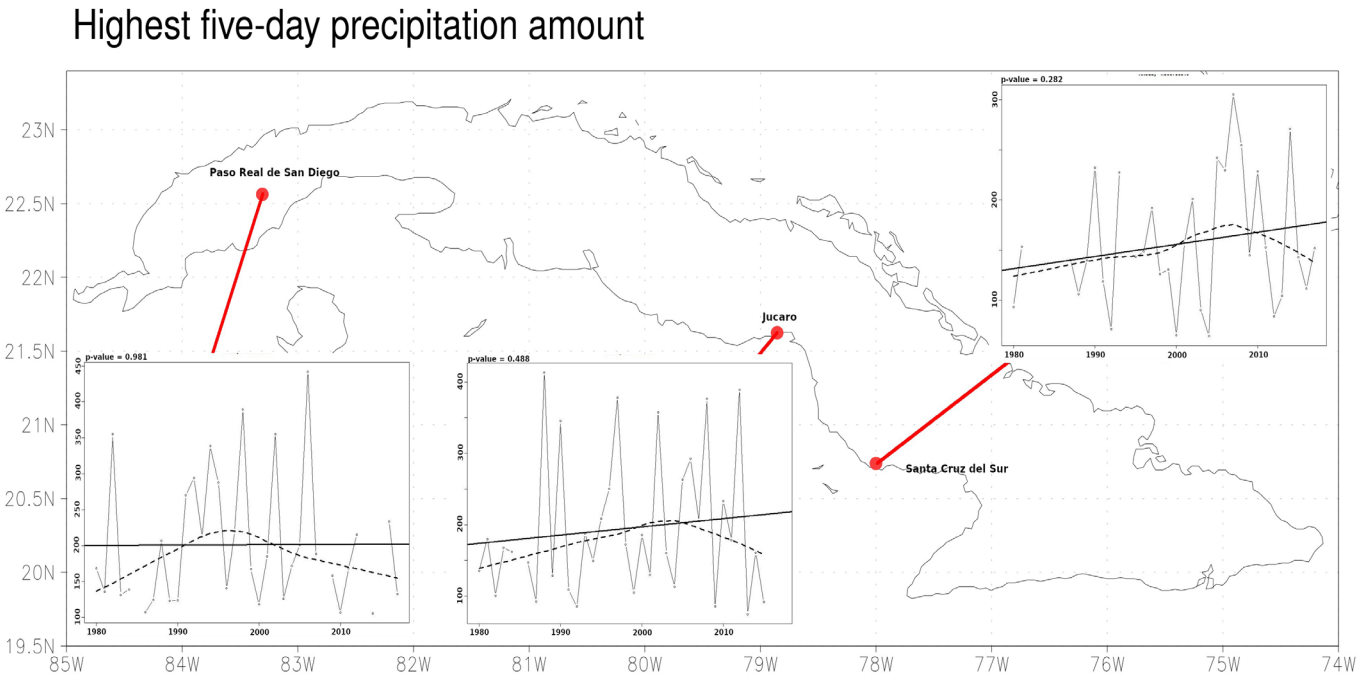
53. These changes in average rainfall are coincident with increases in consecutive dry days (CDD) and decreases in consecutive wet days (CWD) at stations along the southern coast of Cuba (Figure 18), though the trends are not statistically significant.

Figure 18- Trends in number of CDD and CWD along southern coast (1980-2016).



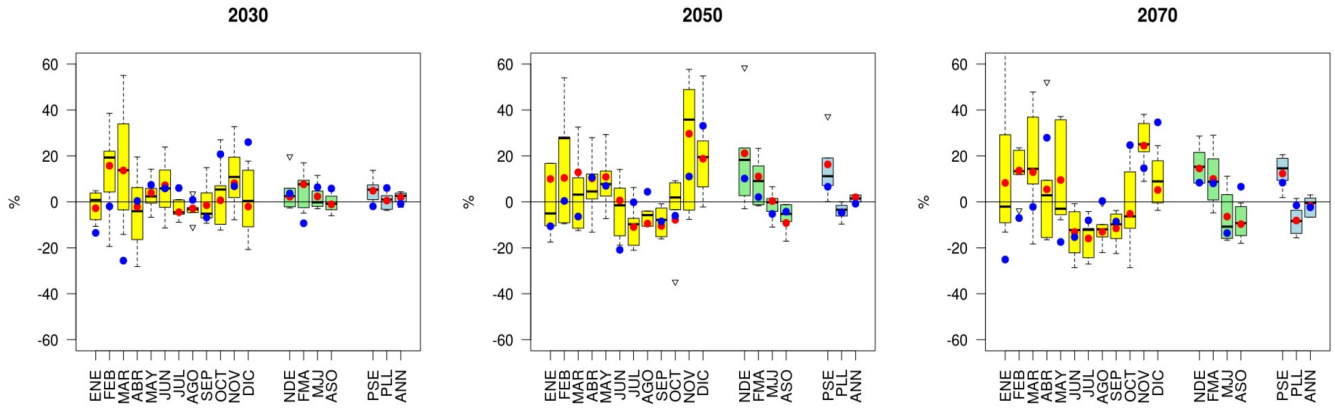
54. Similarly, Figure 16 shows that annual highest 5-day precipitation amounts have been increasing along the south coast, though trends are not statistically significant. Similar increases (non significant) are found for maximum 1 day rainfall, and the frequency of rainfall greater than the 95th and 99th percentile

Figure 19- Trends in number of annual highest 5-day precipitation amount, along southern coast (1980-2016).



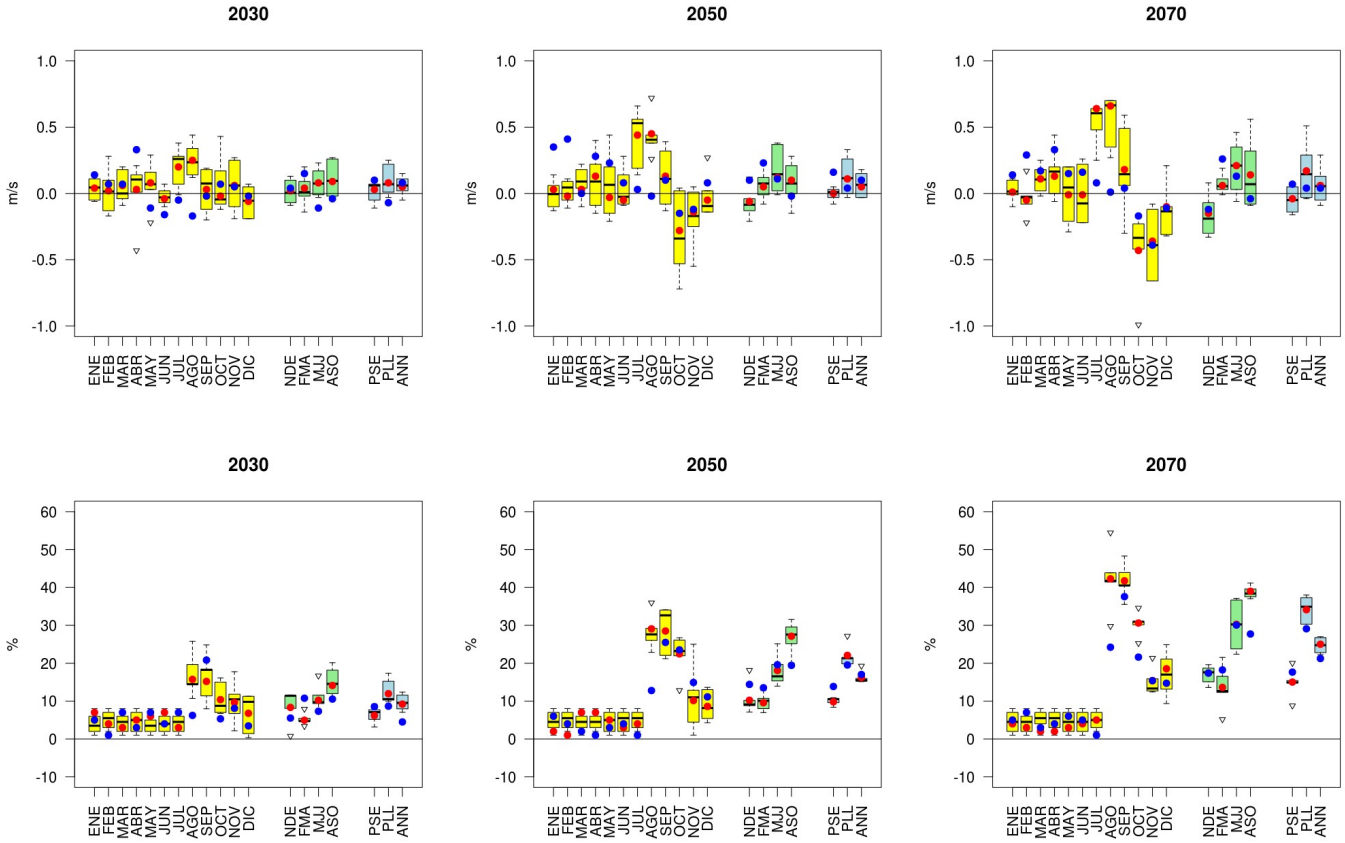
55. Future projections using the multi-parameter ensemble indicate a general reduction in rainfall by 2070, along with an average reduction in relative humidity between 2% and 6% between 2030 and 2070, respectively (Figure 20). Reduced rainfall occurs mostly during the summer rainy season, with relatively smaller increases in winter and dry season rainfall (Figure 18). These changes coincide with an increase in wind velocity and a significant increase of potential evapotranspiration, suggesting a drier climate in the future (Figure 21).

Figure 20- Precipitation projection for 2030, 2050, 2070. Boxes is for QUPM. Red points QUMP mean. Blue points ECHAM5 mean. In yellow the annual temperature distribution. In green quarterly averages (NDE – November, December, January; FMA – February, March, April; MJJ – May, June, July; ASO – August, September, October. In light blue PSE (dry season); PLL (rainy season); ANN (Annual))[11]



[11] Climate projections in Cuba have been based on the estimations of the following three global climate models: QUMP: selection of 6 versions of the Hadley Center (HadCM3) atmospheric model, which differ in a set of physical parameters or have a different parameterization. QUMP is the English acronym for Quantifying Uncertainty in Model Projections.ECHAM5: is a climate model by the Hamburg Centre adapted from the global climate models developed by the European Center for Medium-Range Weather Forecast (ECMWF) in the United Kingdom. HadGEM-ES: one of the latest models developed by the Hadley Center within the Earth System models, which incorporates a larger number of components and interactions of the climate system (eg. the biosphere, the biogeochemistry and the chemistry of atmospheric components.) The results of the QUMP and ECHAM5 models were based on the SRESA1B emissions scenario, while for the HadGEM-ES model representative RCP2.6, RCP4.5 and RCP8.5 concentration scenarios were used.
A dynamic scale reduction method was used by means of the Regional Climate Model PRECIS to obtain a grid of future climate estimations for Cuba with a 25 km resolution

Figure 21- Wind (top row) and ET0 (bottom row) projections for 2030, 2050, 2070. Boxes is for QUPM. Red points QUMP mean. Blue points ECHAM5 mean. In yellow the annual temperature distribution. In green quarterly averages (NDE – November, December, January; FMA – February, March, April; MJJ – May, June, July; ASO – August, September, October. In light blue PSE (dry season); PLL (rainy season); ANN (Annual))[12]



56. Figure 20 indicates that the ensemble projections simulate little change in annual rainfall, with increases in dry season rainfall offset by decreases in wet season rainfall for both the eastern and western regions.

Figure 22- Ensemble projections of annual, dry and wet season precipitation changes over eastern and western regions of the southern coast between 1965 and 2065.

[12] Climate projections in Cuba have been based on the estimations of the following three global climate models: QUMP: selection of 6 versions of the Hadley Center (HadCM3) atmospheric model, which differ in a set of physical parameters or have a different parameterization. QUMP is the English acronym for Quantifying Uncertainty in Model Projections.ECHAM5: is a climate model by the Hamburg Centre adapted from the global climate models developed by the European Center for Medium-Range Weather Forecast (ECMWF) in the United Kingdom. HadGEM-ES: one of the latest models developed by the Hadley Center within the Earth System models, which incorporates a larger number of components and interactions of the climate system (eg. the biosphere, the biogeochemistry and the chemistry of atmospheric components.) The results of the QUMP and ECHAM5 models were based on the SRESA1B emissions scenario, while for the HadGEM-ES model representative RCP2.6, RCP4.5 and RCP8.5 concentration scenarios were used.
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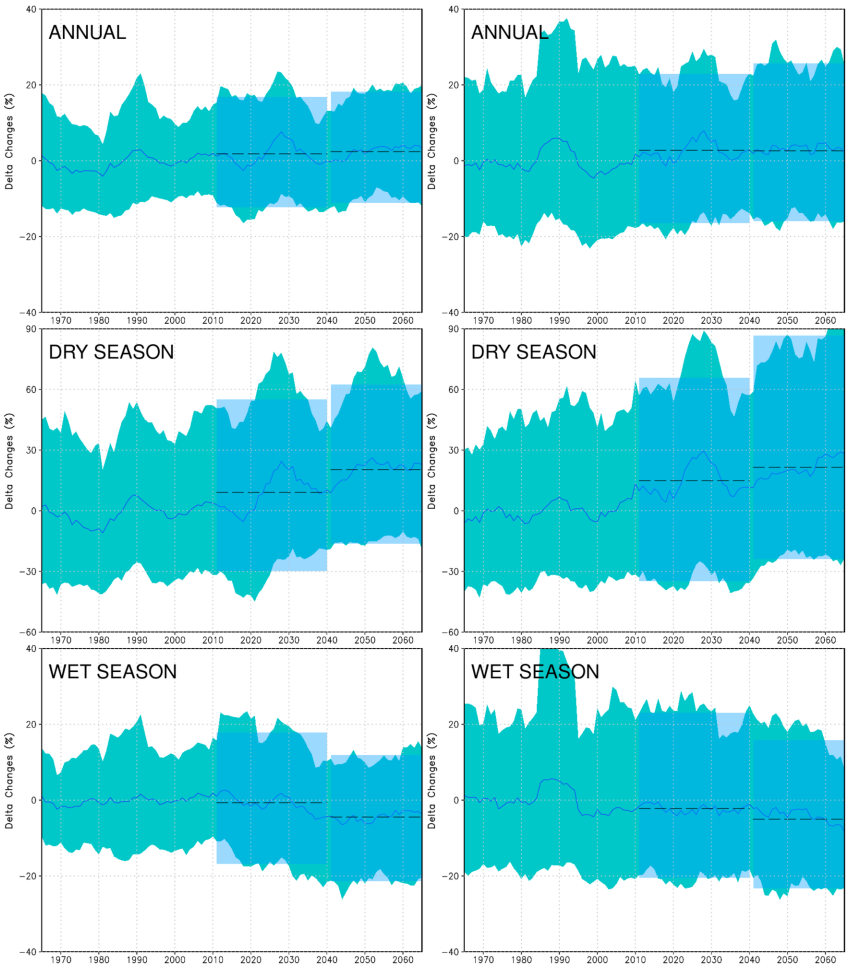
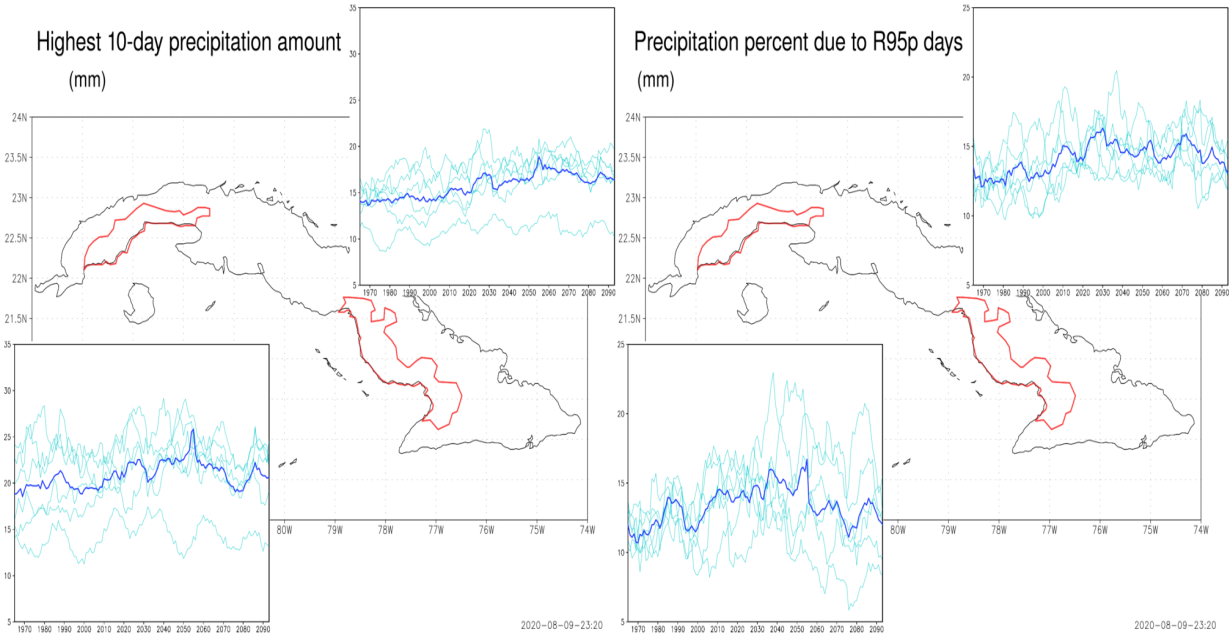


57. Figure 23 further shows that the model ensemble projects decreases in both consecutive dry days and consecutive wet days between 1960 and 2100. Negative changes are more consistently projected for decreases in the number of wet days and particularly for the eastern region.

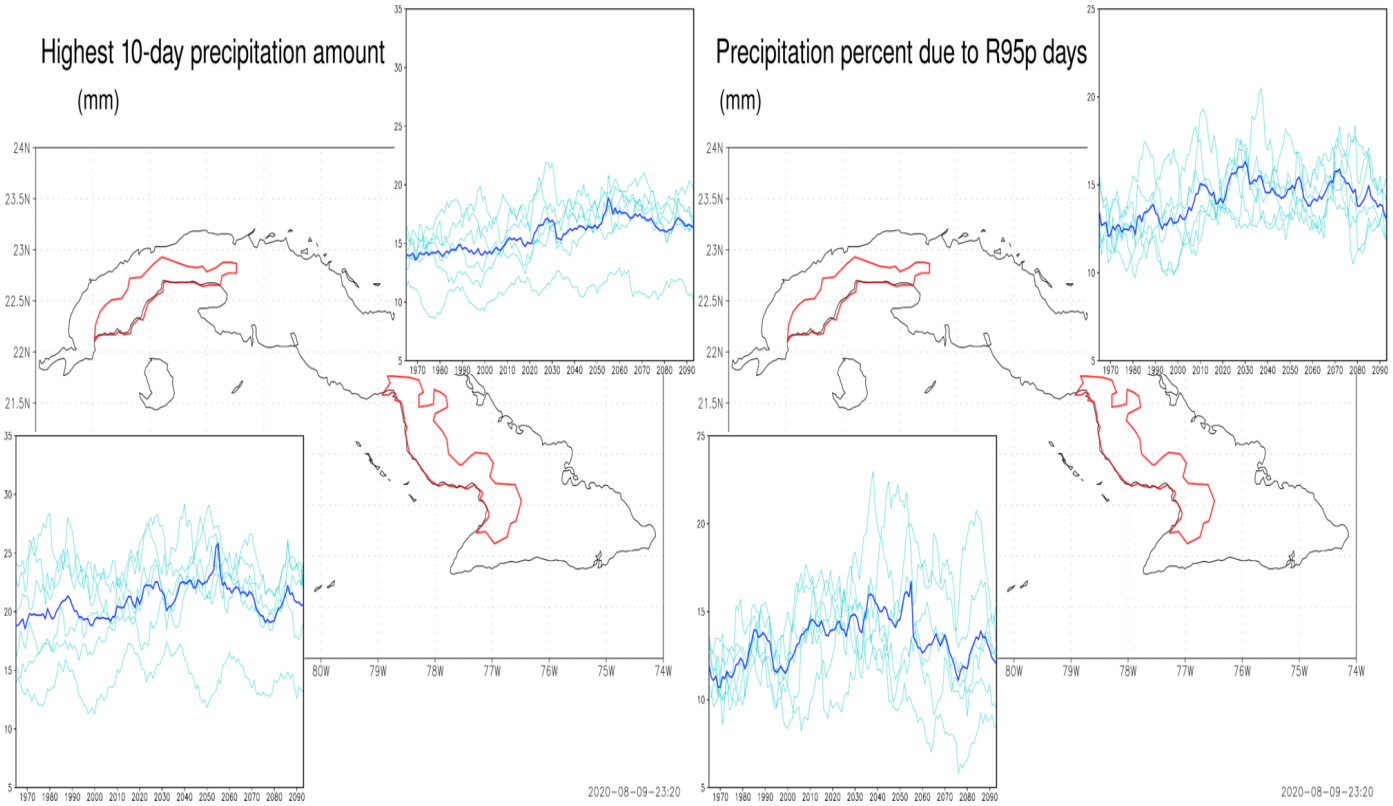
Figure 23- Ensemble projections of maximum number of consecutive dry days and consecutive wet days over eastern and western regions of southern coast between 1960 and 2100.



58. Despite these projected decreases in the maximum number of consecutive wet days, rainfall intensities are simulated to increase. Figure 24 shows ensemble simulated increases in maximum 10-day rainfall and percent of rainfall due to days > 95th percentile over eastern and western regions of

the southern coast. This is expected to lead to higher incidences of flooding, especially in coastal areas when combined with SLR and increases in storm surge (see below).

Figure 24- Model ensemble projections of maximum 10-day rainfall and percent of rainfall due to days > 95th percentile over eastern and western regions of southern coast between 1960 and 2100.



1.3.3 Climate Impacts in Cuba

59. The main impacts of climate change in Cuba, according to vulnerability analysis will be: First, an increase in the average temperature and reductions in rainfall that will create a trend towards a warmer and drier climate on the island (Iturralde y Serrano, 2015). Second, an increase in intense stoms coupled with increased sea level that will produce increased coastal flooding, especially in the lower and flat areas of the island. An increase in the intensity of storms, surges and hurricanes on the island, which will have synergistic effects and cause greater losses of infrastructure and production systems than in the past.

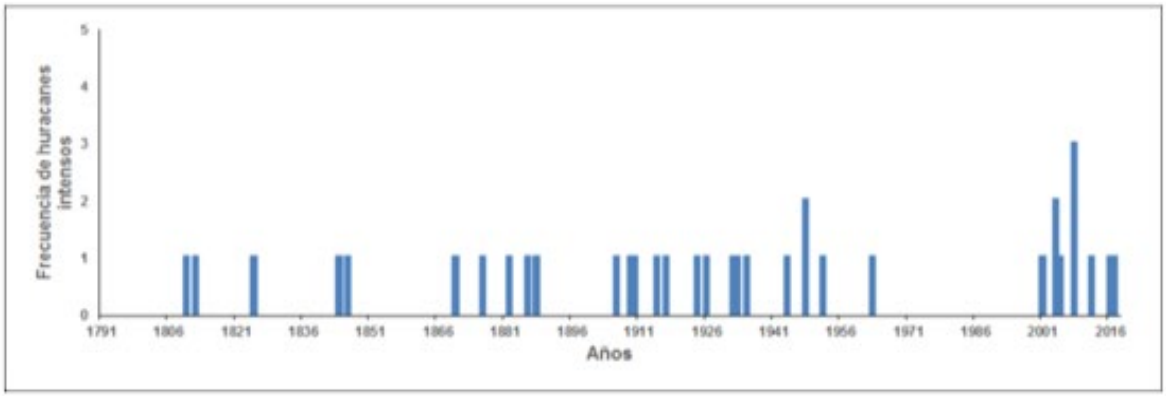
60. Based on current climate trends and the CC scenarios considered for the next 100 years (IPCC. 2007 scenarios A1C and B2), if no action is taken there will be deterioration in overall environmental quality, resulting in a reduction in hydrological potential at regional scale, a loss of land in low coastal zones, soil impoverishment, reductions in the yields of agricultural crops of importance for national food security, a loss in biodiversity (principally in coastal zones), damage to coastal settlements, increases in communicable diseases, and corresponding impacts on economic activity in general (Iturralde and Serrano, 2015).

61. Under a favorable projected CC scenario, potential water availability in 2100 could fall to 14.4 km^3, 37% less than the baseline over the 1961-1990 period. The area with sub-humid/dry climate would extend gradually from the east to the west of the country, making the eastern mountain massifs susceptible to desertification. While these projections are beyond the scope of the 30 year project lifetime, they are important to consider as future scenarios for the country if no action is taken.

Extreme Weather

62. Historically, intense hurricanes (Categories 3,4 and 5) have represented 26% of the total number of hurricanes affecting the country. During the first decade of the 21st century, however, this proportion rose to 78% (Figure 25). This corresponds with an increase in observed intensities across the Atlantic as a whole[13], including the Caribbean, and may be related to the high temperatures observed in the Caribbean since 1998 (Figure 29).

Figure 25-. Annual number of intense hurricanes to hit Cuba (Cat 3, 4 y 5 Saffir – Simpson scale) (1791-2017).[14]



63. Another parameter that is a representation of the intensity of hurricanes is the PDI (Power Dissipation Index). PDI is an aggregate of storm intensity, frequency, and duration and provides a measure of total hurricane power over a hurricane season[15]. As can be seen below there is a strong upward trend in Atlantic PDI (Figure 26), and is well-supported by the reanalysis. This is an evidence of increase in the strength and in the number of the strongest hurricanes in the North Atlantic over the same time period[16]

Figure 26. Recent variations of the Power Dissipation Index (PDI) in the North Atlantic. (Figure source: adapted from Kossin et al. 2007 p93)[17].

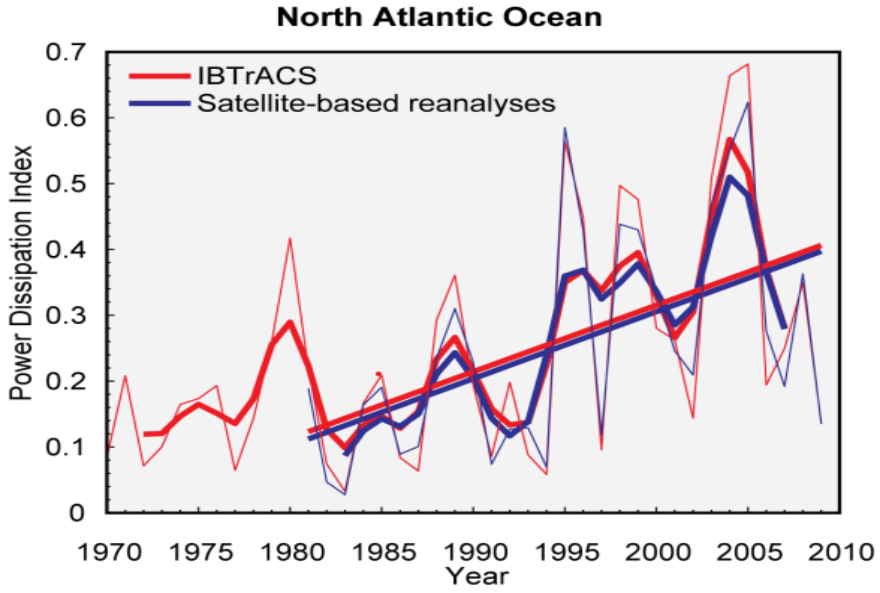
13 Chen, Keping & Mcaneney, John & Cheung, Kevin. (2009). Quantifying changes of wind speed distributions in the historical record of Atlantic tropical cyclones. Natural Hazards and Earth System Sciences. 9. 10.5194/nhess-9-1749-2009

14 Third National Communication to United Nations Framework Convention on Climate Change , November 2020

15 Climate Change Impacts in the United States: The Third National Climate Assessment. 2014

16 Climate Change Impacts in the United States: The Third National Climate Assessment. 2014

17 There is a strong upward trend in Atlantic PDI well-supported by the reanalysis. Separate analyses (not shown) indicate a significant increase in the strength and in the number of the strongest hurricanes (Category 4 and 5) in the North Atlantic over this same time period. The PDI is calculated from historical data (IBTrACS92) and from reanalysis using satellite data (UW/NCDC & ADT-HURSAT93,94). IBTrACS is the International Best Track Archive for Climate Stewardship, UW/NCDC is the University of Wisconsin/NOAA National Climatic Data Center satellite-derived hurricane intensity dataset, and ADT-HURSAT is the Advanced Dvorak Technique–Hurricane Satellite dataset

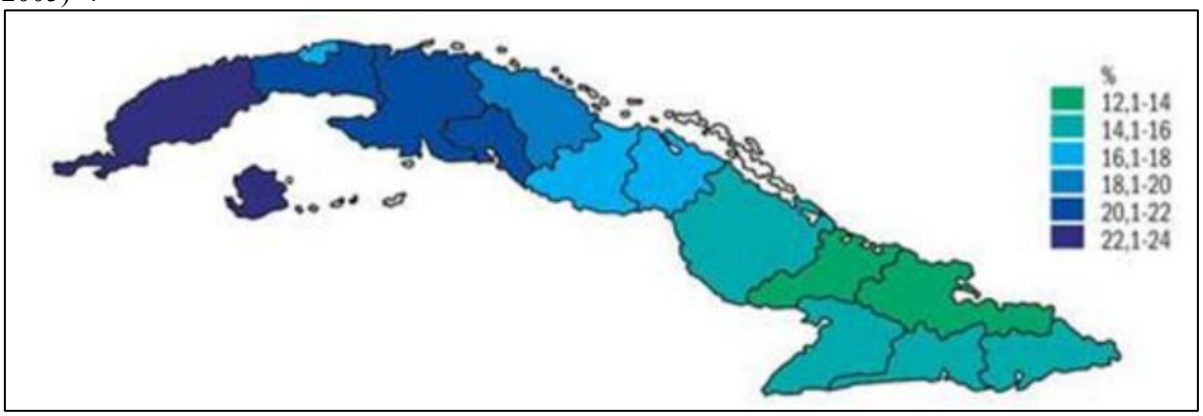


64. These phenomena pose a high risk to housing and other infrastructure due to the strength of winds. Their impacts depend on the characteristics and resilience of the elements affected. As an example of the magnitude of these extreme weather events, Hurricane Dennis in July 2005, a category 4 that increased to category 5 on the Saffir Simpson scale (wind speeds >251km/hour), covered more than 600km of the country over a period of 40 hours, directly affecting 11 provinces with a population of 8 million people. In the same year, the province of Havana was also affected by winds associated with tropical cyclones Katrina, Rita and Wilma, as well as strong southerly dry season winds (sures).

65. Over the last 8 years a total of 13 cyclones have affected the country, causing damage to 1,234,784 homes of which 12.4% collapsed completely. In general, tropical cyclones affect the whole of Cuba; however, the area with greatest probability of occurrence is the Western part of the country.

66. Flooding is also a risk in a scenario with higher number and intensity of cyclones, tropical storms and hurricanes. In total 1,512 settlements, with a total population of 2,145,818 people, have been classified as susceptible to flooding during these extreme rainfall events.

Figure 26-. - Historical probability (%) of occurrence of one or more cyclones in a given year (1799-2005)[18].



67. The settlements at risk are mainly located in low-lying coastal areas, many of which are also affected by the risks of sea level rise and marine incursion described above. As in the case of the coastal flooding, associated with CC-related SLR, this kind of flooding risks damaging infrastructure and overwhelming waste treatment facilities, as well as putting lives and livelihoods at risk.

Figure 27-. - Risk of flooding due to intense rains and dam breaches, by municipality[19].

18 Moreno, C., et al. (2007): Ten Questions and Andswers on Wind Power. Editorial Cubasolar, Habana, Cuba, 335 pp.

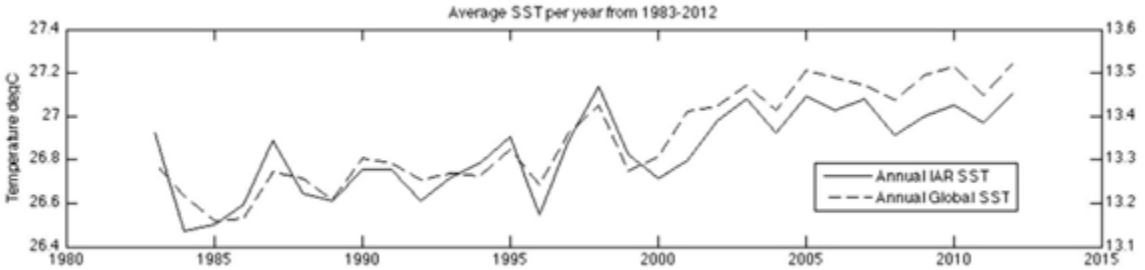
Coastal Flooding

68. Coastal flooding in Cuba is the result of various meteorological phenomena such as tropical cyclones, extratropical systems, cold fronts, southern winds (sures). Flood occurrence is extensive throughout the country with coastal flooding impact being conditioned by the meteorological event itself and its movement with respect to the coastline, as well as by the geographical particularities of the affected area, in particular its bathymetry.

69. Due to the increase in global temperatures in recent decades an increase in the temperature and salinity of both surface and sub-surface waters around Cuba has been observed (Figure 29)[20][21]. This situation results in increases in the thermic energy of the ocean, which is available for the development of atmospheric systems. As argued by Anthes et al. (2006)[22,] increases in temperature and salinity lead to changes in atmospheric and oceanic circulation, which favor the intensification of the transport of moisture from the sub-tropics to higher latitudes; this affects the Multi-Decadal Oscillation of the Atlantic (AMO), which is one of the mechanisms which influence the intensity of tropical cyclones/hurricanes in the Atlantic. The parameters, which best reflect changes in the oceanic circulation are Ocean Surface Temperature and Maximum Salinity, in sub-surface waters (between 150 and 300m below the surface).

70. As a consequence of these changes, the capacity of the sea to accumulate heat has increased, as has the depth of the homogenous layer with temperatures greater than 26°C (Mitrani et al. 2012[23]), leading to increases in the formation and destructive power of tropical cyclones (Hernandez-Zanury and P. Alcolado. 2012[24])

Figure 28-. - Annual SST trend analysis results for the years 1982–2012 for the Intra-Americas Region: global annual average SSTs (dashed line), Intra-Americas Region annual SST (solid line))[25].



20 Mitrani and Díaz O. (2008): "Particularidades de la estructura termohalina y sus tendencias en aguas Cubanas" Revista Cubana de Meteorología, Vol. 14, No. 1 54:73

21 Curry, R. B. Dickson and I. Yashayaev (2003) . A change in the freshwaterbalance of the Atlantic Ocean over the past four decades. NATURE ; Vol 426, December 2003 pp 826-829.

22 Anthes R., R. W. Corell, G. Holland, J. W. Hurrell, M. C. MacCracken, K. E. Trenberth (2006): Huricanes and Global Warming-Potencial Linkages and Consequences, Comments, Bulletin of the American Meteorological Society, 623-628

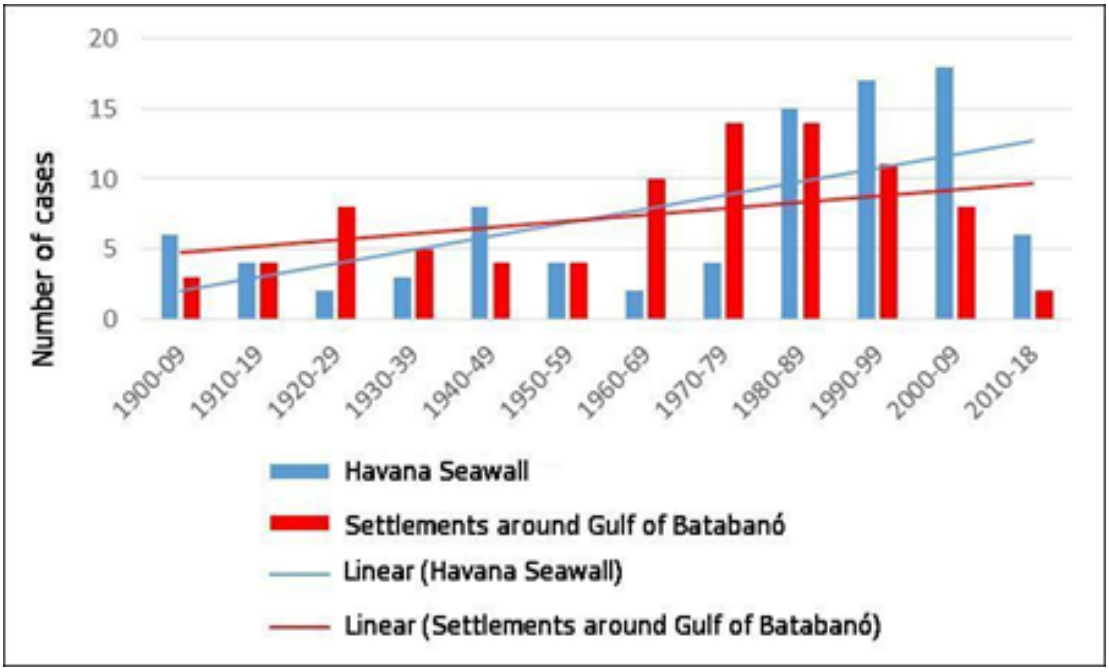
23 Mitrani I., O. Díaz, A.Vichot, I. Hernández, A.Hidalgo, E. García y J. Rodríguez (2012) Ciencias de la Tierra y el Espacio, julio-diciembre, 2012, Vol. 13, No. 2, pp.135-151

24 Hernández-Zanuy A., y Alcolado P. M. (Eds). 2012. La biodiversidad en ecosistemas marinos y costeros del litoral de Iberoamérica y el cambio climático: II. Memorias del Simposio Iberoamericano de biodiversidad marina y cambio climático, de la RED CYTED BIODIVMAR. Balneario Camboriú, Santa Catarina, Brasil, Noviembre 2011

25 Glenn, Equisha & Comarazamy, Daniel & Gonzalez, Jorge & Smith, Thomas. (2015). Detection of recent regional sea surface temperature warming in the Caribbean and surrounding region. Geophysical Research Letters. 42. 10.1002/2015GL065002

71. Positive trends in the frequency of occurrence of floods during the period 1901-2011, have been observed in Cuba[26]. Coastal flooding around Cuba shows an increase in frequency and intensity in the last 40 years. For instance, in the case of Havana Seawall and in coastal settlements located around the Golf of Batabanó (Stretch 1) the coastal flooding's occurred after the 1980's represent 60% and 40% of coastal flooding cases total since 1900 respectively (Figure 30). These increases are statistically significant at 95% of confidence interval.

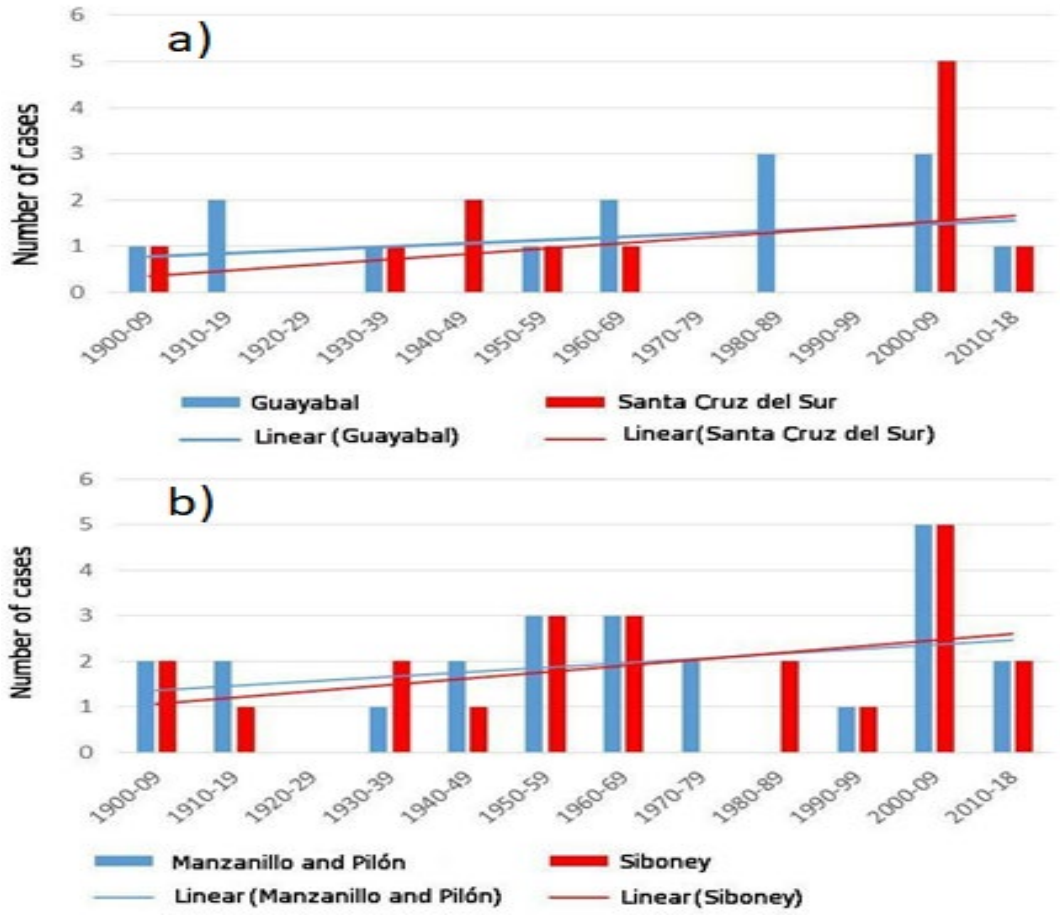
Figure 30 - Coastal flood events by decades for the Havana´s seawall and coastal settlements around the Gulf of Batabanó (Hidalgo et al, 2019[27]).



72. Similar trends were found for other places located at the southeastern part of Cuba, specifically in Santa Cruz del Sur and Manzanillo, cities located in Stretch 2.

Figure 31 - Coastal flood events by decades for, a. Santa Cruz del Sur (Stretch 2) y Guayabal (Stretch 2), b) Manzanillo – Pilon (Stretch 2) y Siboney. (Hidalgo et al, 2019[28])

26 Plano E. et al (2012): " Impacto del Cambio Climático y Medidas de Adaptación en Cuba" Havana Cuba pp. 107-110
27 Hidalgo et al (2019): "Variaciones y tendencias de las inundaciones costeras en el Archipiélago Cubano. Informe de Resultado del proyecto de investigación "Proyección de las inundaciones costeras en el Archipiélago Cubano". Centro Meteorológico Provincial de Holguín, Instituto de Meteorología, 63 pp.
28Hidalgo et al (2019): "Variaciones y tendencias de las inundaciones costeras en el Archipiélago Cubano. Informe de Resultado del proyecto de investigación "Proyección de las inundaciones costeras en el Archipiélago Cubano". Centro Meteorológico Provincial de Holguín, Instituto de Meteorología, 63 pp.



29

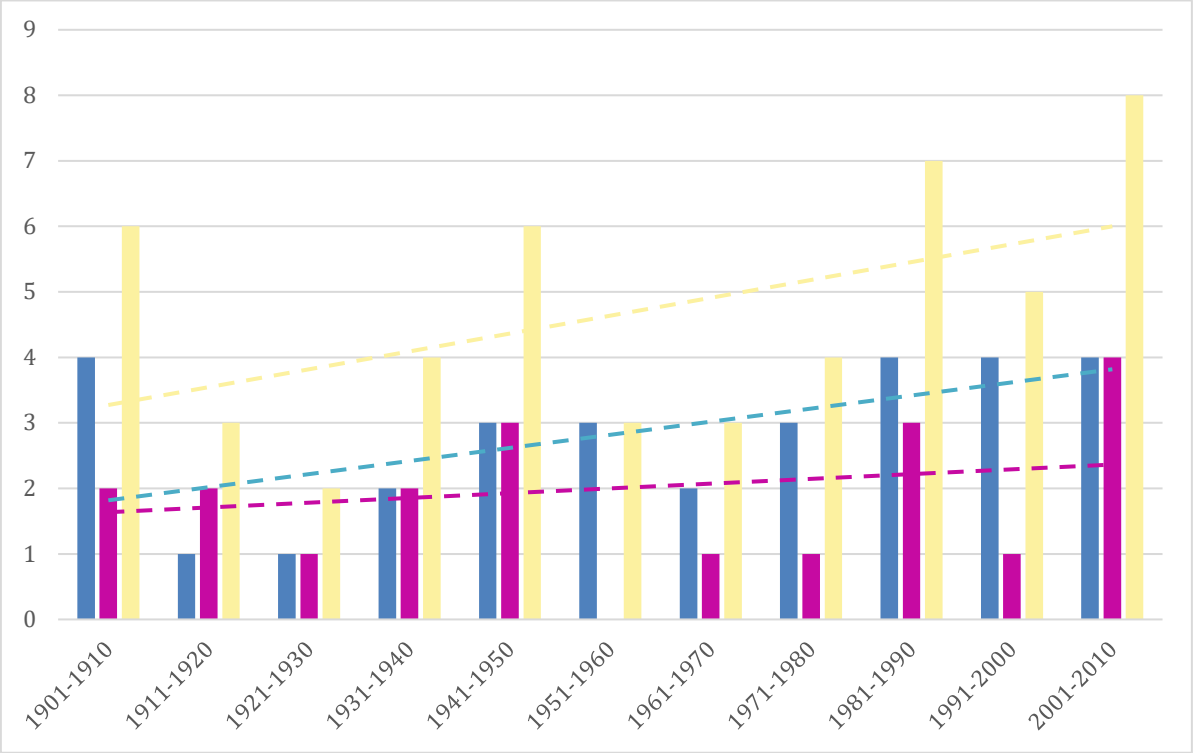
73. Figure 32 shows the combined impact of both hurricanes and cold fronts on flooding in Havanna, indicating that together and individually they have resulted in an increasing frequency of medium and strong flooding. Additionally, increases in the frequency of El Niño has tended to be associated with an increase in coastal flooding caused by extratropical lows[29].

Figure 32 – Occurrence of medium and strong[30] flooding in Havana 1901-2011 and linear trends. Purple: Hurricanes; Blue: Frontal Sistems; Yellow: all. Adapted from Mitrani *etal. 2016*[31]

[29] Ida Mitrani Arenal*, Ivette Hernández Baños, Evelio García Valdés, Axel Hidalgo Mayo, Oscar Onoe Díaz Rodríguez, Alejandro Vichot Llamo, José Alejandro Rodríguez Zas (2016). The Coastal Flood Regime around Cuba, the Thermohaline Structure Influence and Its Climate Tendencies. Environment and Ecology Research 4(2): 37-49, 2016.http://www.hrpub.org/download/20160229/EER1-14005024.pdf

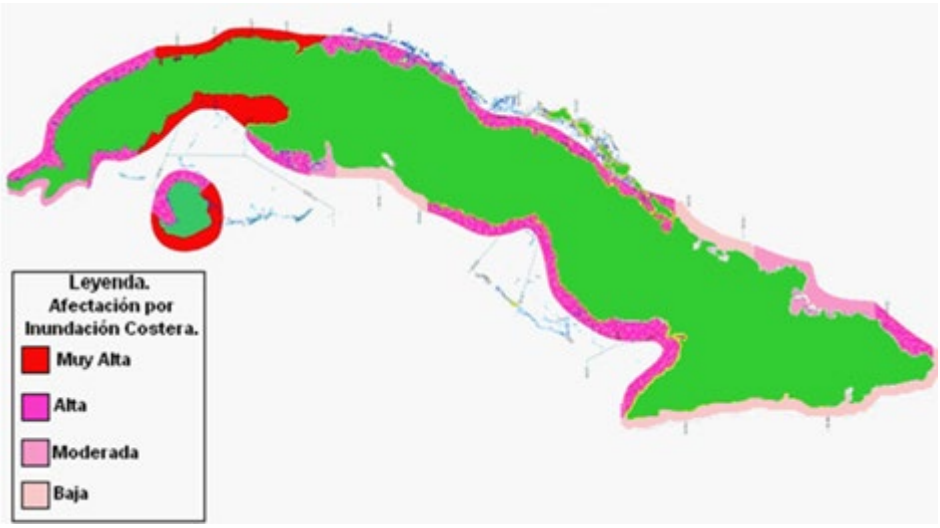
[30] Hidalgo-Mayo, A., Mitrani-Arenal, I., Pérez-Rivas, G. New classification of the coastal floods in Cuba. Revista Cubana de Meteorología, Vol.23, No.2, pp. 209-216, 2017, ISSN: 0864-151X

[31] Ida Mitrani Arenal*, Ivette Hernández Baños, Evelio García Valdés, Axel Hidalgo Mayo, Oscar Onoe Díaz Rodríguez, Alejandro Vichot Llamo, José Alejandro Rodríguez Zas (2016). The Coastal Flood Regime around Cuba, the Thermohaline Structure Influence and Its Climate Tendencies. Environment and Ecology Research 4(2): 37-49, 2016.http://www.hrpub.org/download/20160229/EER1-14005024.pdf



74. The main areas at greatest risk of flooding from hurricanes and associated storm surges are in the western regions of Cuba with large swathes of the southern coast at high risk (Figure 33). These include the project target areas in both the eastern and western regions.

Figure 30 Impact/ Danger of coastal flooding in coastal areas by combination of tropical cyclones and storm surge[32]



31

75. Further expected sea level increases related to climate change, in the case of low-lying coasts, will lead to the increase of flooding risks to cover several kilometers particularly when sea level rise is combined with storms and other extreme meteorological events (See Figures 39 and 43 in Section 3.1 that demonstrate flooding as a result of SLR and storms). Hence, floods that until now have been considered to be of moderate intensity will be more severe and provoke more damage in the future.

Sea Level Rise

[32] Pérez, P. R.; Salas, I.; Samper, S. & Dole, J. 2009. Surgencia provocada por los ciclones tropicales en el Archipiélago Cubano. Escenarios previstos por el cambio climático para los años 2050 y 2100. La Habana, Cuba: Instituto de Meteorología, p. 40.

76. Under IPCC scenarios and levels of climate sensitivity, sea levels in Cuba are expected to rise by 145m by the year 2030 and by 0.29 m and 0.95m by the year 2050 and 2100 respectively (Table 2).

77. In the current modeling of the future (2017) scenario -A1CMI and the MiniCamp model with version 5.3 of the MAGICC / SCENGEN- higher sea rise results are obtained (29.3cm in 2050 and 95cm in 2100) than those calculated with the version 4.1 in 2006 (27 cm. in 2050 and 85cm. in 2100). The new values are aligned with the results offered by the IPCC in its latest report (V Report, 2014) and other authors and Jevrejeva et al. (2014), they update the information for Cuba and show that the expected impact due to the rise in sea level in Cuba must be higher than previous estimates, mainly in low-lying coastal areas and wetlands.[33]

78. The linear annual trends of sea level rise that have been detected in the Cuban archipelago have varied between 2.1 mm/year in Siboney and 0.05mm/year in Casilda. These differences are a function of the oceanographic, hydrographic and topographic conditions in the areas adjacent to the measurement stations (Hernández et al. 2014).

Table 2 - Sea level rise (cm) 2020-2100 in Cuba (A1CMI) and Globally (A1CMI and RCP8.5)[34]

Model	Year	2020	2030	2040	2050	2060	2070	2080	2090	2100
M/SC 4.1 A1CMI Cuba	2006	9.5	15	20	27	37	48	60	72	85
M/SC 5.3 A1CMI Cuba	2017	9.2	14.5	20.7	29.3	39,8	52.4	66.0	80.4	95
Cuba Global	2017	9.4	14.8	21.5	30.5	41.8	54.8	69.1	84.1	99.5
MAGICC (IPCC) RCP 8.5 Global 2013	2013	10	16	23.4	32	42.6	54	68	82	98

Table 3 - Ascent rate (increasing trend) values of the relative mean sea level. Trend calculations are only performed with the longest and highest quality tide logs available.

Tidal station	Registry years	Ascent rate [cm/year]	Latitude N	Longitude W	Stretches of interest
Los Morros	1973 – 2018	*0.0876*	21°54,0´	84°54,4´	Stretch 1 southern coast between Pinar del Río y Mayabeque
Siboney	1966 - 2005	*0.2140*	23°05,6´	82°28,2´	
La Isabela	1973 - 2018	*0.1254*	22°56,4´	80°00,8´	
Gibara	1976 - 2018	*0.2350*	21°06.5´	76°07,5´	
Cayo Loco	1992 – 2018	*0.2660*	22°09,1´	80°27,3´	Stretch 2 Ciego de Ávila - Granma

Coastal Erosion

79. Current coastal erosion rates are attributed to a combination of natural dynamics (waves, currents, extreme events, hurricanes, etc) and human interventions (natural resources extraction, wetlands filling, coastal infrastructure construction excluding natural dynamics, habitat loss, water diversion, etc). An increase in the magnitude of extreme events and increasing SLR can only accelerate natural processes' related erosion, which has been calculated at an average rate of 1.2 m/year[35]. This erosion rates pose a danger to communities, infrastructure and natural habitats that are not tolerant to saline intrusion and provide services to other communities landward.

[33] IPCC-AR5-WGL. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment report (AR5) of the intergovernmental Panel on Climate Change. 2013. The Cuban tide gauge monitoring system values are closed to the global mean sea-level rise from the IPCC's models (AR5, 2013) where four possible trajectories (Representative Concentration Pathways or RCPs) are described on global sea-level rise

[34] Pérez, R. (2019). Ascenso del nivel del mar en Cuba por cambio climático. Revista Cubana de Meteorología, Vol. 25, No. 1, La Habana, pp 76 – 83.

[35] Hernández-Zanuy, A.C., E. Tristá, M. Guerra, R.T. Capote, M. Martínez, M. Hernández, P.M. Alcolado Menéndez, S. Lorenzo, L. Peña-Fuente, M. Esquivel y M. Sosa. 2006. Rehabilitación ecológica del tramo de costa comprendido entre Surgidero de Batabanó y Mayabeque, costa sur de la Provincia de La Habana. Informe Final de Proyecto de Programa Ramal de Protección de Medio Ambiente y Desarrollo Sostenible.

80. In general, coastal erosion is the result of the loss of sediments due to natural factors (waves, currents, hurricanes, etc.), anthropogenic factors (extraction of sand and coastal marine resources for construction, mangrove felling, uncoordinated coastal works and construction of infrastructure very close to the coastline). Also, rivers have contributed a smaller amount of sediment to the coastal system as a result of the construction of infrastructure (for example dams). In addition, rigid structures for coastal protection or other purpose have been designed without an integrated approach, causing erosion and destroying mangrove ecosystems.

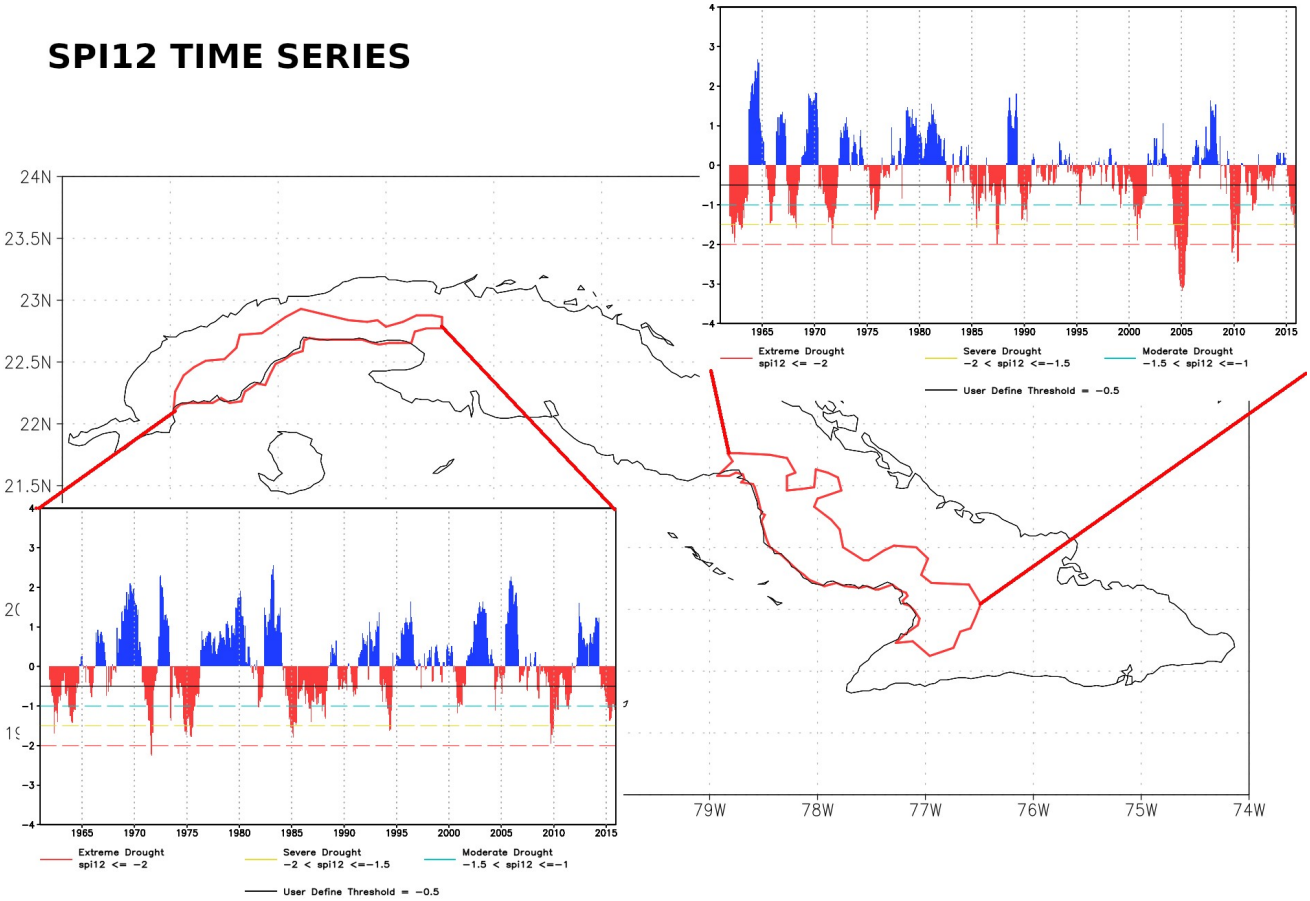
81. Climate change contributes to erosion, through the impact of hurricane storms and the development of greater waves on the coasts, which are exacerbated by the absence or degradation of protective ecosystems, such as mangroves and swamps. However, there is little data to establish its quantitative impact.

Drought

82. In Cuba, as a result of "a high level of response of the regional atmospheric circulation to the main changes of the Climate System on a global scale" (Centella et al., 1997), significant changes have been detected since the late 70s, fully coinciding with the significant global changes that have occurred in surface air and sea temperatures, as well as with a marked polarity in the frequency of occurrence of the warm and cold phases of ENSO events before and after those same years. In correspondence with the above, important variations in the anticyclonic regime on the region, a product of the progressive intensification of the Atlantic anticyclone, have been verified by Brenes and Saborío, 1993, Naranjo and Centella, 1999 and Fonseca, 2002. This is a process that reduces the efficacy of precipitation producing mechanisms, during the rainy season.

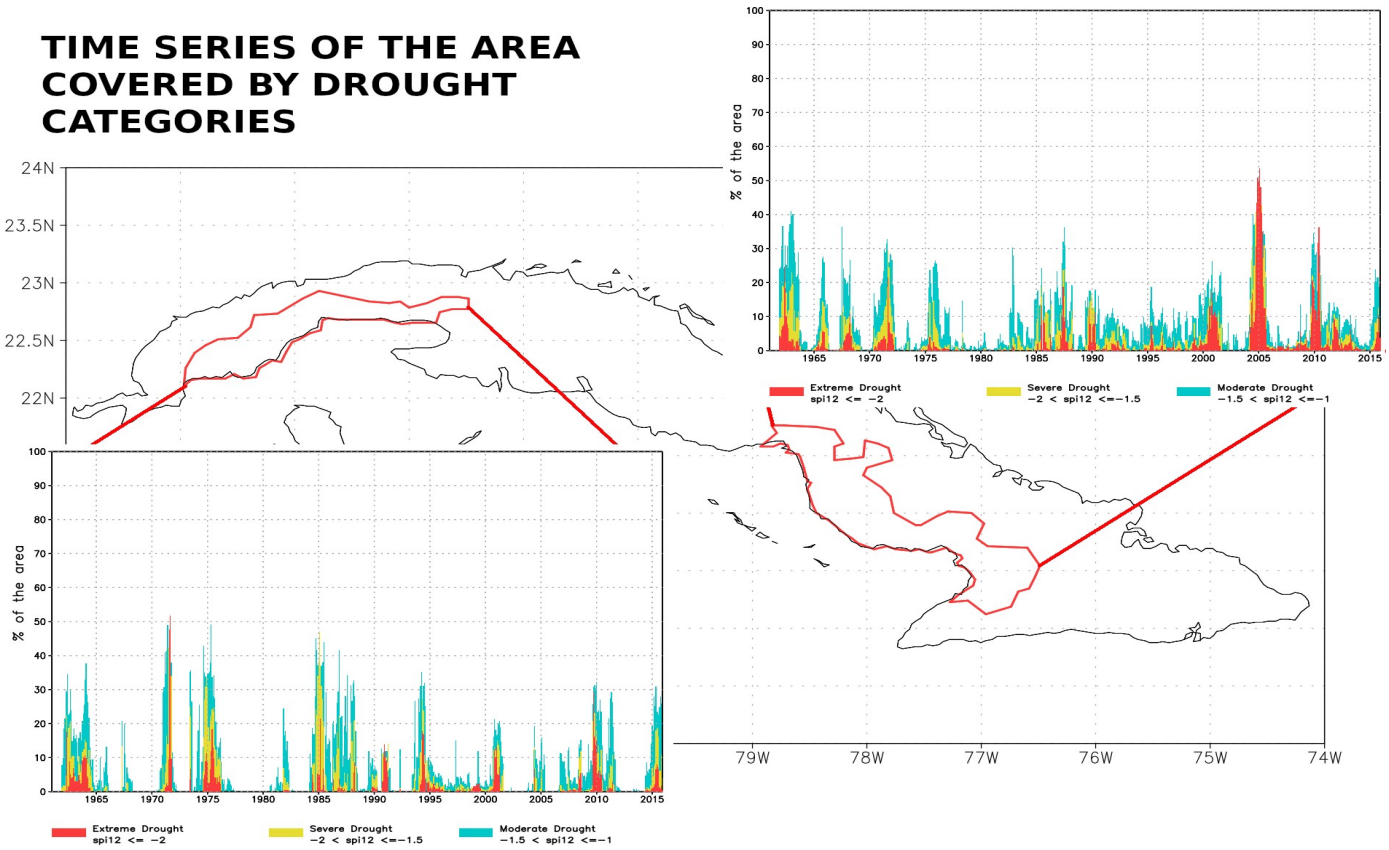
83. Figure 34 shows the timeseries of the standardized precipitation index (SPI) for the western and eastern regions of the Cuban southern coast. Whilst the western region indicates no discernible trend, the eastern region indicates more recent intense drought events (particularly in 2005) and disadvantages in precipitation producing mechanisms, during the rainy season.

Figure 32 Timeseries of standardized precipitation index (SPI) between 1960 and 2016 for area 1 (western) and area 2 (eastern) regions.



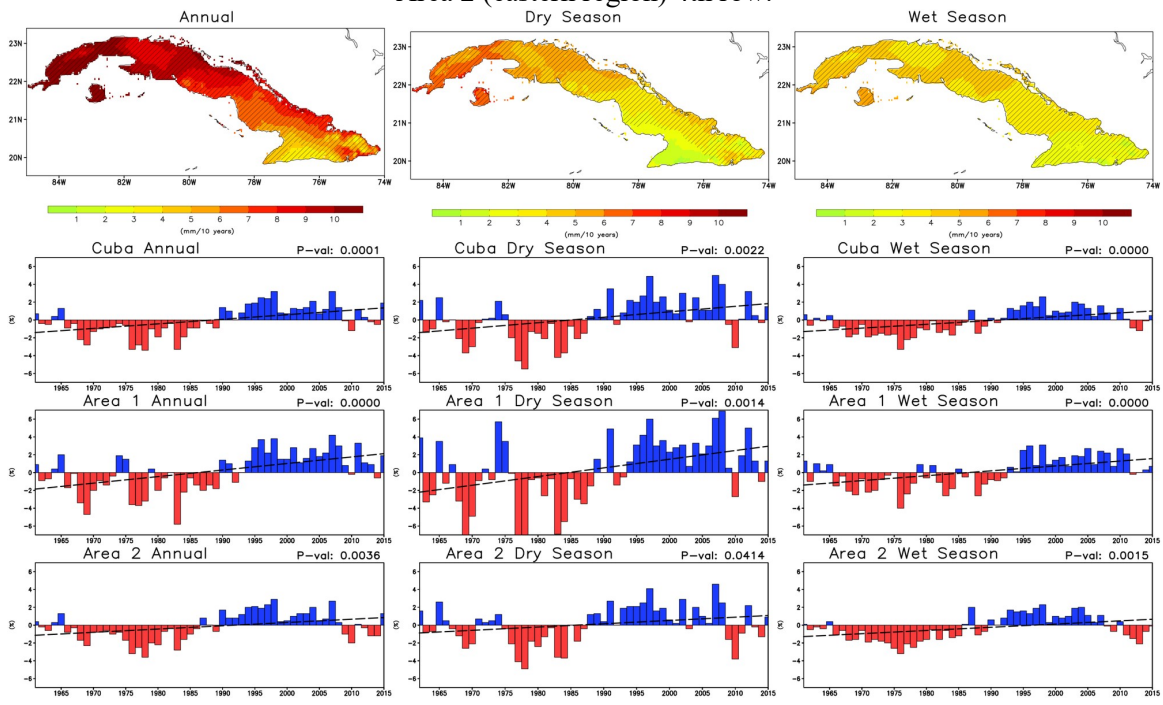
84. To clearly show the increases in drought intensity over time, Figure 35 shows the timeseries of areas covered by different categories of drought (extreme, severe and moderate). Increases in extreme drought (SPI < -2) are observed in the eastern region, coinciding with the significant decreasing trends in rainfall shown in Figure 34.

Figure 33 Areas covered by different drought categories (extreme, severe and moderate) between 1960 and 2016.



85. Furthermore, these trends in drought measured using rainfall alone are exacerbated by increases in potential evapotranspiration (ET0), as shown by the statistically significant (at the 95% confidence level) positive trends in ET0 across Cuba during both the wet and dry season (Figure 36).

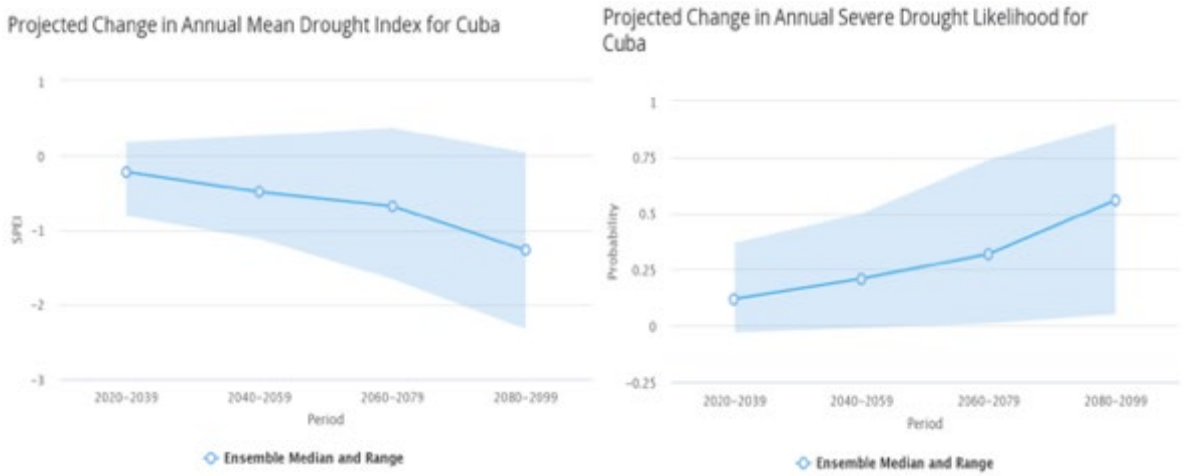
Figure 34 Trends in potential evapotranspiration over Cuba between 1961 and 2015. Annual (left), dry season (middle) and wet season (right). Spatial trend top row (hatching indicates trend statistically significant at 95% confidence level). Cuba 2nd row. Area 1 (western region) 3rd row. Area 2 (eastern region) 4th row.



86. This situation is expected to be aggravated based on climate projections. Whilst increases in dry season rainfall will be offset by decreases in wet season rainfall (Figure 20 above), increases in

evaporation (Figure 36) are projected to increase with reductions in SPEI and increases in the probability of severe drought throughout the 21st century (Figure 37).

Figure 35 Projected changes in SPEI and severe drought.

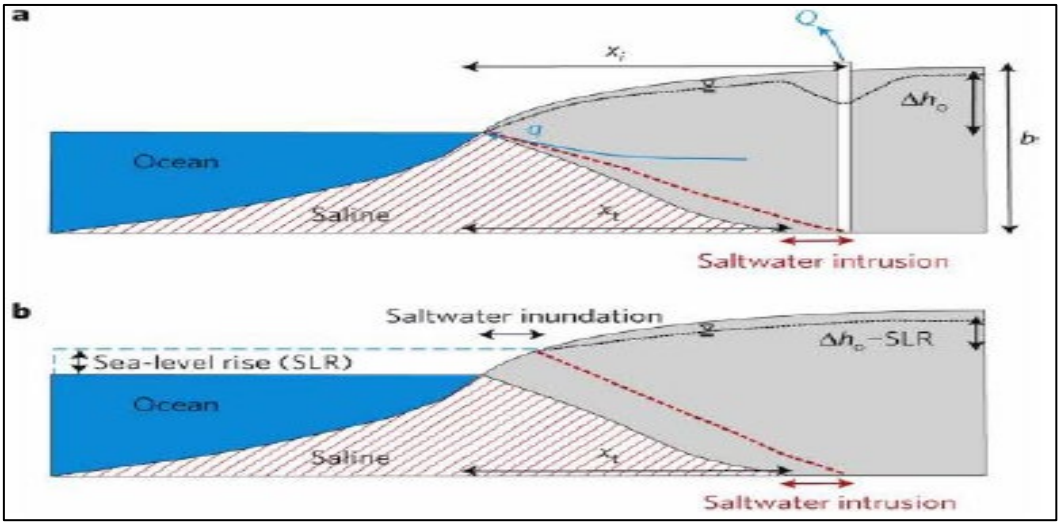


Saltwater Intrusion

87. Saline intrusion represents the most common and extensive cause of degradation for the water quality of the most important Cuban aquifers, which are located beneath its northern and southern coasts. In small and very small islands, it is also the main factor affecting groundwater quality. The karstic geology of much of the country makes it particularly susceptible to saline intrusion that is occurring due to CC: in several cases, isolated lenses of intruded seawater are found dozens of kilometers inland[36].

88. This is illustrated in the conceptual model presented in Figure 38: pre-existing processes of saline intrusion (Figure 24), caused in part by reduced water availability due to CC and over-extraction for human uses, which in turn are exacerbated by increases in sea level resulting from CC.

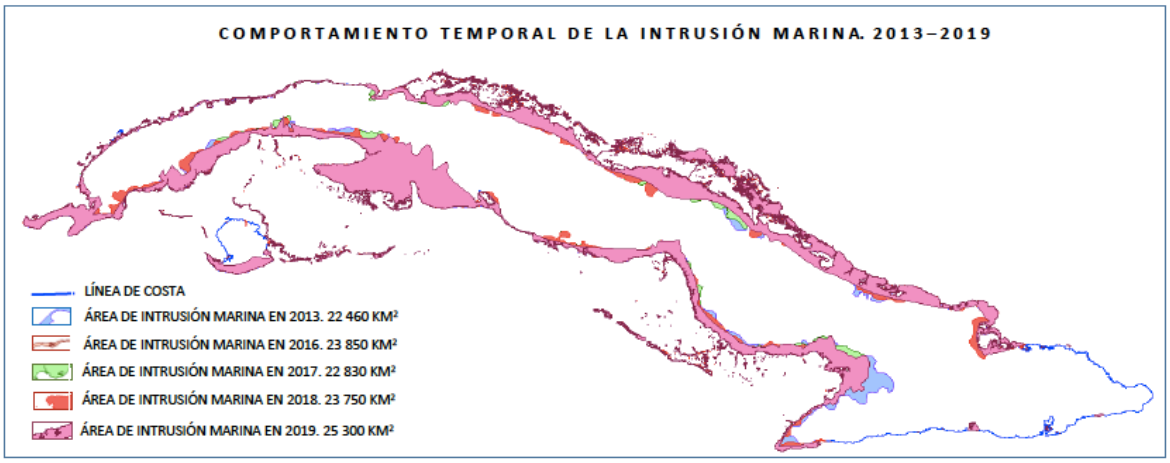
Figure 36- Conceptual model used for simulating the impact of (a) groundwater extraction (a) and (b) sea-level rise [37].



[36] Gonzalez P, Ferrera V, Benitez G, Fagundo JR, Sanchez L (1996). Estudios experimentales de disolucion de rocas carbonatadas en condiciones de mezcla agua dulce-agua de mar. In: Fagundo Catillo JR, Perez Franco D, Alvarez Nodarse A, Garcia JM, Morell I (eds) Contribuciones a la hidrogeologia y medio ambiente en Cuba. Universidad de Castellon, España, pp 357–366; Molerio León LF, Farfán Gonzalez H, Parise M, Aldana Vilas C (2007) Self-purification capability of underground water courses in the humid tropics: results of a tracing experiment at the Gran Caverna de Santo Toma`s, Cuba. Hydrogeol J (Submitted)

[37] Ferguson G and Gleeson T (2012). Vulnerability of coastal aquifers to groundwater use and CC. NATURE CC VOL 2 May 2012. The simulation variables include discharge per unit coastline (q), groundwater extraction rate (Q), aquifer thickness (b), the difference in hydraulic head between the inland boundary of the flow system and the coast before sea-level rise (1ho), and the distance from the coastline to the well (xi) and the toe of the saltwater wedge (xt). The grey area shows the distribution of the fresh aquifer water before extraction or sea-level rise

Figure 37- Temporal Behaviour of marine intrusion 2013-2019.



89. The amount of water contained in an island freshwater basin is determined by the size of the island, the amount of rainfall, the rate of water withdrawal, the permeability of the rock beneath the island, the mixing of salt due to the storm or tide as well as the pressure through flood processes (Karl et al., 2009)[38].

90. In the case of Cuba, the majority of its underground aquifers are open, with a free exchange of water with the sea thus making them highly susceptible to saline intrusion in both a scenario of drought, where fresh water does not allow the capacity of aquifers to recharge and counteract saline water incoming from the sea as well as during periods of sudden storm surges. During repeated and prolonged droughts without appropriate recovery, seawater enters the aquifer replacing fresh water, thus creating a layer of mixed (brackish) water that damages the use capacity of this water. The salt wedge can reach 1 km inland.

91. In a scenario of SLR (Figure 39 on current level of intrusion), the saline contents of groundwater rise in the coastal regions and the saline intrusion wedge increases its influence inland (Figure 38).

92. Saline intrusion in Cuba would result in in a large impact as the nature of the permeability of the soil type facilitates a rapid, in relative terms, saline intrusion. In these conditions it is important to highlight the role of coastal wetlands, particularly swamp grasslands, swamp forests and mangroves, as they are "water traps" where accumulation in times of availability and abundance allows the freshwater recharge to be maintained in the water tables, fighting slowly but persistently the saline intrusion (Bergkman et al. 1998) [39]. On the other hand, they are reservoirs that allow the accumulation of surplus water during floods caused by storms and hurricanes and reduce the impacts on the infrastructures upstream of these ecosystems (Dugan P. 1990)[40].

1.3.4 Climate Change Vulnerability and Cuban's Coasts

93. In Cuba's coastal areas CC will be felt more acutely as the nationwide increases in temperatures and reductions in rainfall will be accompanied by impacts derived from sea level rise, along with the higher intensity of storms [41]. High temperatures as described above will be accompanied by increases in potential evapotranspiration and real evaporation leading to a progressive reduction in access to water, and net primary productivity of terrestrial and agricultural ecosystems in the coasts, as well as in potential biomass density.

38 Karl, T.R., Melillo, J.M., Peterson, T.C., 2009. Global Climate Change Impacts in the United States. Cambridge University Press.
39 Bergkamp, G., Acreman, M., Safford, L. & Matiza, T. 1998. Maintining functioning freshwater ecosystems: The key to sustainable management of water resources. Documento preparado para la Comisión de las Naciones Unidas sobre el Desarrollo Sostenible, 19 páginas.
40 Dugan, P.J. 1990. Wetland Conservation: A Review of Current Issues and Required Action. Unión Mundial para la Naturaleza; 96 páginas.
41 Iturralde-Vinent, M. A. & H. Serrano Méndez. 2015. Peligros y vulnerabilidades de la zona marino-costera de Cuba: estado actual y perspectivas ante el cambio climático hasta el 2100. Editorial Academia. La Habana, Cuba.

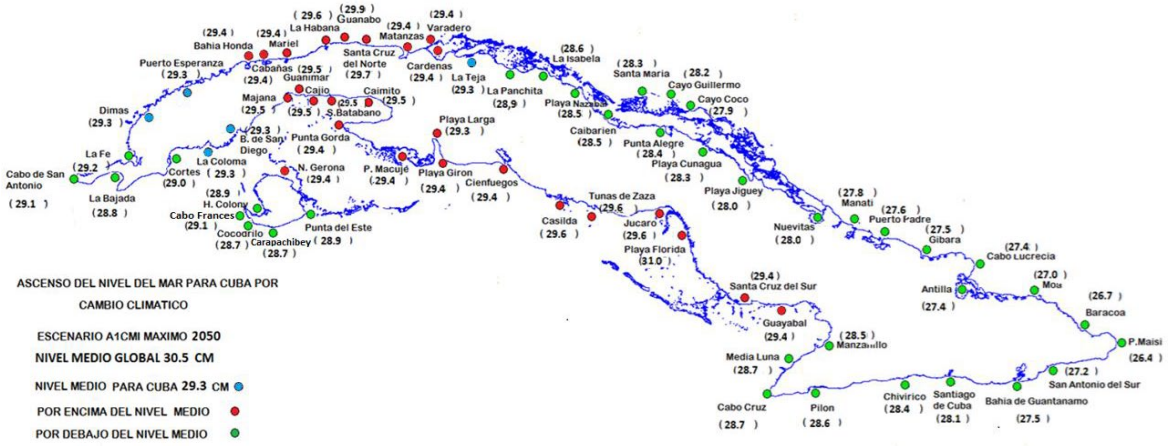
94. More than 10% of the population in Cuba lives at a distance between 0 and 1km from the coastline, in settlements located primarily in low-lying areas, subject to the effects of incidental weather events on the coasts (Moreno et al. 1998, Mitrani et al. 2001).

95. The Coasts of Cuba are highly vulnerable to climate risks. According to the publication of the ONEI for 2016 (National Office of Statistics and Information), from the year 1791 until 2017, 119 hurricanes hit Cuba, of which 51 were Category 1, 31 Category 2, 16 Category 3, 14 Category 4 and 3 Category 5 of them have hit the western region, 54 the central region and 52 the eastern region of the country.

96. According to the analysis of climate change in Cuba, there are three main risks are perceived very clearly in the island described as follow:

- The first is an increase in the average air temperature associated with a reduction in precipitation, causing challenges to water availability. An increased in average temperature of 0.9°C between 1951 and 2010 has been recorded by the Center for Climate of the Meteorological Institute (INSMET). An increase in temperature of 1.9°C, in the same period, would result in an increase of 2 to 3 °C by 2100 (Iturralde and Serrano, 2015).
- The second is a greater intensity of storms, hurricanes and associated waves or swells as a result of extreme situations that cause heavy impact floods and damage to coastal infrastructures due to the mechanical effects of wind and waves. Holland and Bruyere (2014)[42] reports that, for the North Atlantic region, an increase in the sea surface temperature of. 0.8ºC is consistent between 1961 and 2007, and an increase of category 4 and 5 hurricanes of approximately 40% that can be explained by an increase of 1ºC in sea temperature with 90% statistical confidence (Iturralde Y Serrano 2015)[43] . Likewise, they concluded that since 1975 there has been a considerable and observable regional and global increase in the proportion of Category 4 and 5 hurricanes of 25-30% per °C of anthropogenic global warming.
- Third, an increase in sea level (See figures below) that will have major effects on the shallow marine ecosystems and the stability of coastal plains, particularly those with lower slopes (where the greatest impacts of sea penetration will occur), as well as an increase in saline intrusion and greater coastal sensitivity to waves and currents. Iturralde and Serrano (2015) estimate that the increase in sea level in the IPCC scenario (2007) will be between the A1C and B2 4 centimeters for the 2030 in both cases, respectively 27 and 26 centimeters by 2050, 48 and 40 centimeters respectively for 2070 and 85 and 62 centimeters respectively by 2100

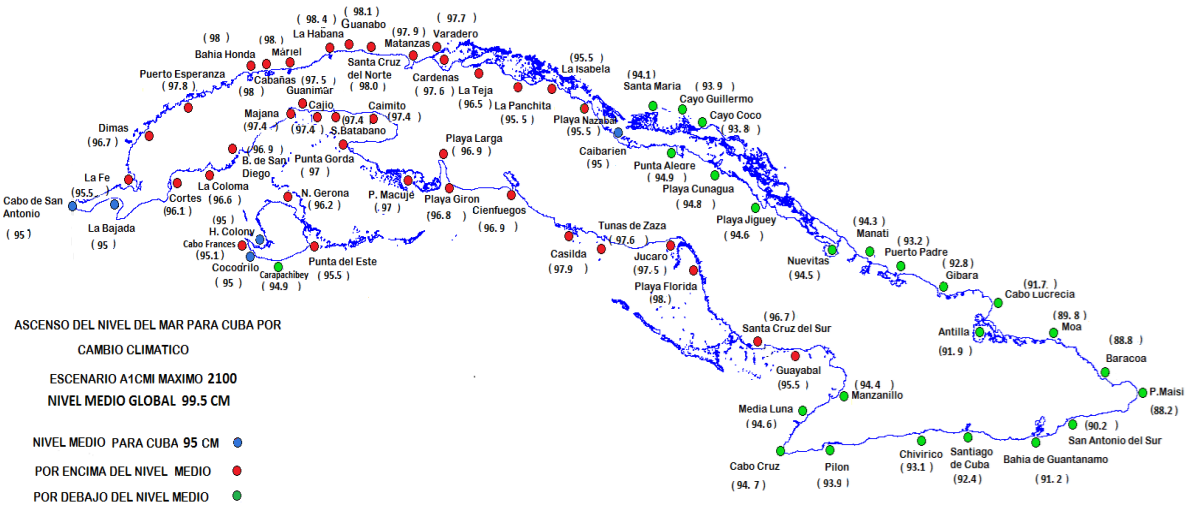
Figure 40-- SLR scenarios for 65 Coastal Settlements in 2050 (Red circles indicate localities above median levels and green below median levels and blue on mean levels)



42 Holland, G. & Bruyère, C.L. Clim Dyn (2014) 42: 617

43 Iturralde M., Serrano H. 2015 Peligros y vulnerabilidades en la zona marino-costera de Cuba: Estado actual y perspectivas ante el Cambio Climático hasta el 2100. Agencia de Medio Ambiente CITMA. Editorial Academia. Cuba. 72 pp.

Figure 38-- SLR scenarios for 65 Coastal Settlements in 2100 (Red circles indicate localities above median levels and green below median levels and blue on mean levels)



97. Climate change is expected to impact Cuban coastal areas due to sea-level rising and the increase of intensity and frequency of tropical storms. These changes will exacerbate erosion and flooding of coastal areas.

II. Cuba's Coasts and its Ecosystems

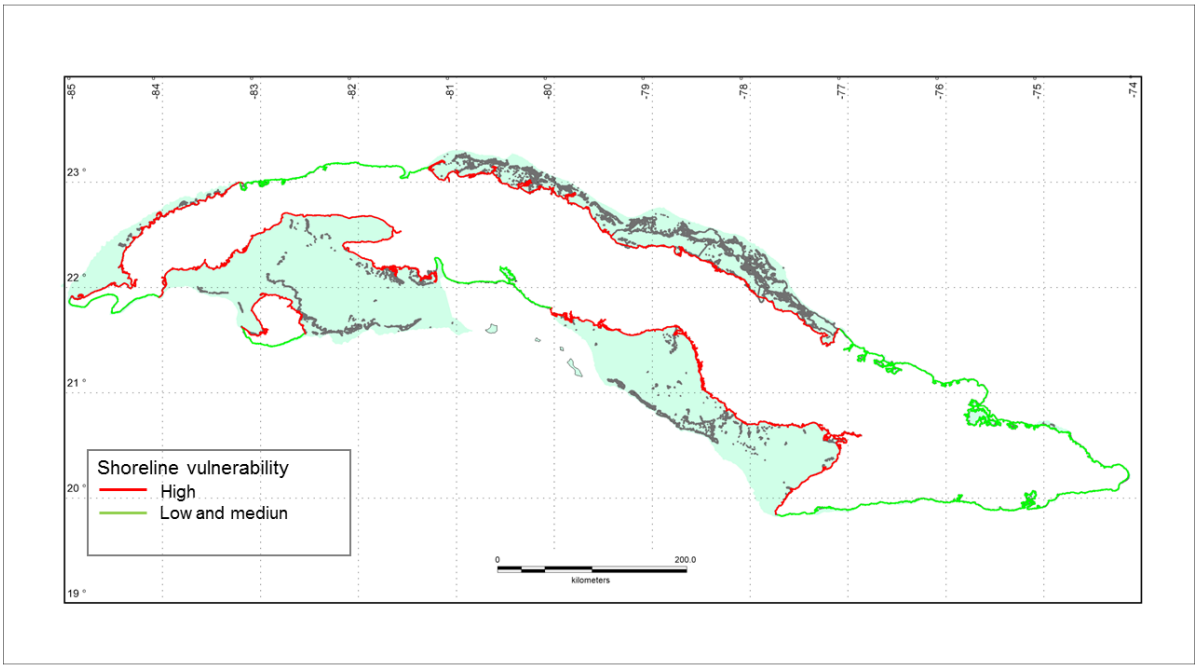
98. Approximately 42% of the Cuban population lives in coastal municipalities. There are 38 municipalities in the Southern Coast totalling 2,095,241 people and 2,576,873 people residing in 43 coastal municipalities located on the North. The coastal capital city of Havana is home to 2.2 million people around 20% of the population. If one takes into account the population of Havana, at least 6,672,114 people live on the Cuban coasts, representing approximately 57% of the population.

99. Most coastal communities, particularly those that are rural are characterized by a narrow economic base, dependent largely on artisan fishing, basic services and tourism; in addition, many members of coastal communities are involved in agriculture and livestock raising in neighboring areas due to limited employment opportunities in their own areas. Coastal communities have also been affected by decreasing employment opportunities due to the decline of the fisheries sector and the degradation of productive infrastructure by the weather and extreme climatic events.

100. In Cuba there are basically two types of coasts: 1) low coasts, swampy, with Sandy-slime-peat substrate, partially flooded, and 2) high coasts with a rocky substrate, either cliffs or with emerged marine terraces (Iturralde and Serrano, 2015). Higher coasts are predominantly rocky but sometimes they are interrupted by several and large pouch-shaped bays, coves, inlets and sandy beaches, while low-lying coasts are fringed by mangroves with coastal lagoons and estuaries. The most striking difference between these two coastal types is the extension of the shelf area, which is very narrow in the high-lying coast, but wide and shallow in the low-lying coast.

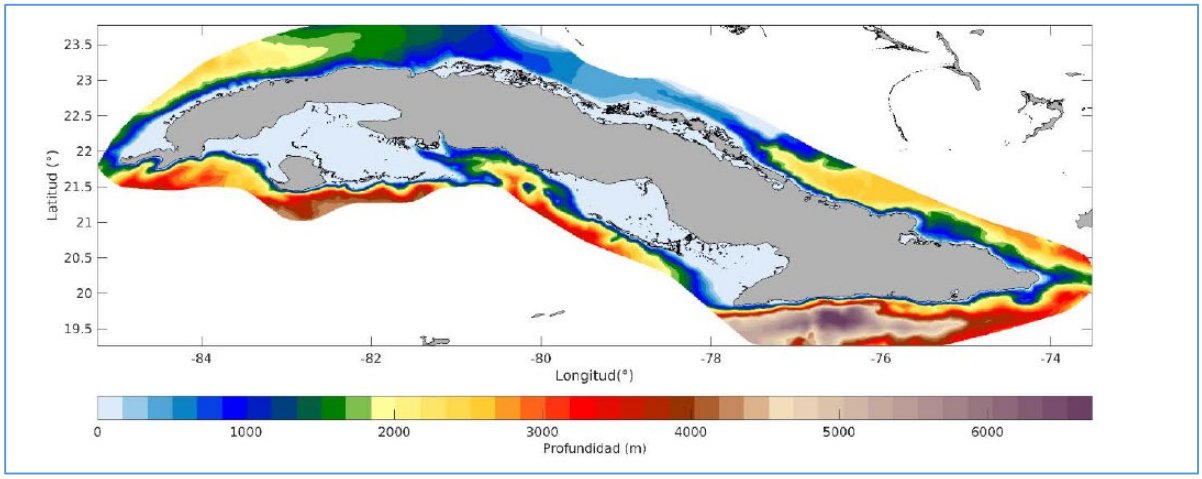
101. According to this classification, the vulnerability of coastal zones to climate associated events is higher in the low lying coasts and lower in high coasts , besides that in the low-lying areas there are some of the most vulnerable settlements to the increase in mean sea level and more likely to be affected by extreme weather events (hurricanes, tropical storms and coastal flooding).

Figure 39-- Vulnerability of Cuban shoreline associated to climate change including the progressive rising of sea level and associated events (Modified from Iturralde and Serrano, 2015).



102. Differences in bathymetry between these coastal types (Figure 25) highlight highly vulnerable areas these being mainly from the Cuban south coast

Figure 40-- Detailed bathymetry of Cuban coastal areas. (Source: Instituto Hidráulica Ambiental, Universidad de Cantabria 2018).



2.1 Key Coastal Ecosystems forming the Coastal Wetlands

103. The coastal diversity in geomorphology and spatial distribution is responsible for the great biological diversity of the Cuban coasts shelters, of regional importance for the great Caribbean. The coastal wetland is formed by the combination of this diversity of various types of marine and coastal ecosystems. It is composed of several closely related marine and coastal ecosystems. The main ecosystems that make up the coastal wetland on the Island of Cuba are cays (of sandy and reef origin), coral reefs, sandy or silts beaches in the cays or on the mainland respectively, seagrass beds, mangroves and swamp forests and swamp Grasslands (Figure 43).

104. In this analysis of coastal ecosystems it is important to reinforce that the different ecosystems that make up the Coastal Wetlands act together as a synergistic system to produce conditions that seek coastal resilience to the project (Figure 33 located in p41).

105. This is why the rehabilitation of degraded areas of ecosystems act together and in a synergistic manner. The goal of rehabilitation interventions in ecosystems is based, therefore, on specific interventions that improve the conditions of resilience in coastal areas in general.

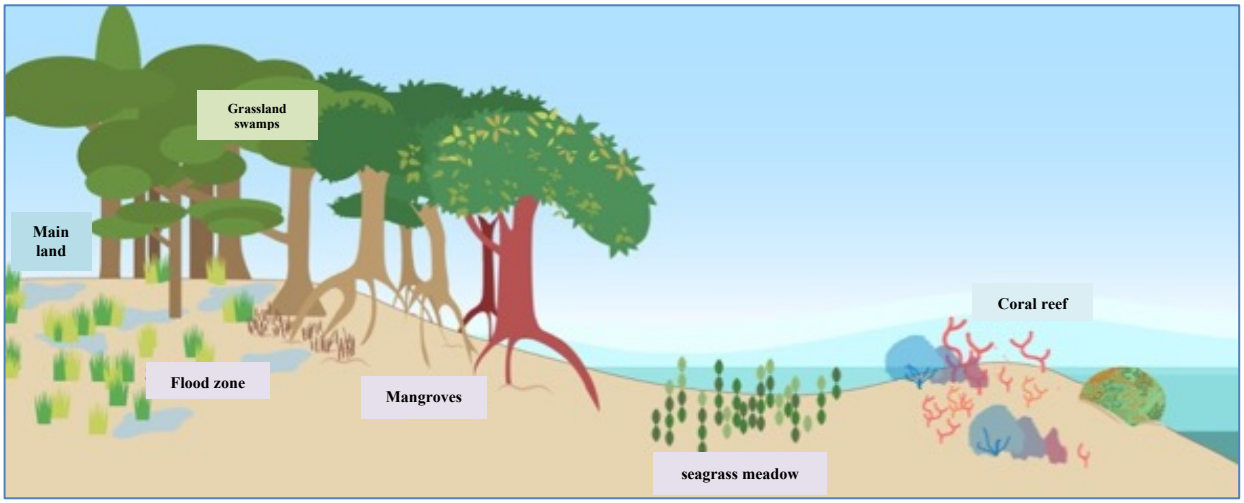


Figure 41-- Schematic representation of the Coastal Wetlands.

2.1.2 Swamp forests and swamp grasslands

106. The swamps are coastal ecosystems that combine shrubs and hydrophilic trees that have a very important role in retaining water and nutrients. The swamps are and function as independent ecosystems. However, in the coastal wetland, they are frequently associated with mangroves and other coastal or marine ecosystems.

107. These freshwater wetlands are of great importance for biodiversity as well as for the maintenance of surface water contributing to the stabilization of floodwaters throughout the year. Ecosystems interact with a series of functional relationships as will be shown in Figures 50 and 52.

108. Swamp forests and grass lands play a key figure in binding sediments and nutrients while, supporting in freshwater discharge and flow which is a key factor for the entire coastal landscape, most immediately the mangroves. In the case of Cuba, these areas are important for ensuring the recharge of acquifers. These systems rely in the capacity of mangroves, seagrass and coral in their capacity to mitigate winds from extreme storms, their capacity to disseminate wave force (up to 50%).

2.1.3 Mangroves

109. Mangroves around the world are extremely rich areas in term of biodiversity according to SánchezPáez et al, (2000), they noted that more than 69 species classified as mangroves are known, of which 3 are ferns, one palm and 65 trees and shrubs, grouped in 24 genera and 19 families. However, mangroves in the Americas report only 11 species of plants, of which four belong to the genus Rhizophora, and four to the genus Avicennia, one to each of the genera Laguncularia, Pelliciera and Conocarpus (Lacerda et al. 1993[44]).

110. The evergreen mangrove forests of Cuba are made up of four tree species: red mangrove (R. mangle); black mangrove (*A. germinans*); patabán (*L. 45eotecto*) and yana or pseudo mangrove (*C. erectus*)[45.] Other plant species associated with mangroves, include *Batis maritima*, in sites with greater salinity, generally accompanying *Avicennia germinans* forests; *Thespesia populnea* locally called "majagua de Florida, *Hibiscus tiliaceus* locally called "majagua", *Bontia daphnoides*, locally called "aceituna Americana", Dalbergia ecastophyllum, *Acrostichum aureum* (mangrove fern) and several tree species of the genus *Bucida*[46].

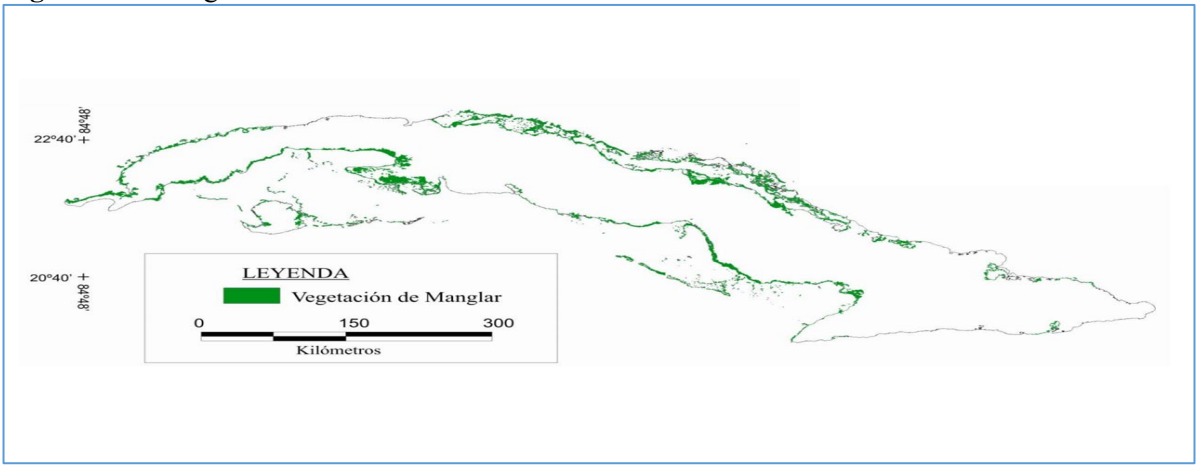
111. Plant species that make up the mangroves have morphological and functional specializations that give them a colonizer character while allowing them to develop in extreme conditions of saline water and muddy and unstable soils. These characteristics are special organs for respiration and support, metabolism adapted to high concentrations of salt, viviparity and long germinating power (Menéndez et al, 2000; Sánchez-Páez et al, 2000)[47] .

112. Cuban mangroves occupy 5.1% of the area of the country and are found on 70% of the coasts. They constitute a valuable forest reserve, representing 20.1% of the forest area of the country. Given the insular nature of Cuba, the mangrove ecosystem has great economic, ecological and strategic importance[48] .

113. The mangroves of the island of Cuba are highly variable. They are found in cays, in coastal plains and associated to river deltas, estuaries and marshes. They extend particularly in the coastal plains with influences of tides and hydraulic patterns dominated by annual or periodic floods. They are forests dominated by three species and host an immense biodiversity associated with their roots and canopy, considered the most productive ecosystems in the world. Mangroves serve as areas of nutrient capture, damming and serve as natural barriers to prevent the effects of the winds and the waves.

44 Lacerda Ld, Araújo Dsd and Maciel Nc. 1993. Dry coastal ecosystems of the tropical Brazilian coast. In: Van Der Maarel E (Eds), Dry Coastal Ecosystems of the World. Vol. 2B, Chapter 32, Elsevier Publ. Co., Amsterdam, p. 477-493.
45 Menéndez L., J. M. Guzmán, L. Rodríguez, N. Gómez, Z. Cuervo, L, Almeida and A. Álvarez of Zayas (2013). "Affectations of the Forests of Mangroves in the Bahía of Cárdenas and Changes in the Ecosystem Services". 143-151 pp. In: (L. Fernández and A. Vanina Eds.) "Evaluation of the Changes of States in Degraded Ecosystems in Iberoamérica". RED CYTED 411RT0430. 283 pp.
46 Oviedo, R. & M. Labrada. 2006. "Mangroves in the Ciénaga of Zapata Wetlands". pp. 219-229. In: L. Menéndez Carrera & J.M. Guzmán Menéndez (eds.): Mangrove Ecosystem in the Cuban Archipelago. Editorial Academia. Habana, Cuba.
47 Menéndez L. and Guzman., 2002. Ecosistemas de manglar en el archipiélago cubano. Editorial Academia de Cuba. UY/2002/SC/ECO/PI/2 471 pp.
48 Menéndez L., J. M. Guzmán, L. Rodríguez, N. Gómez, Z. Cuervo, L, Almeida and A. Álvarez of Zayas (2013). "Affectations of the Forests of Mangroves in the Bahía of Cárdenas and Changes in the Ecosystem Services". 143-151 pp. In: (L. Fernández and A. Vanina Eds.) "Evaluation of the Changes of States in Degraded Ecosystems in Iberoamérica". RED CYTED 411RT0430. 283 pp.

Figure 42-- Mangrove Forests in Cuba.



114. However, the rapid evolution of unfavorable conditions associated with human development has contributed particularly in mangrove coastal edges to reduce the areas of red mangrove (*Rizophora mangle*). This has led to marine penetration (especially in southern Cuba), which has contributed to the degradation of mangroves and losses of up to 50 meters from the edge of the mangrove in some sectors, as well as soil salinization threatening stability and ecosystem resilience against the impact of climate change.

115. Mangroves in southern Cuba are typically dominating in the fringes of estuaries, rivers and coastal areas by an area dominated almost entirely by red mangrove (*Rizophora mangle*), which is more resistant to the direct salinity of the sea, and more resistant to the effect of waves and currents than other mangrove species with more superficial and less extensive or strong root systems, such as the Mangrove Patabán (*Laguncularia 46eotecto*) or the black mangrove (*Avicennia germinans*). The red mangrove stripe is of variable width but in the project intervention sites it can vary between 50 and 150 meters wide, usually followed by larger areas of forests dominated by black mangrove or black mangle mixes with white mangrove.

116. Mangroves in Cuba are affected by many complex factors that interact with each other some anthropogenic (pollution, tourism, agriculture) and some related to climate change (physical damage due to storms and the increase penetration of seawater).[49]

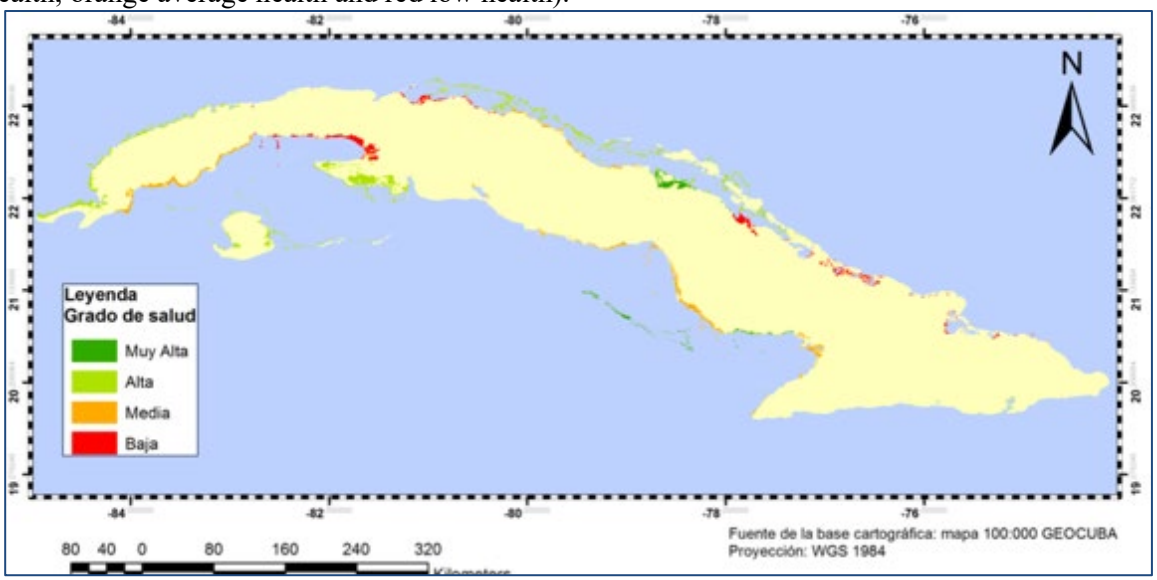
117. Most commonly mangrove deterioration is in Cuba is related to agricultural expansion, direct conversion to urban land uses, road and dam construction, and timber extraction (Milian Padr.n,1999; Lugo, 2002; Suman, 2003; Men.ndez Carrera and Guzman Menendez, 2006; Rodriguez et al., 2006; Spalding et al., 2010; Menendez Carrera, 2013; Suman, 2013; Blanco Rodriguez et al., 2014; Lugo et al., 2014). Estimates of the historical rates of mangrove loss in Cuba are highly variable (Friess and Webb, 2014). However, Suman (2013) indicates that the rate of mangrove loss in the previous several decades has likely decreased due to an increasing emphasis upon sustainable development, including mangrove protection, within Cuban environmental legislation and institutions. Nevertheless, mangrove loss due to coastal development continues to be a threat in Cuba (Menendez Carrera, 2013), especially given anticipated future increases in coastal tourism and tourism-related infrastructure that could affect future increases in coastal tourism and tourism-related infrastructure that could affect mangroves (Spalding et al., 2010; Suman, 2013; Lugo et al., 2014)[50].

118. Iturralde and Serrano (2015) estimated most of the mangroves in Cuba have some degree of deterioration, however no specific numerical data is offered. It will be seen in the characterization that over 80% of mangroves in the project intervention sites are deteriorated. Figure 45 clearly shows that the southern region of Cuba has the greatest areas of mangroves with medium or low health.

49 UN (2018), p12.

50 Michael J. Oslanda, Laura C. Fehera, Jorge López-Portillob, Richard H. Daya, Daniel O. Sumanc, José Manuel Guzmán Menéndezd, Victor H. Rivera-Monroye (2018). "Mangrove forests in a rapidly changing world: Global change impacts and conservation opportunities along the Gulf of Mexico coast." Estuarine, Coastal and Shelf Science 214 (2018) 120–140

Figure 43-- Conservation status of mangroves in Cuba (dark green very good health; green good health; orange average health and red low health).

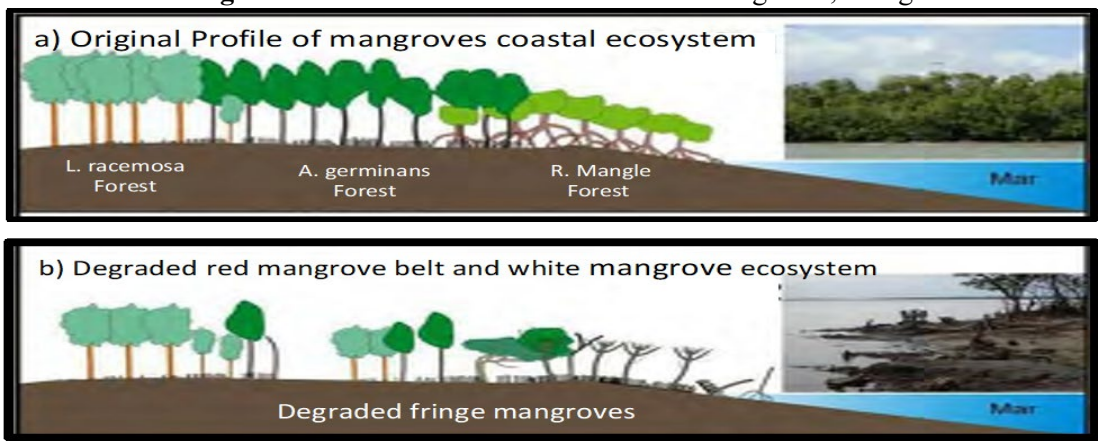


Source; Menéndez, L. 201351

119. In the southern region of Cuba, generally, there is a degradation of red mangrove strips of the coastal edges, which gradually disappear giving way to waves and currents during periods of waves, storms and hurricanes. Areas where the sea has penetrated more than 150 meters have evidenced the breaking down of the red mangrove strip, exposing areas dominated by black or white mangroves. These processes also contribute to increased salinization of coastal wetlands that can eventually kill the mangroves due to metabolic increase to exclude salt from their tissues and affect other surrounding coastal ecosystems.

120. In the absence of red mangrove, greater energy from waves and currents on the black and white mangroves have a negative impact because these species have weaker systems and shallower roots. The final effect is the fall of standing trees, living or dead, as shown in Figure 46 below.

Figure 44- The final effect is the fall of standing trees, living or dead.



121. Source: "Manglar Vivo" PRODOC

Figure 45– Coastal edge with dominance of black and white mangrove and absence of red mangrove, highly sensitive to erosion and destruction of the forest due to the mechanical effect of the currents and swell due to having a very superficial radicular system and without adaptations for these conditions.

51 Menéndez, Leda. 2013 Tesis Doctora El Sistema de Manglar Cubano; Bases para su gestión. Universidad de Alicante. España 2013. 172 pp.

122. According to Lugo and Snedaker (1974)[52], the mangrove recovery process by itself is slow, and depends largely on the tree species that make up the mangrove, topography, drainage, sedimentation and proximity to the path of the hurricane (Roth, 1992)[53.]

123. Research has pointed to the importance of implementing "future focused" landscape conservation planning that further favors the capacity of mangrove forests to adjust to the pressures arising from both anthropogenic and climate pressures, this includes favoring conditions in response to SLR that allow for the landward migration of mangrove forests through conservation planning efforts to identify and protect upslope and upriver migration corridors; in the face altered rainfall and reduced fresh water availability, hydrological restoration and water flow regimes will provide to be an important aspect of restoration processes allowing water to filter to mangrove forests and prevent drying conditions; in the case of increased temperatures where the risk of mangrove expansion at the expense of salt marshes could prove harmful it maybe necessary to establish refugia for salt marsh ecosystems in the coldest coastal reaches in the region. See Table 4 below for potential strategies for the conservation, restoration and adaptation of mangrove forest in response to global change drivers

Table 4 – Potential strategies for conservation, restoration, and adaptation of mangrove forests in response to each of the nine global change drivers.[54]

Global Change Driver	**Strategies for conservation, restoration and adaptation**
Rise in temperature	Protect and manage climatic refugia, minimize non native species introduction, protect and manage hot spots for mangrove dispersal
Alterations in precipitation	Restore hydrological connectivity, manage freshwater inputs to maximize resilience to extremes, target resistant species for restoration
SLR	Restore hydrological connectivity, protect and mange landward migration corridors, maximize connectivity between ecosystems, land acquisition
Tropical cyclone intensity	Future focus land use planning, mangrove restoration and creation, protect and manage landward migration corridors, maximise green infraestructure
Rise atmospheric CO2	Anticipate outcomes from altered biotic interactions, maximise diversity to increase resistance and resilience
Changes in nutrient availability	Mangrove restoration and creation, land use planning to manage anthropogenic nutrient inputs, protect and manage connectivity to enable positive responses to nutrient alterations
Invasive non native species	Anticipate and avoid novel introductions, early eradication, strategic management of established problematic species.

52 Lugo, A. E. y S. C. Snedaker (1974): The ecology of mangroves. Annual Review of Ecology and Systematics. 5: 30-64.
53 Roth, L. C. (1992): Hurricanes and mangrove regeneratios: Efects of hurriacane Joan, October 1988, on the vegetation of Isla del Venado, Bluefields, Nicaragua. Biotropica, 24: 373-384.
54 MJ Osland et al (2018).

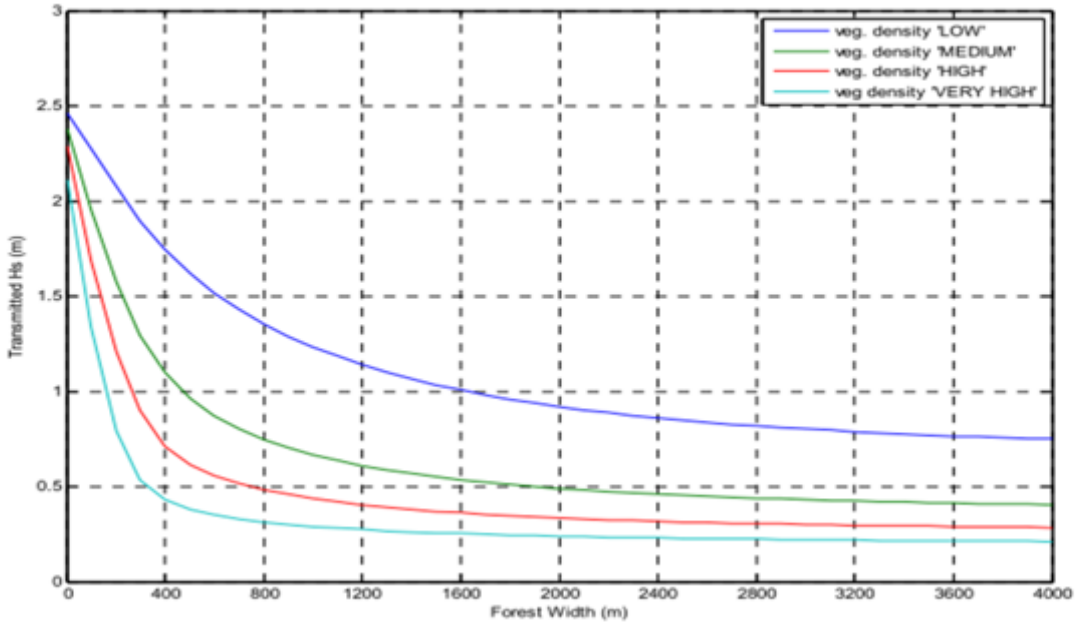
124. Tree species in mangrove ecosystems are highly "plastic", that is, adaptable to varying environmental conditions. However, it is clear that there are factors that are ideal for the development of the Neotropic mangroves, among which we can mention; (1) Sediments with alluvial origin or high organic content, (2) a mild hydrology with flows less than one meter per second, (3) Periodic and variable floods with tidal influences that produce brackish water of between 25 and 5 ppm. (4) Tropical or subtropical temperatures. These factors, along with the existence of several healthy and resistant samples of these ecosystems in the system of protected areas, allow that in the event of massive or intense stress due to CC existing deteriorated mangroves can recover.

125. Areas occupied by mangroves are considered areas of high geo-ecological fragility and constitute systems of transition between the terrestrial and marine environment, which gives them an important ecological function. From a functional point of view, they can be considered collector landscapes because they receive all the support from catchments inland and marine environment. Mangroves are nurseries of biological diversity, sources of water and primary productivity on which innumerable plant and animal species depend for subsistence.

126. In terms coastal protection, mangroves can provide protection from waves, such as those that occur during hurricanes, due to friction with the roots, stems and canopy of this vegetation, so that the reduction coefficient varies mainly according to the width of the mangrove (estimated at 1.6km in our target areas), vegetation density and water depth (see figure below).

127. Mangroves provide many goods and services. Many of these services are related to the capacity

Figure 28 - Transmitted wave heights across forest width for varying vegetation density values and fixed hydraulic parameters (h=9.6m. H s =2.5m, T p =15s)



of mangroves to capture and metabolize sediments and organic matter, as well as the accumulation of water and the prevention of floods. Hence, they are important for the support of coastal swamplands and forests while also providing water filtration capacities to marine systems. The processing of organic material allows the export of biomass through the support services for fishing, among many other products.

2.1.4 Coastal Keys and Sandy beaches

128. Keys, or cays, are typically formations of coralline origin accompanied by sandy deposits of coralline origin that create little white beaches with dunes. These dunes are normally populated by xerophytic or succulent vegetation. The cays and the sandy beaches associated with them fulfill the role of mitigating wave forces and slightly dissipating the effects of the winds before approaching the coast. Their effect is highly variable because there are very distant cays off the coast (up to 45 miles out).

129. In the sites selected for this project there are no extensive sandy beaches. Fringe mangroves dominate the coasts in the project sites and the sandy beaches are associated with the small partridge

beds that are located far from the coast itself, therefore interventions on the sandy beaches are not considered necessary.

2.1.5 Seagrasses

130. There are only 60 species of marine angiosperms worldwide, of which six species occur in Cuba. Seagrasses are typically composed of ***Thalassia testudinum*** (known as turtle grass or seiba), ***Syringodium filiforme*** (manatee grass), ***Halodule wrightii*** (grass bass), ***Halophila engelmanni***, ***Halophila decipiens*** and ***Ruppia maritima***. The most abundant is ***Thalassia***, although all play an important role in the ecosystem.

131. Seagrasses are coastal ecosystems dominated by marine phanerogams, mainly ***Thalassia testudinum*** forming refuge and breeding sites for many marine species associated with shallow marine platforms of between half and ten meters deep. These submarine platforms covered with underwater vegetation have a high roughness to the currents and act as an important dissipating effect of the currents and of the previous wave to their reach to the coastal zones. Seagrasses develop and stabilize sediments in rather shallow areas that can reach up to 20 meters in depth when the water transparency allows and develops typically between a few centimeters and 10 meters of depth.

132. Cuba has considerable extensions of seagrass, thanks to its wide and shallow marine platform (53,126 km^2), and it is estimated that they occupy more than 50% of it (Claro, 2006)[55]. This represents at least 26,569 Km^2 of seagrass beds. Marine grasses occupy half of the Cuban platform. Northwest Cuban coastal waters contain about 2,050km^2 of seagrass coverage (Buesa, 1974) while other un-surveyed beds exist around Cuba (Hoskins, 1964)[56]. In the intervention sites they occupy 15,846 Km^2. They have been reduced to 13,818 km^2 in 15 years, representing a loss of approximately 10%. (Jiménez and Alcolado, 1990[57] and Cerdeira et al.2004[58]).

133. According to Ogden and Gladfelter (1983), mangroves and seagrasses represent breeding sites that stand out as places with a high structural complexity and protected from the high levels of predation present in coral reefs, the protection provided by the structural complexity of the masses of leaves and roots to small organisms, and the rich supply of food from plant detritus, associated microorganisms and small invertebrates. Therefore, they play a complementary and important role for the conservation of biodiversity as well as for the maintenance of numerous species of commercial value such as shrimp and lobsters, which are particularly important for the Cuban fishing economy.

134. Seagrasses have been declining on a global scale for several decades (Larkum et al., 2006). The rate of this decline is estimated at around 1-2% per year and seems to accelerate in recent years, which places them among the most vulnerable ecosystems on the planet (Borum et al., 2004). Seagrass losses are attributed to physical and chemical factors as a result of anthropogenic development, as well as to the effects of global climate change such as the increase in surface temperature (Short and Neckles, 1999).

135. The intrusion of ocean water into areas of previously fresh or brackish water directly affects the distribution of estuarine plants as does the reduction of fresh water intake from natural occurring flows, hence highlighting the important role that mangroves play in their protection as well as interventiosn directed at restoring natural hydrological patterns. Changes in distribution result from the effects of salinity change on seed germination, propagule formation, photosynthesis, growth and biomass. Increasing the depth of the water, which reduces the amount of light reaching the existing seagrass beds directly reduce the productivity of the plant where plants are limited by light.

136. As stated above, seagrass beds provide services in the energy dissipation of currents and attenuation of the height of the waves. Seagrasses retain sediments, being strong stabilizers of marine platforms and contributing to the continuous retention of sediments that serve to self-sustain platforms of low depths thus preventing wave growth and dissipating the energy of currents.

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55 Claro, R. (Ed.) (2006). La biodiversidad marina de Cuba. Instituto de Oceanología, La Habana. CD-ROM, ISBN: 978-959-298-001-3.

56 Hopkins, 1964. Seagrass distribution and abundance in Eastern Gulf of Mexico coastal waters. Richard L. Iverson, Henry F. Bittaker. Estuarine, Coastal and Shelf Science. Volume 22, Issue 5, May 1986, Pages 577-602

57 Jiménez, C., & Alcolado, P. M. (1990). Características del macrofitobentos de la macrolaguna del Golfo de Batabanó. *El bentos de la macrolaguna del Golfo de Batabanó. Editorial Academia, La Habana*, 8-12

58 Cerdeira-Estrada, S., Lorenzo-Sánchez, S., Areces-Mallea, A., & Martínez-Bayón, C. (2008). Cartografía de la distribución espacial de los hábitats bentónicos en el Golfo de Batabanó utilizando imágenes Landsat-7. *Ciencias marinas*, *34*(2), 213-222.

137. The value of the goods and services provided by seagrasses has been estimated at about US$19,000 per hectare per year, taking as reference only their importance in the recycling of nutrients (Costanza, et al., 1997). Virnstein and Morris (1996) estimated that about 32,000 hectares of seagrasses in Indian River (Florida) produced approximately one billion dollars annually in environmental services related to fishing. More recently Costanza et al (2014) determined that the value of seagrasses increased from 26,509 dollars per hectare per year in 1997 to an estimated value of 28,916 dollars per hectare per year in 2011. This was due to the improvements in information and refinements of the valuation methods.

138. The biological services generated by seagrass beds influence the health, and therefore also the CC resilience and buffering services, of the coastal environment as a whole, including other ecosystems such as coral reefs and mangroves. They serve to increase the substrate available for the growth of different organisms; to protect the sea floor from high light levels and allow the development of a microenvironment at the base of the sea grasses; to create high concentrations of dissolved oxygen resulting from photosynthesis; to function as an important entry point for energy into the coastal and marine system as a whole through detritus inputs, in association with herbivores such as sea urchins; and to provide physical sites for breeding, refuge and feeding of many juvenile fish and invertebrates, a function related to that of mangrove forests and coral reefs.

139. Natural phenomena, some associated with climate change, can impact seagrasses, such as erosion due to increased energy in coastal areas by extreme weather events (such as storms or hurricanes whose waves can dig up the plants) and floods as they cause sediment discharges and sudden changes in salinity (van Tussenbroek, 1994, Short and Wyllie-Echeverría, 1996, McKenzie, Roder, Roelofs and Lee Long, 2000). Degradation of both the reef crest and the roughness of the coral reef can be a factor that increases the potential impacts of climatic and physical factors that degrade seagrasses.

2.1.6 Coral reefs

140. The coral reefs of Cuba are among the most diverse and best preserved in the Caribbean and can be found along almost the entire border of the Cuban shelf, and extend inshore across broad areas of the shelf. The southern shelf is intermittently fringed by fore reefs along 1,631 km (Figures 48-49). These fore reefs exhibit great variation in their profiles and ecological zones. In many places these reefs bear reef crests at their shallowest zone and the term “crest reefs” for the complex reef crest-fore reef has been proposed.

Figure 46-- Location of fore reefs (grey color) in the Gulf of Batabanó.

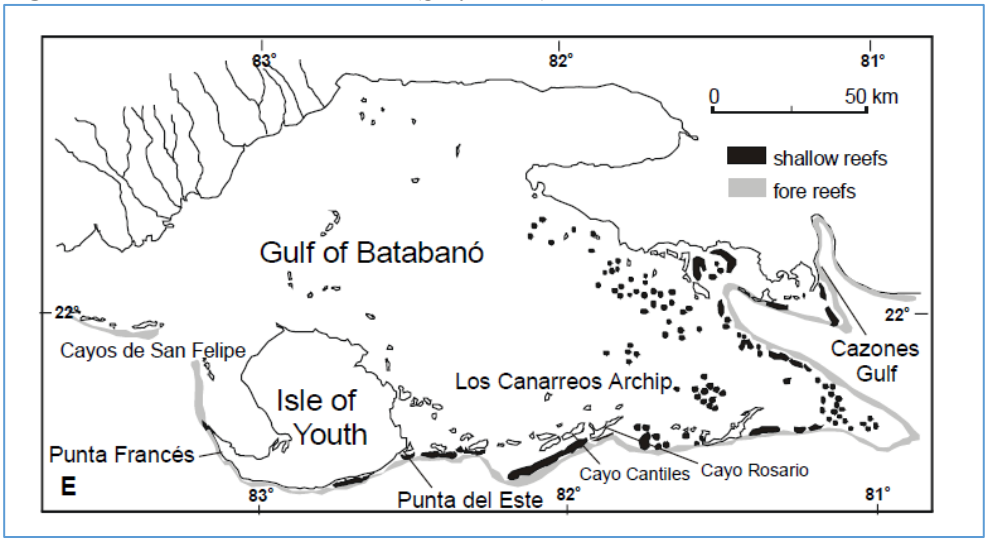
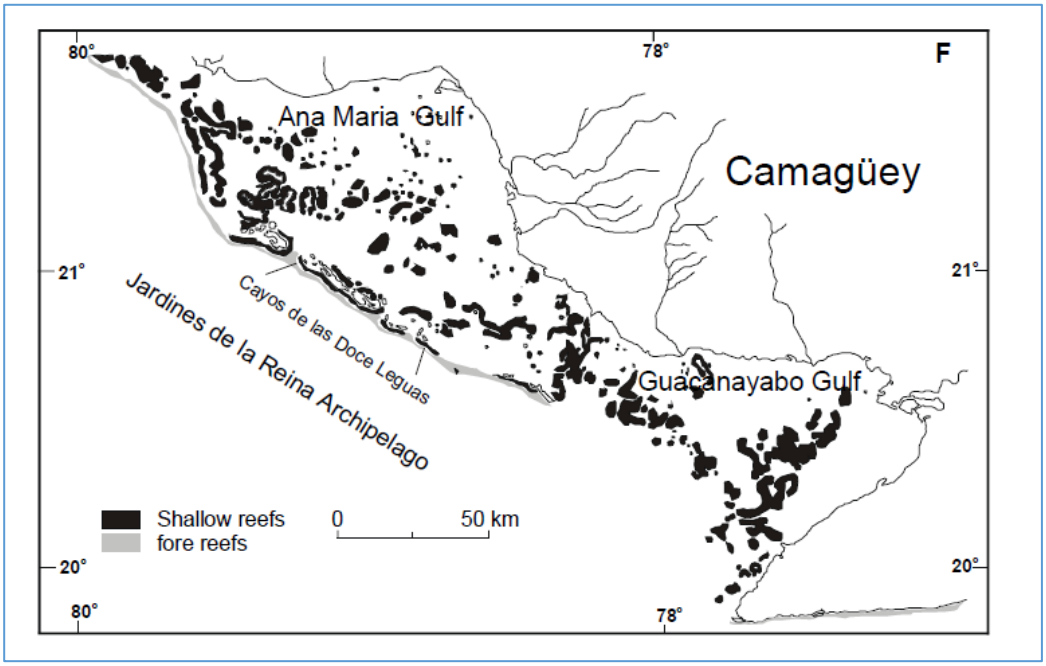


Figure 47-- Location of fore reefs (grey color) in the Cuban southeastern shelf.



141. Coral reefs grow along virtually the entire border of the Cuban shelf (>98%) and extend inshore across broad areas of the shelf. This shelf edge is 2,150km long on the north coast and 1,816km on the south. Inshore patch reefs are dispersed in the western Gulf of Guanahacabibes and Gulf of Batabanó, and the eastern Gulf of Ana María-Guacanayabo

142. A recent study published by ECLAC estimates that coral reefs in Cuba provide annual protective services valued at USD 401milllion in avoided damages and in reducing 76km^2 of flooded surface area, if specific storm surges are taken into account benefits can be calculated in the reduction of flooding in 1,398 km^2 and USD 5 billion in avoided damages. [59]

143. According to Beck, et al. (2018) an analysis in 71,000 km of coasts in 30 countries of the world, the reefs reduce the annual damages caused by storms in more than US$ 4 billion. Without reefs, annual damages would more than double (118%) and the flooding of the land would increase by 69% and affect 81% more people annually. The results of Beck et al. (2018) show that reefs provide more benefits to frequent storms of lesser intensity, but even during extreme events reef benefits for people and properties are substantial. For events of 25 years of return rates, the reefs reduce floods in more than 8,700 km^2 of land and 1.7 million people, and provide US$36 billion in avoided damages to capital investments built in the sites studied. For 100-year events, a 1 m loss in the reef crest and the resulting reduction in reef roughness provide a reduction in benefits due to flooding of US$ 130 billion.

144. These data coincide with the assessment of global coral reefs presented by Costanza et al. (2014) where the values are estimated at an average of 352,915 dollars per hectare per year, considering 94 different estimates.

145. Coral reefs have shown signs of bleaching and degradation that have been attributed to mangrove and sea grass degradation (including natural flows alteration, invasive species, water contamination, and habitat destruction among other, increased impacts of hurricanes).

146. After the line of protection provided by the “callerias” (series of islands, cays, islets and coral reefs), waves dissipate and the roughness of seagrasses prevents the surge.

147. Taking into account the baseline condition of coral reefs in Cuba and its role in coastal protection, investments need to be made in ensuring and further monitoring the conditions for the protection and general resilience of coral reefs to manage climate impact. This includes evaluating the conditions to ensure their health for providing protection to coastal landscapes and their ability to recover from the current impacts.

59 UN (2018), Efectos del cambio climatico en la costa de America Latina y el Caribe: Evaluacion de los sistemas de proteccion de los corales y manglares de Cuba, 15-16pp.

148. The most important examples of resilience factors include[60] ; (1) maintaining a system of healthy protected areas that guarantees a broad representation of the reefs and of the most important species for resilience, (2) ensuring that the sites that show resistance conditions are represented in that system of protected areas, (3) guaranteeing the protection of the herbivory in the reef, in the Caribbean, particularly the conservation of the parrotfish or the surgeon fish, (4) maintaining conditions that favor the calceiform algae over the fleshy algae, (5) protecting relevant biological processes that contribute to reef resilience, such as protecting sites of reproductive aggregations among others; and (6) ensuring improved monitoring and management that guarantees the protection of protected processes and resources in the system.

149. Investments in the monitoring the health of coral reef to provide protection services and through the protection and rehabilitation of coastal marshes and mangroves will have positive effects on three key factors that will help improve the resiliency of coral reefs and submerged systems as part of a larger coastal landscape. These factors include (1) hydraulic flow rehabilitation in coastal wetland, (2) reduction of sedimentation, and (3) nutrient supply in all coastal wetland ecosystems. The monitoring of reefs and seagrass beds will allow measurement of the positive effects of these interventions and will generate a larger body knowledge that can be applied in measuring the overall coastal resilience of specific coastal stretches.

2.2 Functional Relationships Along the Coastal Ecosystem (Coastal Ecosystem Landscapes) and their Services

150. There are numerous functional relationships of the ecosystems that form the Coastal Wetlands. These relationships include binding sediment and nutrient absorption, which combined with water retention, develops an environment of stability that is basic to coastal ecosystems such as the swamp grassland, swamp forest, and the mangroves. These relationships also create favorable conditions for seagrass beds and coral reefs. They also create conditions that favor coastal freshwater infiltration and facilitate the exchange of organic matter at all levels among the coastal and marine ecosystems.

151. Functional relationships are varied and complex, and they serve as enabling conditions between ecosystems. Coastal wetlands produce a series of goods and services from which coastal communities and economic sectors directly benefit, even those outside the wetland. Among the most outstanding ecosystem services of coastal wetlands we can include: (1) Binder sediments, (2) Absorbent of nutrients (3) Deceleration of fresh water discharge (4) Exporting biomass through invertebrates and fish larvae (5) Contributing to infiltration (6) Habitat of fish and invertebrates (7) Dispelling coastal winds (8) Nursery Habitat (9) Biodiversity Habitat, among other aesthetic and / or cultural services.

152. All of these functions are strongly interrelated (Figures 50 and 52). In addition to the exchanges of matter and energy, the ecosystems that are part of the coastal wetland have natural mechanisms to modify their environment, dissipating the natural costs of energy and reducing the physical impacts of wind or waves. This way each of the coastal ecosystems contributes to others in a way that has allowed them to coexist and evolve effectively in a highly variable environment with various sources of stress, including eventual catastrophic events.

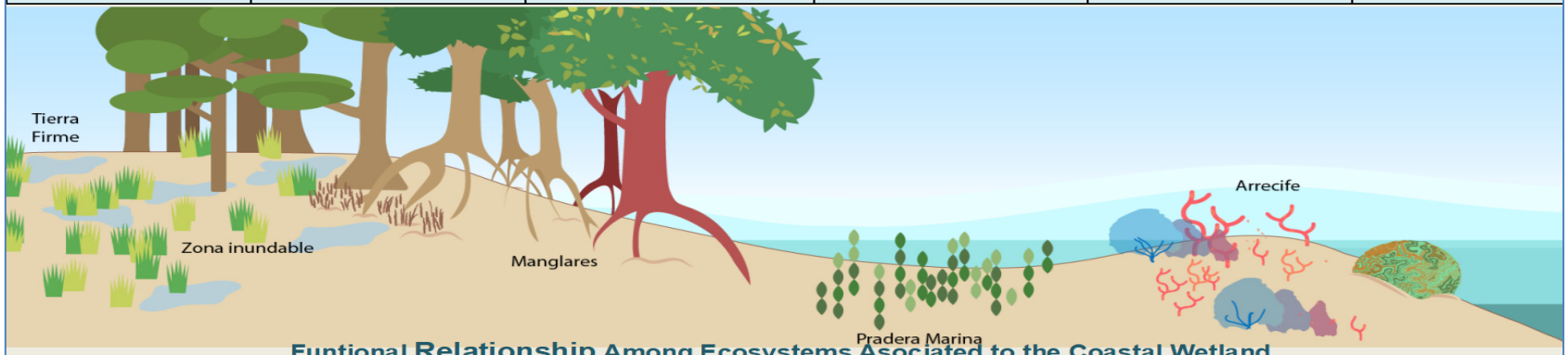
153. The functional relationships of the ecosystem components of the coastal wetland are strong interrelations that create a delicate balance that gives resilience to the impacts exacerbated by CC (Figure 50, 51 and 52).

60 TNC 2013, A Trainers Guide to Reef Resilience and Climate Change Training Workshop, 159 pp.

Figure 48-- Functional relationships of the coastal ecosystems of the Caribbean and the ecosystem services they produce.

Enviromental Services

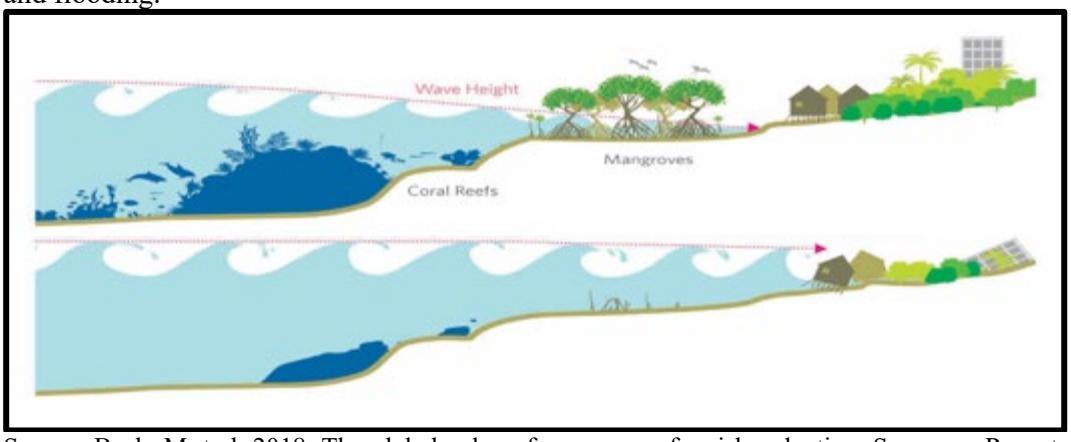
Swamp grassland	Swamp Forest	Mangroves	Sea Grassess	Coral Reef	Sandy Beaches
Fresh Water Recharge Freshwater retention Sediment retention Biodiversity Habitat Carbon sequestration	Strom Buffering Fresh Water Recharge Freshwater retention Digestion of organic material Sediment retention Biodiversity Habitat Carbon sequestration	Strom Buffering Fresh Water Recharge Freshwater retention Digestion of organic material Sediment retention Erosion Mitigation Biodiversity Habitat Carbon sequestration	Strom Buffering Digestion of organic material Sediment retention Biodiversity Habitat Carbon sequestration	Strom Buffering Digestion of organic material Sediment retention Biodiversity Habitat Carbon sequestration	Strom Buffering Biodiversity Habitat



Funtional Relationship Among Ecosystems Asociated to the Coastal Wetland

Swamp grassland	Swamp Forest	Mangroves	Sea Grassess	Coral Reef	Sandy Beaches
Binding Sediments Absrob nutrientes Slow Freshwater discharge Expbrt Invertebrates and fis larvae Contributes to infiltration Nursery Habitat (Birds) Biodiversity Habitat	Binding Sediments Absrob nutrientes Slow Freshwater discharge Export Invertebrates and fis larvae Contributes to infiltration Fish and Invertebrate habitad Coastal wind dissipater Biodiversity Habitat	Binding Sediments Absrob nutrientes Slow Freshwater discharge Export Invertebrates and fish larvae Contributes to infiltration Fish and Invertebrate habitad Coastal wind dissipater Nursery Habitat Biomass Export (fisheries) Biodiversity Habitat	Binding Sediments Absrob nutrientes Slow coastal currents Export Invertebrates and fish larvae Waves dissipater Fish and Invertebrate habitad Nursery Habitat Biomass Export (fisheries) Biodiversity Habitat	Strom Buffering (wave and currents) Binding Sediments Absrob nutrientes Slow coastal currents Export Invertebrates and fish larvae Waves dissipater Fish and Invertebrate habitad Nursery Habitat Biomass Export (fisheries) Biodiversity Habitat	Slow Coastal winds Absrob nutrientes Locally Slow coastal currents Waves dissipater Nursery Habitat (birds and invertebrates) Biodiversity Habitat

Figure 49-- Mangroves and Coral Reef prevent erosion and reduce the force of waves, storm surge and flooding.



Source; Beck, M. t al. 2018. The global value of mangroves for risk reduction. Summary Report. The Nature Conservancy, Berlin.

154. Further, as stated above, coastal wetlands are valuable to general hydrological processes by acting as "water traps" where accumulation in times of availability and abundance allows the freshwater recharge to be maintained in the water tables, fighting slowly but persistently the saline intrusion (Bergkman et al. 1998) [61].

155. There are many estimates of the value of wetlands, from total values or partial valuations of some of their ecological goods and services, as shown in Table 5. Taking into account the variation in the value of mangroves based on market values, the result presented by Constanza et al. seems to be very conservative. Applying this estimate from Constanza et al.to the project area, this would be equivalent to an additional sustained sum of US$ 886,248,000/ year.

Table 5 - Estimation of mangroves ecosystems services value around the world.

Source	Region	Ecosystem services included	Value, USD/ha/yr.
Constanza *et al.*	Worldwide	All services	9,900
Sathirathai and Barbier	Thailand	All services	27,264-35,921
Ronnback	Worldwide	All fisheries	750-11,280
Aburto-Oropeza *et al.*	Mexico	Fish and blue crab fisheries	37,500

2.3 Ecosystem degradation and its Implications

156. A combination of impacts arising from hurricanes and storms as well as by human impacts (constructions, pollution) have resulted in the decrease of the hydrological flows required by the system. These include a decrease of water accumulation accompanied by an increased accumulation of sediments and nutrients that as a whole have resulted in the degradation of mangroves habitat, seagrass beds and corals, as well as a deterioration of wetland grasslands and forest swamps.

157. In general, coastal erosion is the result of the loss of sediments due to natural factors (waves, currents, hurricanes, etc.), anthropogenic factors (extraction of sand and coastal marine resources for construction, mangrove felling, uncoordinated coastal works and construction of infrastructure very close to the coastline) and CC.

158. Furthermore, rivers have contributed a smaller amount of sediment to the coastal system as a result of the construction of physical infrastructure (for example dams). In addition, rigid structures

61 Bergkamp, G., Acreman, M., Safford, L. & Matiza, T. 1998. Maintining functioning freshwater ecosystems: The key to sustainable management of water resources. Documento preparado para la Comisión de las Naciones Unidas sobre el Desarrollo Sostenible, 19 páginas.

for coastal protection or other purpose have been designed without an integrated approach, causing erosion and destroying mangrove ecosystems. Erosion has also been aggravated by a relative increase in sea level due to climate change and tectonic movements.

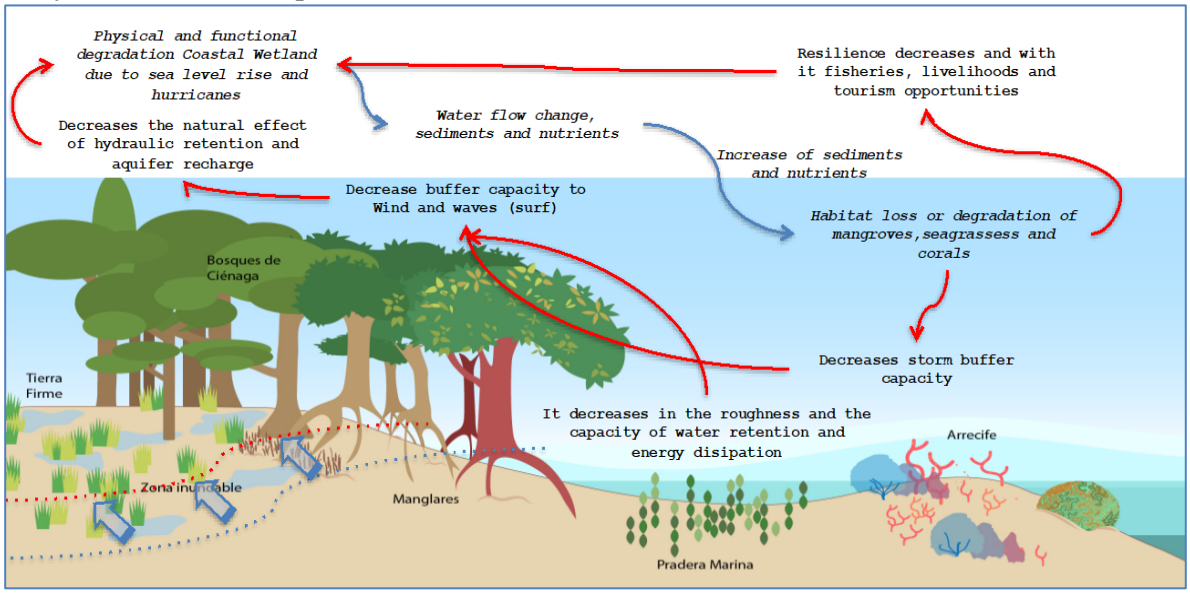
159. For example, studies carried out by the Fisheries Research Center (Suarez et al., 1979; Piñeiro et al., 2011) indicate that the water volume contributed by the main rivers from the south of Pinar del Río to the coastal zone was about 9.1 million m3/day; although this flow has decreased to 1.9 million m3/day, a reduction in almost 5 times. At present, it is estimated that the reduction in water volume has been up to 80% or more of the historical volume (INRH, 1982). As a result, coastal salinization occurred, penetrating inland and affecting the aquifer, soils and mangrove forests.

160. The combination of all contributing factors described above have led to a decrease in climate resilience of ecosystems, reducing their ability to cushion the physical effect of storms, the dissipation of currents and waves due to the physical presence and the roughness of the background. Additionally, forest ecosystems have reduced their structural development losing their capacity to prevent the impact of winds. And coastal wetlands have reduced their ability to serve as water reservoirs, causing stronger coastal flooding and decreasing the chances of stopping saline intrusion.

161. It is projected that CC will intensity the negative effects on the coasts, increasing average sea level further, and compounding existing coastal dynamics (i.e. coastal flooding). According to the trends, the intensification of CC effects will further increase the vulnerability of people and local communities in the coastal zone of Cuba. It is estimated that the proposed interventions with the project will provide direct benefits to at least 444,793 people and indirect benefits to 879,321 people in the regions selected as project intervention areas in the southern coast of Cuba.

162. As such, there is a pressing need to advance in risk reduction and to progress with adaptation strategies to reduce the impacts of CC described in the Figure 33 below, especially floods and the effects of saltwater intrusion in coastal areas. The impacts of coastal flooding, destruction by hurricanes and storms and saline intrusion are substantial and growing, due to population growth, disorderly coastal development and climate change. Unfortunately, these risks are often ignored in development options particularly at a local level. These need to include preventive measures based on the development or adaptation agreements or risk-based ecosystem. To achieve this, local and national governments need to enure that frameworks and coordination mechanisms take into account EBA, considering the the health of ecosystems as a both a measure of preventive action and indicator for coastal climate resilience.

Figure 50-- Conceptual model of the effects of climate change on the services provided by the ecosystems that make up the coastal wetland in Cuba.



2.4 The Nature and Implications of CC in Cuba's Coasts

163. The rise in the air temperature, decrease of rainfall, growing salinity of the oceans resulting from reductions in the flow of fresh water to the platform, and coastline retreat, will all negatively on Cuban Coasts.

164. Higher temperatures and reductions in rainfall will be accompanied by impacts derived from sea level rise, along with the higher intensity of storms[62] . High temperatures will be accompanied by increases in potential evapotranspiration and real evaporation leading to a progressive reduction in access to water, and net primary productivity of terrestrial and agricultural ecosystems in the coasts, as well as in potential biomass density.

165. Under a favorable projected CC scenario, potential water availability in 2100 could fall to 14.4 km3, 37% less than the baseline over the 1961-1990 period. The area with sub-humid/dry climate would extend gradually from the east to the west of the country, making the eastern mountain massifs susceptible to desertification.

166. Coastal populations, in this scenario, will be affected by the following implications of CC:

- Health consequences due to excessive heat
- Reduced access to water sources
- Loss of homes and infrastructure in coastal areas, and difficulty in transportation, due to loss of land area, resulting from a rise in sea level
- Losses due to climate-related disasters, as these are projected to increase. In the past years, the intensity of extreme meteorological events has increased, which, together with existing vulnerabilities, have increased the risks for natural disasters that negatively impact societies, economies and the environment.

167. The coasts in Cuba will be greatly affected by coastal flooding that will be intensified as a result of SLR and increased storm intensity as described in Section I, reducing the availability and quality of fresh water as well as causing damage to coastal infrastructure, the erosion of coastal zones, saline stress, mangrove death, sediments due to relative sinking of the coastline, and eotectonics movements of sinking of low areas[57].

168. Hurricanes and tropical storms can bring large quantities of precipitation that cause occasional or periodic floods. The residence times of floods and flood level depend largely on the Working conditions of the local hydrological network, levels of waterproofing of soils due to infrastructures or land uses. The presence of natural ecosystems that have the capacity to absorb and retain floodwaters, such as mangroves, grasslands swamps or swamp forests, can however be a key factor for the regulation of their expected impacts.

169. Coastal flooding associated with tropical cyclones, and sea flooding resulting from high waves and strong winds, have resulted in impacts on human settlements, coastal ecosystems and crops in low-lying areas. The effects of these phenomena typically affect most severely the areas located within the first 1,000m from the shoreline, with elevations of less than 1m above sea level (Iturralde y Serrano, 2015). The area most affected by these phenomena is the stretch of coastline between Estero of the Caimanes (in the south of Consolation of the Sur municipality, Pinar del Río province) and Punta Gorda on Zapata Peninsula, Matanzas[63].

170. Storm surges are caused by extreme weather events such as strong wind and low atmospheric pressure (Flather et al., 1998[64]), and large tsunamis, which can be generated by events such as, submarine earthquakes and landslides (Auffret et al., 1982). It is known that local bathymetry and topography (e.g. Cook and Merwade, 2009)[65,] sea-bottom roughness (e.g. Gelfenbaum et al., 2011[66]), and coastal vegetation coverage (Kaiser et al., 2011) can significantly affect the inundation extent and damage caused by flood events along a specific coastal area.

62 Iturralde-Vinent, M. A. & H. Serrano Méndez. 2015. Peligros y vulnerabilidades de la zona marino-costera de Cuba: estado actual y perspectivas ante el cambio climático hasta el 2100. Editorial Academia. La Habana, Cuba.

63 Moreno, A., R. Pérez, O. García, M. Portela, et al. (1998): Development of Techniques of Prediction of the Coastal floods, Prevention and Reduction of their Destructive Actions. Project Cuba/94/003, UNDP. Final Reports, Habana, Cuba, 172 pp.

64 Flather, Curtis H.; Knowles, Michael S.; Kendall, Iris A. 1998. Threatened and endangered species geography: characteristics of hot spots in the conterminous United States. BioScience. 48(5): 365-376

65 Cook A. And V. Merwade, 2009. Effect of Topographic Data, Geometric Configuration and Modeling Approach on Flood Inundation Mapping. Journal of Hydrology. 377(1):131-142

66 Gelfenbaum, Guy & Apotsos, Alex & Stevens, Andrew & Jaffe, Bruce. (2011). Effects of fringing reefs on tsunami inundation: American Samoa. Earth-Science Reviews. 107. 12-22.

171. Flooding due to wave activity, which depends on factors including wind speed and persistence, its spatial extent (fetch) and the geographical configuration of the coastline (orientation, depth, seafloor slope and platform size), is expected to increase. During the winter, the intensity of winds (northerly and southerly) increases, provoking coastal flooding. The area most affected by southerly winds is the southern coasts of western provinces.

172. Further, median sea level is projected to increase by 27cm by 2050, and 85cm by 2100 (131)[67]. Low lying areas such as the Southern Coastline of Cuba are expected to decrease significantly in area, with coastal retreat of up to 7km, and numerous cays with maximum altitude of less than 0.5m will disappear completely; there will be increased fluctuation in tidal ranges, in non-tidal variations in sea level, in the velocity of marine currents, in the depth of water on the insular shelf, and in water exchange between coastal waters and the wider ocean; and there will be changes in the spatial distribution of sediments along the coast[68].

173. An increase in the magnitude of extreme events and increasing SLR can only accelerate natural processes' related erosion, calculated at an average rate of 1.2 m/year. On the south coast of the provinces of Artemisa and Mayabeque the retreat has been at the rate of 3m/year, resulting in the loss of infrastructure and dunes over the last 50 years[69] as demonstrated through the technical report derived from the Macroproject Research.

174. This scenario, combined with a reduction in rainfall levels, will compound the potential deficit of fresh water and will increase the salinization of subterranean aquifers. These impacts will further increase the current levels of competition that exist between water availability and growing human demand.

175. The inadequacy of facilities for sewage treatment and disposal also creates additional threats under conditions of CC. Given the increased risks of CC-related coastal flooding overwhelming the treatment facilities and causing the untreated sewage to spread widely throughout settlements, leading to increased health problems, and through natural ecosystems, undermining their ability to generate ecosystem goods and services in support of local livelihoods, and to buffer the population against the impacts of CC.

2.4.1 Impacts of CC on coastal vegetation and biodiversity

176. If no action is taken, it is estimated that CC in 2100 will affect 1.98 million hectares of permanent wetlands, 507,500 hectares of forests and 11,900 hectares of scrub, a figure that could increase according Iturralde and Serrano (2015) affecting up to 2.6 million hectares of coastal ecosystems

177. CC will potentially exacerbate the risks posed by Invasive Alien Species (IAS), resulting in exotic species which are not currently invasive becoming so as climatic conditions favor their spread. Ecosystem disturbance as a result of CC-related extreme weather events and fires also risk providing opportunities for exotic species with pioneer characteristics gaining a foothold in otherwise intact ecosystems and preventing their return to their original state through natural regeneration. Although it has not been determined in terms of quantities, it is expected that these effects of CC on IAS will affect the stability of coastal native ecosystems and their resilience capacity.

178. Pressures related to CC affecting upper areas of the watersheds also determine ecosystem and livelihood resilience in coastal zones. Hurricanes and extreme rainfall events result in major peaks of erosion and run-off from mountain areas. This leads to negative impacts in the form of sedimentation of coral reefs; losses of forest cover particularly in upper catchments and are increasing the vulnerability of the areas to such events. Changes in temperature and rainfall regimes have direct impacts on the conservation status of natural ecosystems, modifying their ecology and geographical extent, and on specific species, with amphibians being particularly sensitive (Bergós L, 2014)[70]. Meanwhile drought events increase the vulnerability of natural ecosystems and forest plantations to fire; while the loss of soil organic matter due to poor soil and vegetation management is increasing the

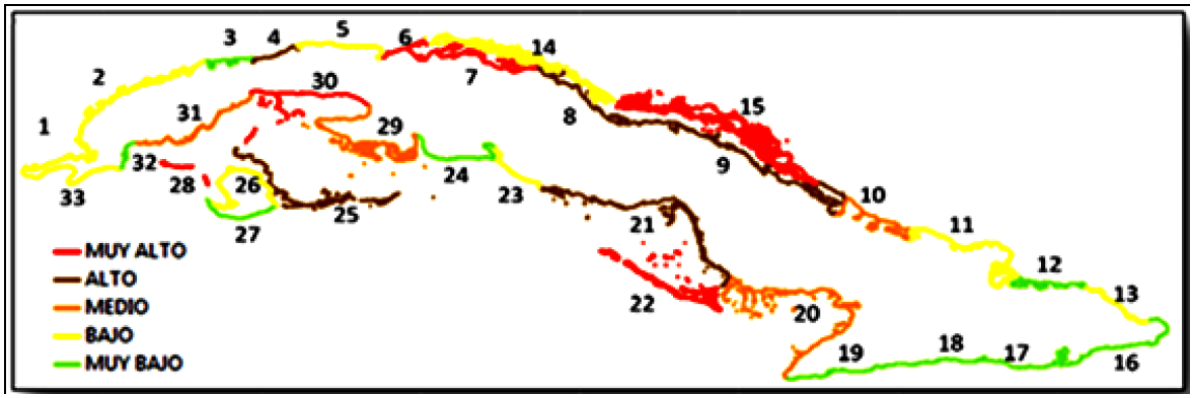
67 Salas I., R. Pérez, S. Samper, J. Dole, A.L. Pérez, C. Rodríguez, B. Pantaleón, L. Favier and R. Restivo (2006): "Impact of the Upwelling in the Cuban Archipelago, Considering the CC" Case Study of the Institute of Meteorology, Habana, Cuba, 252 pp.
68 Irurralde, M.A. and H.Serrano, 2015.
69 Informe Tecnico del Proyecto 2. Macroproyecto. Gobierno de Cuba.
70 Bergós, Lucía. (2014). Estrategias para la conservación de anfibios y reptiles vulnerables al cambio climático.

vulnerability of natural ecosystems and agricultural production systems to moisture stress during such events.

179. The marine areas of Cuba present varying degrees of vulnerability to the progressive sea level rise, depending on the state of health of ecosystems and the morphology of the section in question. This vulnerability is determined by the susceptibility of ecosystems and correlates with the degree to which the ecosystem has lost its ability to protect the coasts (due to its current state and level of impairment). The estimate of susceptibility is established by the combination of geological-geomorphological and level of degradation of the ecosystems factors. Taking into account the analysis carried out by Iturralde-Serrano (2016) the marine areas in Cuba can be subdivided into three categories (high, medium and low susceptibility) to the threats arising from the progressive sea level rise and associated threats. In the sections with high susceptibility the ecosystems must be protected to increase its resilience.

180. Figure 53 (below) shows the most vulnerable areas of the coast of Cuba by the effect of climate change, this can be seen very clearly that southern area and particularly the southwest is the most sensitive to the effects of climate change and is where are presented according to Iturralde and Serrano (2015) higher levels of flooding and greater overall impact of coastal ecosystems, as well as some of the most degraded mangroves in Cuba (Menendez and Guzman, 2002).

Figure 51-- Qualitative rating of effects of SLR on coastal ecosystems and settlements, for the scenario of 85cm by 2100.



2.4.2 Economic Impact of CC to Cuba's Coasts

181. In terms of impact hurricanes and tropical storms and ensuing floods have very important physical effects on housing infrastructure, on productive infrastructure such as agriculture, livestock and aquaculture among others. It requires unscheduled investments for recovery, which affects productivity of the country as seen in Table 4.

182. According to data from the National Office of Statistics and Information (ONEI), the hurricanes that affected Cuba have had great economic impact. It is also recognized that these losses could be much higher due to the ability of Cubans to prevent disasters that has minimized human losses during these extreme weather events. In relation to economic costs, it is estimated that Hurricane Matthew, which crossed the eastern end of Cuba in October 2016, caused damages amounting to 97.2 million dollars, a figure that makes it the third most devastating hurricane to strike the island in the last decade, just behind Ike (2008) and Sandy (2012), with equivalent costs of 293 and 278 million dollars respectively.

Table 6- Economic Impact of the hurricanes between 2005 and 2016 in Cuba.

Years / Hurricanes/ Category in Saffir Simpson Scale	Expenses in preventive measures	Replacement cost of housing	Facilities	Farming	Goods and services not received	Other costs	Total	GNP	Total cost as % of GDP
2005								**42643.8**	
Dennis (July)- Cat 4	18,7	1026,1	201,0	603,4	265,3	10,3	**2,124.8**		4.98
Rita (September)- Cat 5	25,0	3,1	8,9	117,7	52,3	-	**207,0**		0.49
Wilma (October) Cat 5	73,5	45,6	3,3	172,3	340,4	69,1	**704,2**		1.65

2006								**52,742.8**	
Ernesto (September)- Cat 2	15,2	24,6	-	-	40,0	15,3	**95,1**		0.18
2007								**58,603.9**	
Tropical Storm Noel (October)	12,8	364,4	168,5	559,5	32,6	17,6	**1155,4**		1.97
2008								**60,806.3**	
Tropical Storm Fay (August)	1,6	16,8	4,9	7,1	4,0	3,4	**37,8**		0.06
Gustav (September)- Cat 5	30,9	1121,5	59,6	868,4	9,8	6,5	**2,096.7**		3.45
Ike (September)- Cat 4	95,9	3764,7	304,8	2540,2	501,9	117,8	**7,325.3**		12.05
Paloma (November)- Cat 4	9,3	80,8	**3,6**	190,1	9,7	6.00	**299,5**		0.49
2012								**73,141**	
Sandy (November)- Cat 3	70,6	3546,6	295,8	2,469.00	398,0	186,9	**6,966,9**		9.30
2016								**91,370**	
Matthew (October)- Cat 6	24,1	388,5	70,1	519,5	81,9	1346,7	**2,430,8**		2.66

183. The floods generated due to hurricanes cause one of the greatest impacts of extreme weather events in Cuba. Collected data in Cuba from MacroProject estimated the impacts of floods in the selected project intervention stretches. It is estimated that the extent of land inundated by hurricanes could reach 192,990 ha; 310,950 ha; 440,540 ha for hurricanes categories 1, 3 and 5 respectively. These flooded extensions for Category 5 hurricane could affect at least 100 villages on stage by 2050 (Table 5).

Table 7 - Flooded Areas and communities affected by hurricanes in the stretches of proposed intervention.

STRETCHES	FLOOD FOR HURRICANES (ha)			Settlements affected By cat.5 hurricane
	CATEG. 1	CATEG. 3	CATEG. 5	TOTAL 2050
Stretch 1	62290	110890	155280	49
Stretch 2	130700	200060	285260	51
Total	192990	310950	440540	100

Source; MacroProject

184. By the year 2100, it is estimated that a total of 112,491ha of agricultural land will have been permanently or temporarily affected by saline intrusion and SLR; if combined with a Category V hurricane, this area would increase to an estimated 1,658,665 ha, or 25.5% of the agricultural land in the country. The crops most likely to be affected would be pasture, sugar cane and rice.

185. According to the CITMA report on adaptation to CC (2012), a category V hurricane would directly affect at least 194,000 inhabitants due to coastal flooding, while the total flood-prone area could reach 210.4 km^2 (not simultaneously). The time of these floods will vary between hours or days, depending on the local physical factors, the coincidence with high tides and the drainage of each locality. The largest numbers of affected settlements are rural, with partial and total effects in similar proportions; and the 23 urban centers on the coast of Cuba can be totally affected (CITMA, 2012). The area built in human settlements that would be temporarily affected in the country could occupy 297.0 km^2 (excluding the capital.

186. In general terms, the provinces of Artemisa, Mayabeque, Pinar del Río and Matanzas are those that register the greatest number of affected settlements, due to the effects of CC and saline intrusion. This takes into account valuation of damages to infrastructure and damages related to agricultural activities (productive losses). On the other hand, other temporary and partial effects are concentrated

in the provinces of Holguín, Granma, Santiago de Cuba and, to a lesser extent, in Guantánamo (Iturralde and Serrano, 2015).

Table 8 - Coastal settlements and estimated population that will be affected by CC scenarios including extreme weather.

Date	Population actual tendencies			Population (optimistic scenario)		
	Totally affected settlements	Partially affected settlements	Total	Totally affected settlements	Partially affected settlements	Total
2050	6,306	21,509	27,815	6,370	21,858	28,228
2100	2,088	354,652	356,740	2,221	418,888	421,109
TOTAL	8,394	376,061	384,455	8,591	440,746	449,337

Source; MacroProject 2010

Table 9- Expected impact of 122 settlements in the two SLR scenarios reported by CITMA 2012.

Indicators	Totally affected		Partially affected	
	0.27 m Scenario	0.85 m Scenario	0.27 m Scenario	0.85 m Scenario
Area KM^2	3.48	0.63	11.73	17.26
Population (person)	6,655	1,956	10,576	34,115
Homes (unit)	4,176	966	4,595	11,900
Infrastructure (unit)	40	19	108	149
Technical networks (Km)	2,732.71	25.25	234.69	446.38

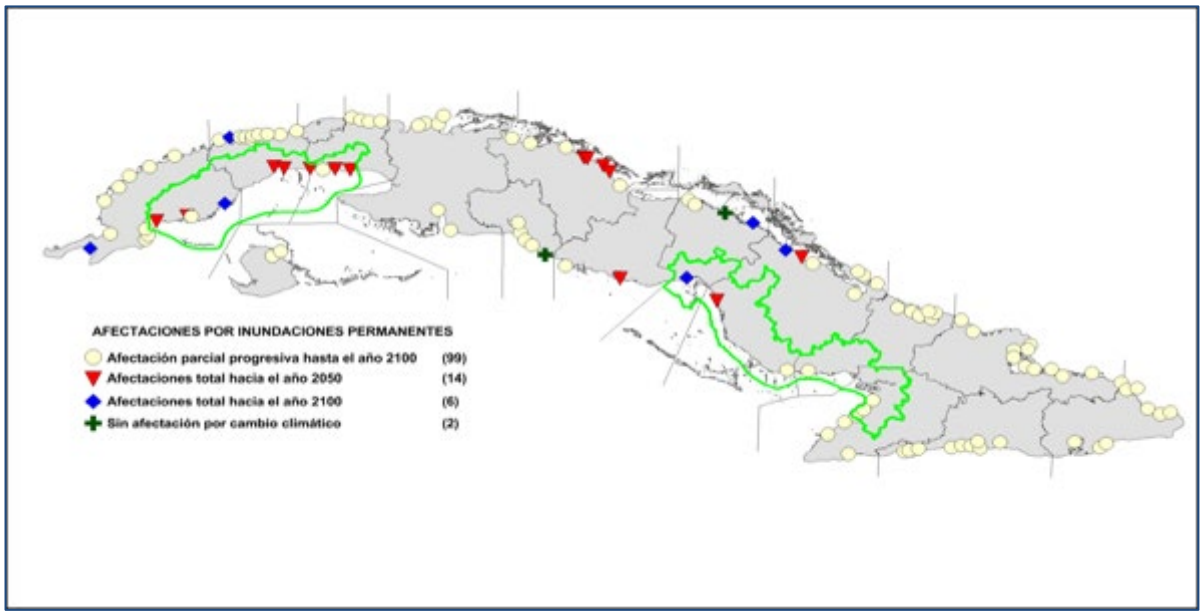
Source; MacroProject 2010

III. Prioritized target areas for project intervention

187. As demonstrated above, in Cuba coastal ecosystems are particularly vulnerable to climate impacts, however particularly vulnerable are coastlines in lower areas of Southern Coast, these being located in an area highly vulnerable to extreme weather and due to its topography and general geography amost vulnerable to climate impacts (coastal flooding, saline intrusion, erosion).

188. Figure 54 (below) shows the most vulnerable areas of the coast of Cuba to the effect of CC. According to Iturralde and Serrano (2015) this is also where the higher levels of flooding occur and greater overall impact of coastal ecosystems, as well as some of the most degraded mangroves in Cuba (Menendez and Guzman, 2002). This is precisely the region where the two stretches were selected for project interventions. Each of the Stretches is described in greater detail in the following sections of the document.

Figure 52-- Susceptibility coastal areas to threats to Climate Change (erosion, floods, salt intrusion).



189. Low, swampy and mangrove-lined shores in these areas are surrounded by an extensive, shallow submarine platform, bordered by numerous cays and coral reefs in the project stretches. These structures, as a whole, provide effective protection against the waves generated in deeper waters. However, there is evidence of deterioration of these ecosystems caused by the synergistic effects of local anthropogenic pressures (sedimentation due to erosion, organic pollution or nutrition, mechanical damage) and events associated with climate change (damage from more intense storms.[71]

190. On the basis of a prioritization, the project will focus specifically on two coastal stretches (see Figure 36):

- La Coloma to Surgidero de Batabanó (Southwest coast)
- Júcaro to Manzanillo (Southeast coast)

191. The sections selected for the proposed project include an extension of 1,300 linear kilometers of coastline, with an extension of 2,732,000 hectares, of which 62,95% corresponds to the land section and 37.05% to the marine area, from which it is clear that the marine platform in this region of the coasts of Cuba is very broad and generally quite shallow. In these areas are the most threatened mangroves in Cuba (Iturralde y Serrano, 2015; Menendez y Guzman, 2002[72]).

192. In these areas are the most threatened mangroves in Cuba (Iturralde y Serrano, 2015; Menendez y Guzman, 2002[73]) with an area of approximately 89,520 hectares, which represents 16.81% of the

[71] Iturralde and Serrano 2015 and Alcolado et al 2013

[72] Menéndez, L. JJ. Guzmán. Ed. 2002 Ecosistemas de manglar en el archipiélago Cubano, Editorial Académica de Cuba, proyecto UY/2002/SC/ECO/PI/2. 471 pp.

73 Menéndez, L. JJ. Guzmán. Ed. 2002 Ecosistemas de manglar en el archipiélago Cubano, Editorial Académica de Cuba, proyecto UY/2002/SC/ECO/PI/2. 471 pp.

country's mangroves, according to the extension reported by Menéndez y Priego (1994)[74]. The swamp grasslands and the swamp forests meanwhile are very important for the regulation of floods and water flow and represent 60,101 hectares and 28,146 hectares respectively, as can be seen in Table 8.

Figure 53-- Targetted Coastline Stretches

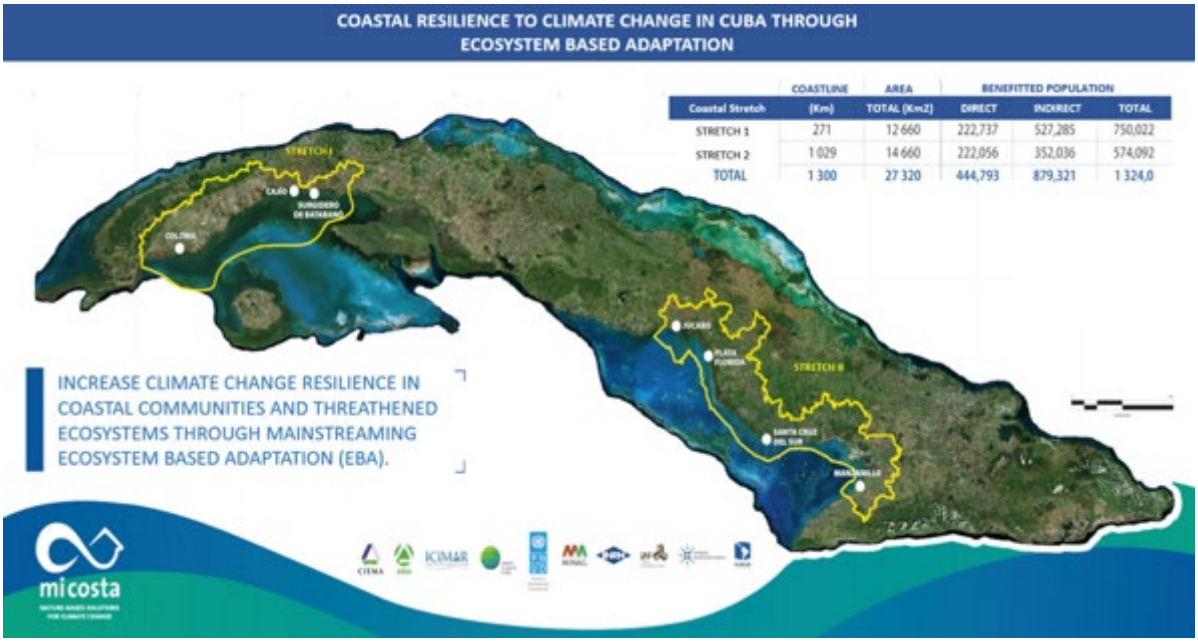


Table 8 - Summary of project stretches ecosystem characteristics.

Geografic Areas	Coastal Line (Km)	Area Km2	Land Area Km2	Marine Area Km2	Direct Beneficiaries	In-Direct Beneficiaries	Total Beneficiaries
Stretch 1	271.00	12,660	6,500.00	6,682.00	222,737.00	527,285.00	750,021.00
Stretch 2	1,029.00	14,660	11,007.00	3,623.00	222,056.00	352,036.00	574,092.00
Total	1,300.00	27 320.00	17,507.00	10,305.00	444,793.00	879,321.00	1,324,114.00

193. The Southern coast of Cuba is most vulnerable to the effects of CC-related sea level rise, combined with intense tides and storm surges (see Figure 54). This is due to the low elevation and largely flat topography of the extensive coastal plains that dominates the area, and the highly permeable karstic geology that underlies it, thus making it susceptible to CC-related saline intrusion (Iturralde and Serrano, 2015). Shallow wetlands, mangroves, coastal lagoons together with seagrass beds and coral reefs in the adjacent marine areas, dominate the Southern coast. All of these ecosystems play vital roles in livelihood support and resilience to CC.

194. The focus of the project's investments on ecosystem rehabilitation, both those of GCF and the government of Cuba, will serve precisely to increase capacity of the Cuban communities and authorities at all levels but especially at the national, provincial and municipal levels to incorporate EBA measures as an alternative tool to the costlier gray infrastructures, which are also difficult to maintain in the conditions of Cuba given the blockade and restrictions for the acquisition of equipment and materials. The EBA measures in the other hand, allow a greater involvement of the actors and are much more economical and equally effective.

195. Table 8 shows the project site stretches occupy an area of almost 27 thousand square kilometers, of which over 10,000 refer to the marine area. The selection of these coastal stretches in the Southern coast is also justified by the economic importance and size of human settlements in these areas. For

74 Menéndez, L. y A. Priego (1994): Los manglares de Cuba: Ecología. En: El ecosistema de manglar en América Latinay la cuenca del Caribe: su manejo y conservación. (D. O. Suman, ed.), Rosenstiel School of Marine and AtmosphericScience, Universidad de Miami, pp 64-75

example, the communities included in the project sites include the four main fishing and main agricultural zones in the country.

196. The number of direct beneficiaries of the project is estimated at over more than 444 thousand people and the indirect beneficiaries (over 879 thousand people who will receive benefits from EBA interventions and the ecosystem services they provide) are estimated at 1.3 million people.

3.1 Stretch I: From the Coloma to Surgidero de Batabanó, on the Southwest coast

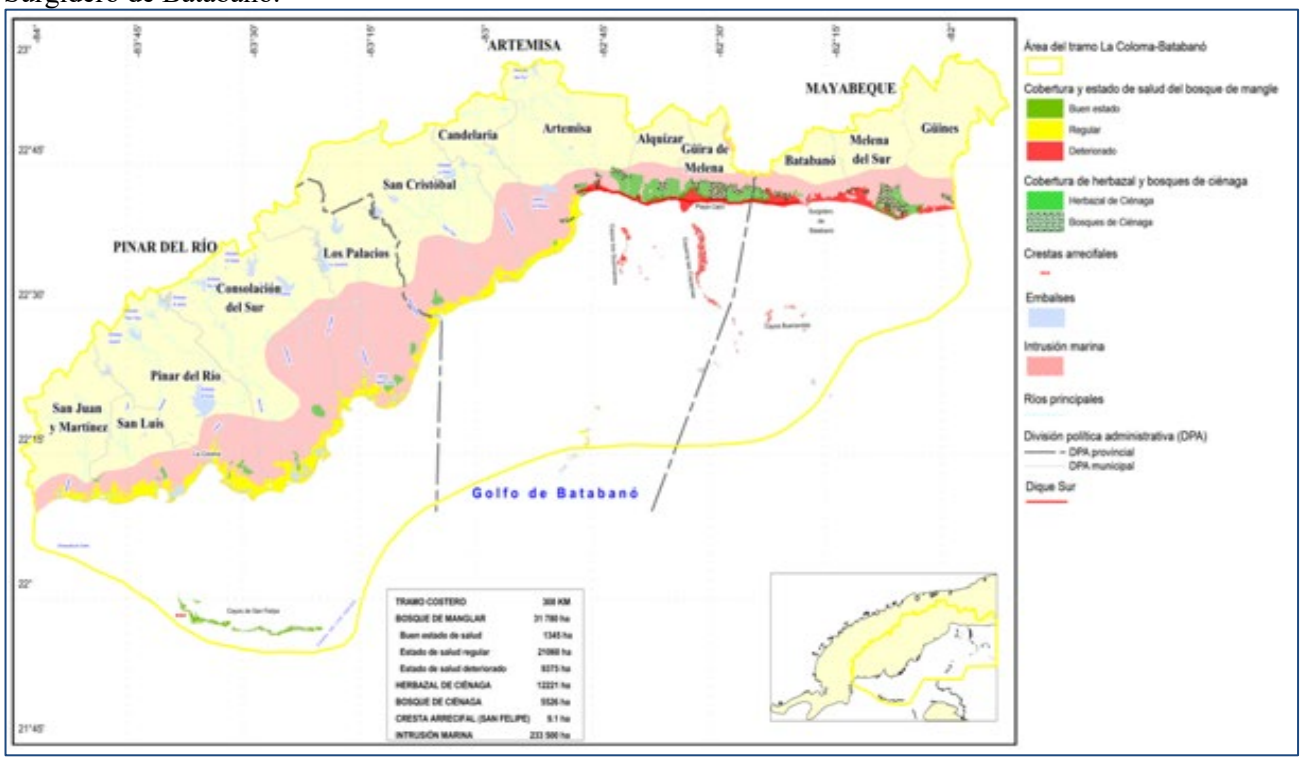
197. This stretch covers three provinces (Pinar del Río, Artemisa and Mayabeque) and 13 municipalities (San Juan y Martinez, San Luis, Pinar del Rio, Consolacion del Sur, Los Palacios, San Cristobal, Candelaria, Artemisa, Alquizar, Guira de Melena, Batabano, Melena del Sur and Guines).

198. The proposed locations for direct intervention (Coloma, Cajío, Batabanó), are found in low, easily flooded areas, susceptible to coastal flooding and where the sustained rise of sea level and coastal erosion will have medium- and long-term impacts in the lowest areas of these settlements. The strip of mangroves and swamp forests, which should represent an important barrier against winds, waves and coastal erosion, has been impacted by the increase in salinity and waves in coastal areas. These processes are exacerbated by impacts of past logging, changes in land use, pollution, as well as by the use of gray and inappropriate measures of coastal protection in the past, urbanization, and the reduction of flood flows, water and sediments.

199. This stretch encompasses 271 kilometers of coastline and 1,266,000 hectares hectares of which 650,000 ha are terrestrial and 668,200 ha are marine. The main features of this area are: low-lying, often swampy, coastal areas, in which the predominant type of vegetation is mangrove, associated with coastal lagoons, interior beaches, seagrass beds and coral reefs (see table 8 above), with a broad insular platform bounded by a line of cays and small islands. It also includes the westernmost part of the Zapata Swamp (Ciénaga of Zapata), which is the most extensive and important wetland in Cuba and the Caribbean and has under-exploited subterranean water reserves.

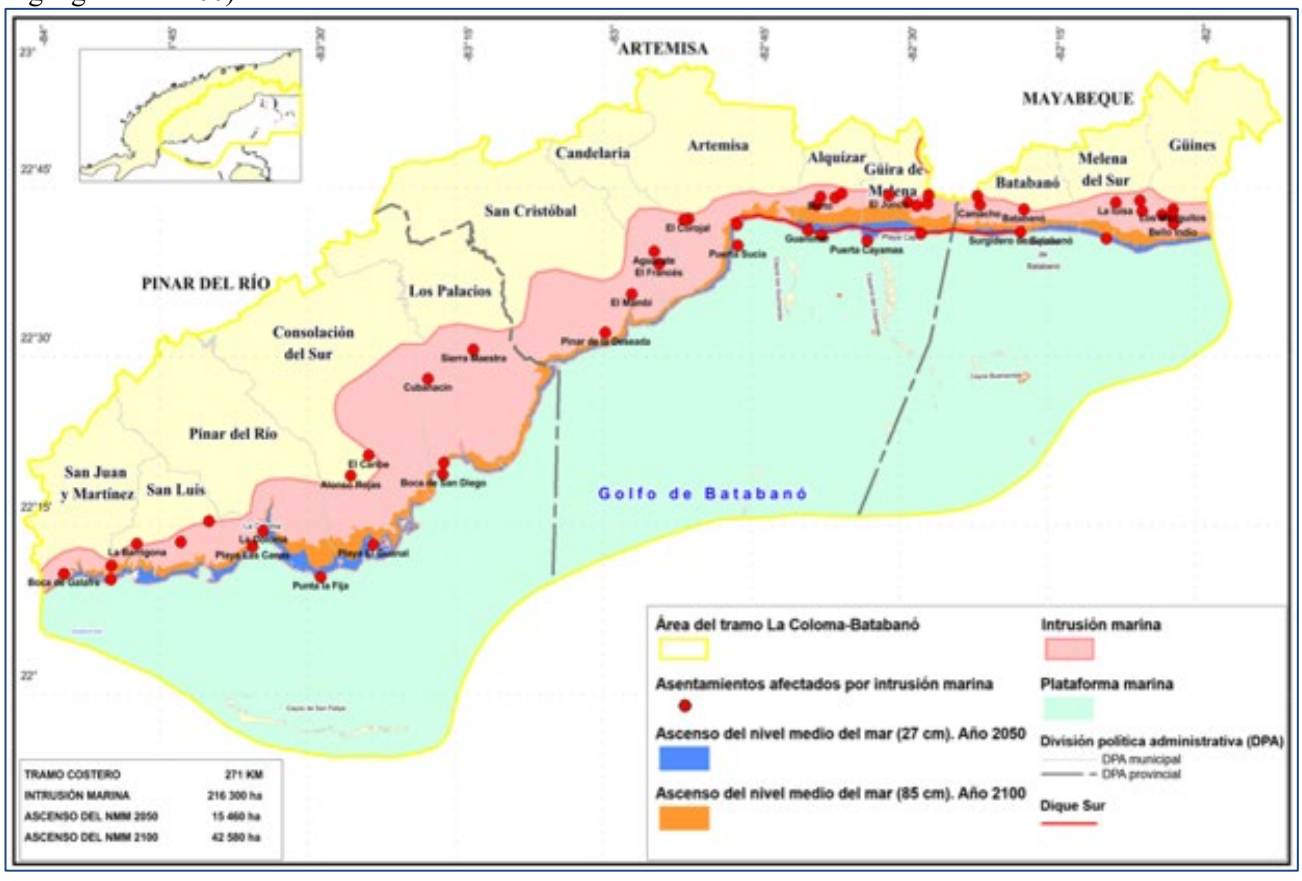
200. The land area of 650,000 hectares has characteristic ecosystems that surround the communities. This includes 31,780 hectares of mangroves, 12,221 hectares of swamp grasslands and 31,780 hectares of swamp forests. The marine zone is dominated by a system of keys that includes islands and islets that protect the interior coasts (at least to the east of the area). In this stretch there are 13,813 hectares of seagrass beds, mostly in the Batabano gulf. The conservation status of mangroves, swamp grasslands and swamp forest ecosystems in Stretch 1 is presented in Figure 56.

Figure 54-- Conservation status of ecosystems and vulnerable areas of Stretch 1: La Coloma to Surgidero de Batabanó.



201. In this area the project will benefit direct 222,737 and 527,285 indirect beneficiaries for a total of 750,021 beneficiaries (see table 8 above).

Figure 55-- Main vulnerabilities in Stretch 1. La Coloma to Surgidero de Batabanó (Pink area represents marine intrusion, red dots settlements affected by marine intrsusion, blue mean SLR 2050, organge SLR 2100).



202. The main settlements in which the project will intervene in stretch 1 include (1) La Coloma in Pinar del Rio Province; (2) Beach Cajío in Artemisa province; (3) Surgidero Batabanó in Mayabeque Province. The main vulnerabilities registered for these areas include, but are not limited to: (a) Flooding due to sea penetration, (b) Flooding due to rains and storms, (c) Effect of wind and floods due to hurricanes, (d) Ground water saline intrusion, (e) Effect of Invasive Alien Species (IAS) that displace local species in natural ecosystems. Figure 30 above shows the main vulnerabilities in Stretch 1. The pink shaded area corresponds to where saline intrusion has already intruded freshwater aquifers. Orange shaded areas will be flooded by 2100 and blue by 2050 due to SLR.

203. This stretch in particular is a rare example of the use of gray infrastructure to combat the impacts of CC that has had effects on the degradation of ecosystems. In the 80's the issue of salt intrusion led to the construction of the Southern Dike. An infrastructure of approximately 57 km long aiming to accumulate runoff fresh water to halt the infiltration of saline water in the interior of the southern aquifer. Its effect on allowing a longer residence time of waters and a greater percolation worked to contain at least temporarily the progress of the saline wedge, but the evidences of Iturralde and Serrano (2015) show that in the face of the progress of climate change its effectiveness is at risk.

204. On the other hand, disruption of runoff to the mangroves on the coast to the south of the dike resulted in a degradation of mangroves due to the increase in salinity of the combined effect of the absence of freshwater runoff and penetration of high tides combined with surges and increasingly intense and frequent storms and hurricanes. Due to damage to its structure and changing species composition, the mangrove has lost its ability to protect the coastline and is being eliminated by wave energy that it could previously withstand, which is rapidly eliminating the coastline up to 2 meters by year.

205. The rate of coastal erosion in this area, has been calculated at an average rate of 1.2 m/year in the Gulf. An increase in the magnitude of extreme events and increasing SLR can only accelerate natural processes' related erosion, Current coastal erosion rates are attributed to a combination of natural dynamics (waves, currents, extreme events, hurricanes, etc) and human interventions (natural resources extraction, wetlands filling, coastal infrastructure construction excluding natural dynamics, habitat loss, water diversion, etc).

206. The terrestrial portions of this target area will be affected by progressive sea level rise (figure 39). The total area of land that could be permanently covered by ocean waters in 2050, due to a rise of the average sea levels of up to 0.27m, could be 15,460 hectares. It is predicted that by 2100 a total of 42,580 hectares within the area will have been flooded and 5 communities will have disappeared altogether, if the necessary adaptation measures are not properly implemented.

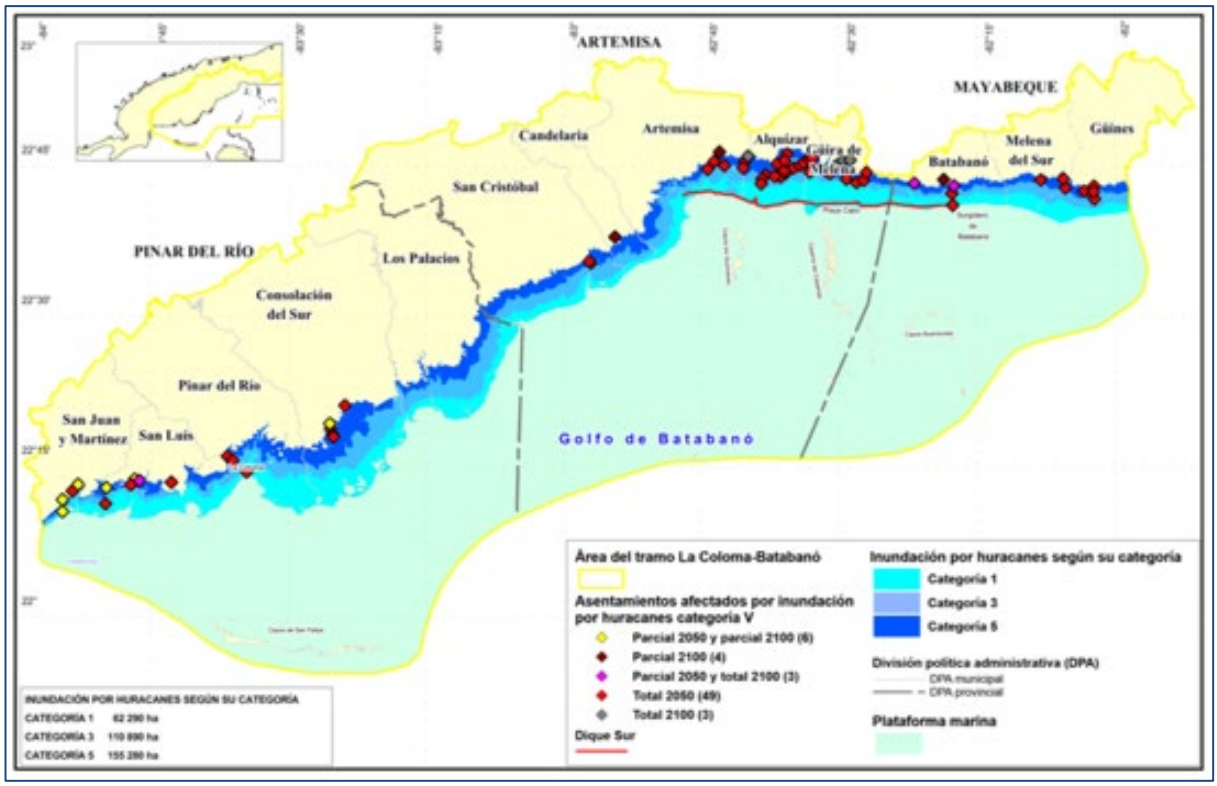
207. Figure 39 below, shows the flood estimates produced by the average rainfall for category 1, 3 and 5 hurricanes that would flood areas of 62,290 hectares, 110,890 hectares and 155,280 hectares, respectively. It has been estimated that category 5 Hurricane floods could have impacts on at least 49 human settlements established in stretch 1 by 2050 and three additional settlements by 2100.

208. The marine part of this area consists of the Gulf of Batabanó, which is associated with the southern plains of Havana and Matanzas. These are the main sources of food for the provinces of Havana (the national capital) as well as for provinces Artemisa, Mayabeque and Matanzas. Therefore, the aquifer in the southern basin is strategic for the supply of capital and growing areas of the provinces of Artemisa and Mayabeque. This region is also important as one of the main fishing areas of the country.

209. In this stretch the strong penetration of saline intrusion covers about 233,500 hectares (see figure 37). Besides SLR and other CC impacts, this is impacted by water used for irrigation and human consumption.

210. The population of this stretch has strong links to the marine environment, being heavily dependent on fishing, basic services and national tourism, with many also involved in agriculture and livestock to compensate lack of job opportunities. Employment opportunities have further been affected by the degradation of productive infrastructure by climatic factors.

Figure 56-- Human settlements in Stretch 1 and flooding areas due to hurricanes categories 1 light blue, 3 blue and 5 dark blue. Dots settlements affected marine intrsusion and hurricanes



211. Throughout the entire coastal area live around 150, 000 people in a vast plain bordered on the north by two mountain ranges. Although this entire region constitutes a unit from a geomorphological point of view, it can be divided into two sub regions: 1) a western sub region, which extends from Cortés to Artemisa (Southern Coastal Plain) and 2) an eastern sub region that extends from Artemisa to the Ciénaga de Zapata (Red Plain of Havana-Matanzas).

3.2 Stretch II: From Júcaro to Manzanillo, on the southeastern coast

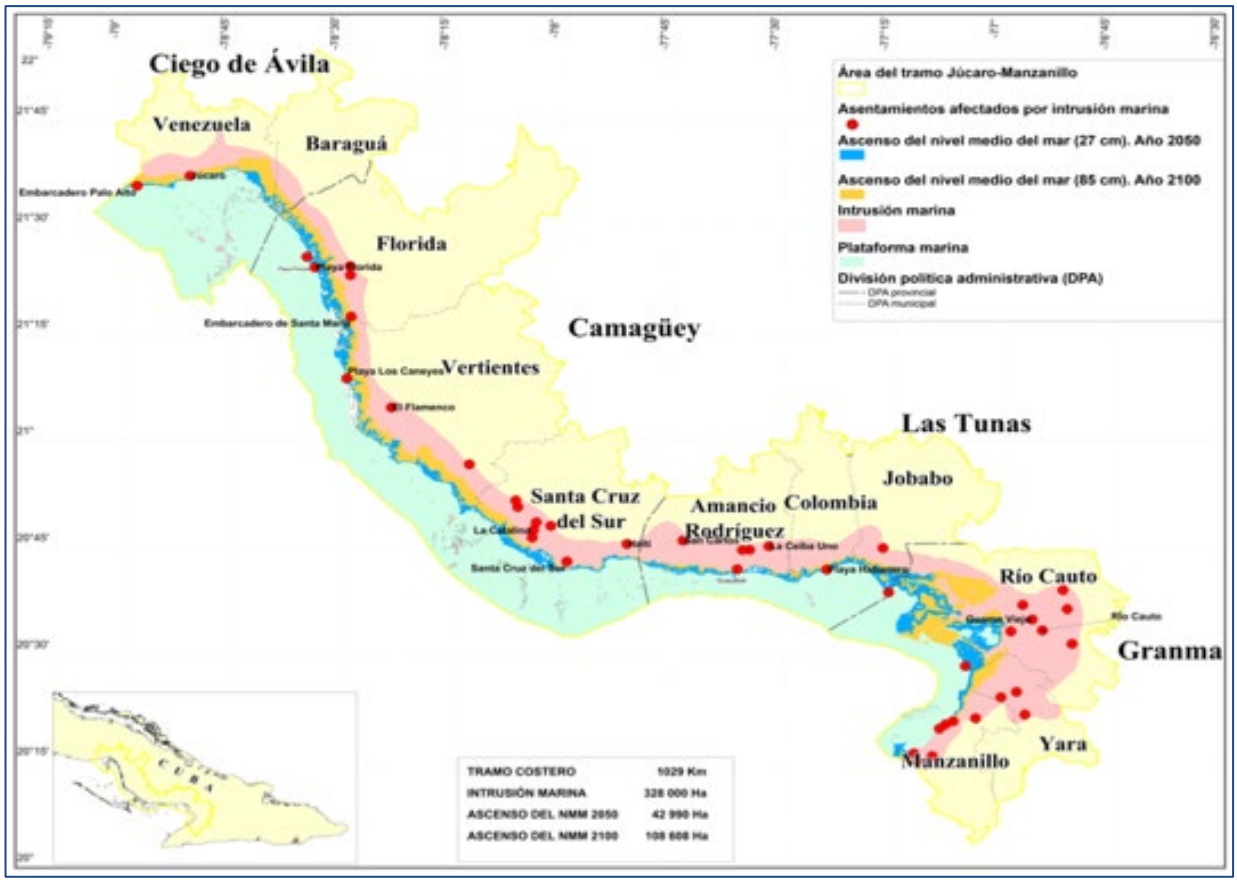
212. This stretch covers four provinces (Ciego of Ávila, Camagüey, Las Tunas and Granma) and 11 muncipalities (Venezuela, Baragua, Florida, Vertientes, Santa Cruz del Sur, Amancio Rodriguez, Colombia, Jobabo, Rio Cauto, Yara and Manzanillo).

213. This stretch encompasses 1029 km of coastline and covers 1,466,000 hectares. The marine part of this intervention area includes the Gulfs of Ana María and Guacanayabo, with a mean depth between 15 and 20m and area of 362,300 hectares. This stretch incorporates 222,056 direct beneficiaries and 352,036 indirect beneficiaries for a total of 574,092 beneficiaries. The stretch is characterized by extensive coastal wetlands dominated by mangroves, swamps grasslands and swamp forests.

214. The main localities for direct intervene in stretch 2 include (1) Júcaro in Ciego de Avila Province; (2) Santa Cruz del Sur and Florida beach in Camagüey Province; (3) Manzanillo in Gramma Province. The main vulnerabilities registered for these areas include, but are not limited to: (a) Flood by penetration of the sea, (b) Floods derived from rains and storms, (c) Effect of wind and floods due to hurricanes, (d) saline intrusion into groundwater, (e) Effect of Invasive Alien Species (IAS) that displace local species in natural ecosystems.

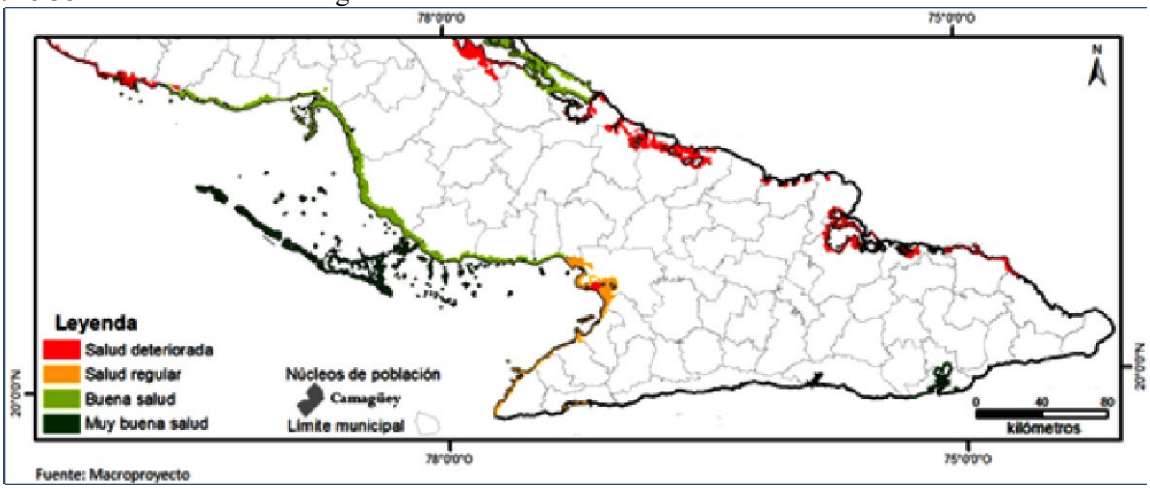
215. Figure 59 shows the main vulnerabilities of Stretch 2.

Figure 57- Main vulnerabilities in Stretch 2. Júcaro-Manzanillo. Pink area represents marine intrusion, red dots settlements affected by marine intrsusion, blue mean SLR 2050, organge SLR 2100, green is marine platform



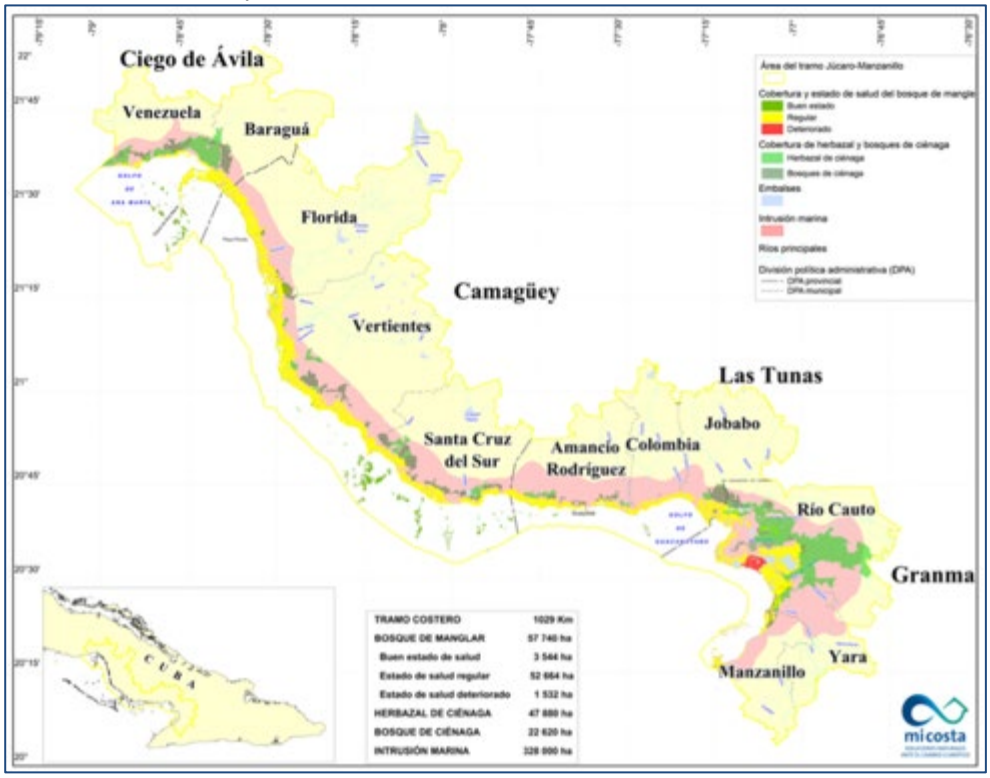
216. In stretch 2 there are 57,740 hectares of mangroves of which only 3,544 (6%) are in good condition, while 52,664 (91%) are in a fair state, and 1,532 (3%) are degraded. This mangroves data strongly concurs with the reports from Iturralde and Serrano (2015) (see figure 60).

Figure 58-- Health status of mangroves in Eastern Cuba.



217. In this stretch there is an extension of 47,880 hectares of swamp grasslands and 22,620 hectares of swamp forests. In this stretch the strong saline intrusion covering about 328.000 hectares (see Figure 61 below). The large number of water reservoirs for irrigation, water for human consumption in the area, which greatly limit the availability of ecological flow required, affects this. It is also observed, the strong association between mangroves, swamp grasslands and swamp forests.

Figure 59-- Situation of ecosystems and vulnerable areas of Stretch 2; Júcaro-Manzanillo.



218. The land area of 1,100,700 hectares has characteristic ecosystems that surround the communities that include 57,740 hectares of mangroves, 47,880 hectares of swamp grasslands and 22,620 hectares of swamp forests. The marine zone is dominated by a system of Keys that includes islands and islets that protect the interior coasts at least to the east of the area. In this stretch there are 1,631 kilometers of coral reefs and 255,500 hectares of seagrass beds mostly located in the Gulf of Ana Maria. It is predicted that the greatest impacts to the mangrove ecosystem, due to the increase of the mean sea level, will occur in the coastal section of the southern provinces of Ciego de Ávila, Las Tunas and Camagüey (Menéndez and Guzman. 200075).

219. The coral crests of the area's broad insular platform, which stretches for 46km, are mostly classified as very deteriorated (Grade 4) or extremely deteriorated (Grade 5) (Iturralde y Serrano, 2015).

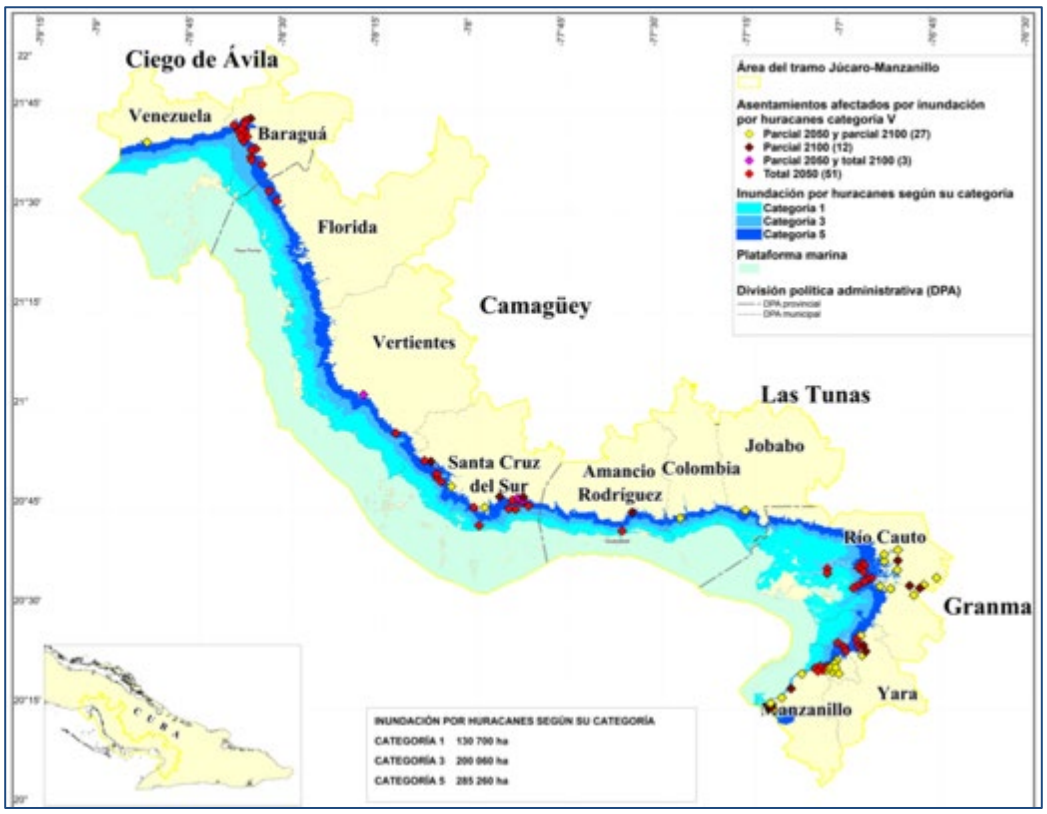
220. It is mainly in the prairie marshes where the pipeline has been drying wetlands to transform it into other uses such as agriculture or livestock. This reduces the water retention capacity, both swamp grasslands as swamp forests, as well as mangrove affects its role in reducing infiltration into the aquifer. In fieldwork, a very high incidence of invasive alien species, particularly trees and shrubs, was also observed in this stretch.

221. The target settlements in this area were selected based on the level of impact they have undergone and their risk of disappearance due to CC induced impacts. According to the first scenario of the Framework Project and "Tarea Vida" (see situation analysis), the city of Manzanillo is considered a priority due to its high vulnerability to the effects of CC, particularly sea level rise. Seawater penetration is predicted to reach an average of 0.15km inland, and up to 8.3km in some places. Relative sea level rise has accelerated over the last 5 years.

222. Figure 62 shows the flood estimates produced by the average rainfall for category 1, 3 and 5 hurricanes that approximately would produce floods of 130,700 hectares, 200,060 hectares and 285,260 hectares, respectively.

75 Menéndez L. and Guzman., 2000. Ecosistemas de manglar en el archipiélago cubano. Editorial Academia de Cuba. UY/2002/SC/ECO/PI/2 471 pp.

Figure 60- Human settlements in Stretch 2 and flooding areas due to hurricanes categories 1, 3 and 5.



223. This second stretch is one of the most important fishery zones of the country, accounting for around 39% of the total catch of the Cuban insular platform. It is also amongst the most important rice producers in the country. CC poses a threat to these sectors by virtue of the effects of rises in temperature and sea levels on the coral reefs that constitute vital fisheries habitat; temperature stresses on rice crops; and damage to infrastructure caused by storms. In addition, marine intrusion is becoming increasingly significant due to a combination of CC-related sea level rise and the overexploitation of aquifers, with the upper aquifer of the Cauto delta being affected by saline intrusion along its entire length.

224. Vulnerabilities described above (Figures 38 and 40 above) are exacerbated by construction practices in the edge of the coast. They are fully exposed infrastructure, located in flood zones between the coast and the coastal marsh, at ground level. They therefore have a very high vulnerability to wind and wave energy, as well as to floods. This situation is exacerbated by limited knowledge of local players and a false sense of security that was perceived during the design phase of the project through interviews and consultations with local team by FLACSO-Cuba and ICIMAR.

IV. Institutional Analysis

225. Cuba has a unique economic, political and social system with specific characteristics that are relevant for the design and implementation of the proposed Project. This section will detail these through a discussion of the legal and policy frameworks accorded by the GoC in managing CC and its implementation through its various productive and economic ministries at a national and local level. The secion will also provide an analysis of the poltical and legal framework that exists in thr country as well key issues that the GoC must manage when implementing international development projects.

226. According to its Constitution, recently reformed in April 2019, Cuba is a Socialist State organized in the form of a Republic. The economic system is essentially based on the social ownership of the entire people over the fundamental means of production, although it also recognizes cooperative ownership; the property of small farmers; ownership of political, social and mass organizations; and personal property.

4.1 Legal Framework for Environmental Management and Climate Change

227. Cuba has a comprehensive legal framework that considers environmental and natural resources in key pieces of national legislation with particular relevance to key issues such as biodiversity, water and climate change.

228. The Constitution of the Republic states: "The State protects the environment and natural resources of the country, recognizes the close links with sustainable economic and social development to make human life more rational and ensure the survival, well-being and security of present and future generations. It is up to the competent bodies to implement this policy, and it is the duty of citizens to contribute to the protection of water, air, soil, flora, fauna and all the rich potential nature"

229. In 1997, Law 81 (the Environmental Law), which generally deals with environmental issues and the sustainable management and use of natural resources, was approved constituting the legal rule governing this matter for the country. It establishes that the Ministry of Science, Technology and Environment (CITMA) is the body of the Central State Administration responsible for proposing environmental policy and directing its execution.

230. Under the Environmental Law, three Decree-Laws were established, Decree-Law 190 of the Biological Security, Decree-Law 201 of the National System of Protected Areas and Decree-Law 200 of the Contraventions and administrative infractions on environmental matters; More recently, Decree-Law 212 on Environmental Management of the Coastal Zone was issued in August 2000. This policy instrument is of interest for the project as it specifically targets coastal planning, although it is not mandatory and therefore does not apply in all municipalities alike. However, it is expected that the results of this proposed project will provide very relevant information for the integral coastal planning.

231. The Ministry of Science, Technology and Environment (CITMA) has also been working on the regulatory provisions that complement this legal framework, such as the regulations on Environmental Impact Assessment, State Environmental Inspection, Toxic Chemicals and Hazardous Waste, among others (Table 9).

Table 9 - Regulatory Framework relevant to issues related to Climate Change.

Legal Instrument	hierarchical level
L/24 On terrestrial waters	Law
L/81 Environment Act	Law
L/85 Forestry Act	Law
L/76 Mine Act	Law
L/75 National Defense Act	Law
DL/337 Decree on terrestrial waters	Decree-Law
DL/164 Fisheries Decree	Decree-Law
DL/21, Decree on Physical Planning	Decree-Law
DL/170 Civil Defense System Measures Decree	Decree-Law
DL/201 National Protected Areas Decree	Decree-Law
DL/190 Biological Security Decree	Decree-Law

Legal Instrument	hierarchical level
DL/212 Coastal Zone Management Decree	Decree-Law
DL/136 Forestry and Wildlife transgression Decree	Decree-Law
DL/200 System for Environmental transgressions Decree	Decree-Law
D/179 Decree about Soil use and Conservation Protection	Decree
D/No. 1-2005 Directive for Planning and preparation for Disasters under natural disasters.	Directive
R/40 Environment National Strategy 2007-10	Ministerial Resolution

232. In addition to the legal framework, there are a number of important policy and regulatory documents in Cuba, including those related to CC. Among these are:

- National Biodiversity Program and National Action Plan (PNDB), 2016-2020 (CITMA, 2016), which prioritizes areas within the new strategic cycle for the potential value of biodiversity and ecosystem services due to the effects of CC. Consequently, several goals and actions of the PNDB are aimed at favoring the resilience of natural ecosystems to the effects of CC.
- Bases for the National Plan for Economic and Social Development 2030: Vision of the Nation, Axes and Strategic Sectors where the need to take into account the impacts of CC and adaptation measures are specified, with emphasis on the protection of natural resources and the use of renewable sources of energy.
- National Environmental Strategy 2016-2020, which defined the impacts of CC as one of the main problems in the country.

233. In terms of managing the impacts of CC, the GoC has acknowledged its oversize impact and has enshrined in it policies recognizing that CC constitutes an additional and significant challenge for sustainable development in the country and hence has prioritized CCA in state policies for the into the development planning and management at local, regional and national levels, in a way that it becomes a climate-resilient development.

234. In 2015, in order to address this challenge more effectively, the government of Cuba formalized the establishment of the National Climate Change Group. CITMA coordinates the National Climate Change Group which brings together national institutions from different sectors involved in this issue (energy and mines, land use, agriculture, foreign affairs, transport, fisheries, construction, water resources). This work also involves academic institutions and NGOs.

235. CITMA will use its different structures and mechanisms at national, provincial, local and community levels to coordinate with all stakeholders at all levels and with different sectors during the implementation of the project.

236. In its initial phases, the National Climate Chance Group proposed the following goals according to its official establishment:

- Identify the national measures required for adaptation and mitigation to CC and propose a program of actions to implement them.
- Evaluate the impact of international environmental policies related to CC and their possible implications at the national level, proposing options consistent with the main lines of economic and social development.
- Present proposals for the permanent updating and better implementation of the policy and the program to face the impact of CC.

237. In 2015 CITMA began coordinating a process of updating documents related to managing CC, with the following objectives:

- To base national actions on the most recent results of science and technological innovation.

- Prioritize national actions for CC management that involve investments or are directly related to investment processes.
- To assign a greater weight to sector policies.
- Identify sources of financing to fulfill national tasks for CC management.

238. As a result of the consultations and exchanges since 2015, eleven organisms of the Central State Administration identified a group of actions (organizational measures, studies and investments) to tackle CC impact until 2020. Based on this, the Economic and Financial Commission analyzed a proposal for new directives and a first estimate of the total budget to implement them on January 5th, 2016.

239. In parallel, and to ensure the necessary legal backing, CITMA prepared and submitted to the Secretariat of the Council of Ministers, during 2016, the blueprints for updating the legal rules relating to tackling CC, including a new Decree-Law with its Regulatory Decree and Decree Law Facing Climate Change. In addition, the foundation was presented to update or modify the Environment Law (No. 81/1997) to consistently address CC, among other issues. The result of this entire process was the adoption, in April 2017, of the State Plan for Tackling Climate Change, known as "Tarea Vida".

240. In May 2017, the Council of Ministers of the Republic of Cuba approved State Plan for facing Climate Change in the Republic of Cuba, known as “Tarea Vida”, in order to counteract the damage that could occur in Cuba due to CC in the next years. This Plan is based on research on CC initiated by the Academy of Sciences of Cuba in 1991, as well as on the analysis of vulnerability in coastal areas of Cuba against the expected impacts of climate change in 2030, 2050 and 2100 published by Iturralde and Serrano (2015).

241. In 2018, to better coordinate cooperation related to managing climate change, the GoC created the Inter-ministerial Coordination Committee (CCI) of the Green Climate Fund. The CCI is a coordination mechanism that was established through Agreement No. 8379 of the Council of Ministers, dated May 25, 2018, with the main function of ordering, attending and approving projects in the country that may qualify to be presented to GCF and other climate funds. It is chaired by the Central Bank of Cuba (BCC) and the Ministry of Science, Technology and Environment (CITMA) acts as Secretariat. It is composed of the Ministry of Economy and Planning (MEP), the Ministry of Foreign Trade and Foreign Investment (MINCEX), the Ministry of Finance and Prices (MFP), the Ministry of Energy and Mines (MINEM), the Ministry of Agriculture (MINAG), and the National Institute of Hydraulic Resources (INRH).

4.1.1 State Plan for facing Climate Change “Tarea Vida”

242. The national directive “Tarea Vida” was approved in 2017. This Plan takes into account the current and future impact of CC for the Cuban archipelago, as informed by the scientific and technological results arising from efforts like the Macro-project. As such, “Tarea Vida” puts into action the measures required to:

- Identify the zones, areas and locations where actions are most urgent, and direct efforts and resources to them. This includes the prioritization and recuperation of beaches and coasts, as well as proposing measure to address drought.
- Present an integrated plan containing a step by step approach to determine priorities and actions, location by location, and addresses the dangers and vulnerabilities associated with CC in the short, medium, long and very long terms, while looking to identify in the Economic and Financial Commission the financial resources that will be required for its execution.
- Ensure and implement the necessary judicial basis for the implementation of the Plan, giving CITMA the responsibility to report on results of its actions of supervision and control.
- Explain and raise awareness of CC and its consequences on the economy of the country and on coastal zones.
- Convert the scientific results obtained to date into actionable proposals to the Government.

243. A notable characteristic of “Tarea Vida” is its scope and hierarchical level, which raises the directive into a formal national plan that foresees a program of progressive location-specific investments, in the short (2020), medium (2030), long (2050) and very long (2100) terms. This document defines 5 strategic actions and 11 tasks that include mitigation and adaptation actions to be developed in the country as part of its policy of tackling CC. Table 10 briefly describes the “Tarea

Vida" tasks. The project being proposed was designed to directly or indirectly address almost all the elements of "Tarea Vida" as can be seen in the infographic below.

Table 10 - Strategic Actions and Tasks for tackling CC under "*Tarea Vida"*

Strategic action 1: Prohibit the construction of new dwellings in the most vulnerable and threatened coastal settlements that are predicted to disappear due to permanent flooding. Reduce the population density in low-lying coastal areas.
Strategic action 2: Develop constructive conceptions in infrastructure, adapted to coastal flooding for low-lying areas.
Strategic action 3: Adapt agro-livestock activities, particularly those with the greatest impact on the country's food security, to changes in land use as a consequence of sea level rise and drought.
Strategic action 4: Reduce the cultivation areas near the coasts or areas affected by saline intrusion. Diversify crops, improve soil conditions, introduce and develop varieties resistant to the new temperature scenario.
Strategic action 5: Plan urban reorganization processes of the threatened settlements and infrastructures within the specified terms, in accordance with the country's economic conditions of the country. Start with low cost measures, such as induced natural solutions (beach recovery, reforestation).
Task 1. To identify and undertake comprehensive and gradual actions and projects for adaptation to CC, needed to reduce the existing priority vulnerabilities. Actions and projects should consider how the threatened population might act, as well as their physical safety, their food security, and the development of tourism.
Task 2. To implement the legal norms necessary to endorse the implementation of the Plan of State; secure its strict fulfillment with special attention to the measures directed at reducing the vulnerability of heritage constructions, prioritizing threatened coastal communities.
Task 3. Comprehensively preserve, maintain, and restore the sandy beaches of the Cuban archipelago, prioritizing urban and tourism communities, and reducing the structural vulnerability of heritage constructions.
Task 4. Secure the availability and efficient use of water as part drought planning, using water saving technologies and providing enough water to satisfy local demands. Improve and maintain the water infrastructure, and implement actions to measure water efficiency and productivity.
Task 5. Manage reforestation for maximum protection of the soil and water in quantity and quality; as well as the recovery of most affected mangroves. Prioritize basins, canals and water regulator stretches of the river basins of the main bays and coasts of the island platforms.
Task 6. Stop the deterioration, rehabilitate and conserve the coral reefs in the entire archipelago, especially the ridges that limit the island platform and protect urbanized beaches from tourist use. Avoid overfishing of species that favor coral reefs.
Task 7. Maintain and introduce the scientific results of the MacroProject on Hazards and Vulnerabilities of the Coastal Zone (2050-2100) in urban and land-use planning. Include the Studies on Hazards, Vulnerabilities, and Risk in the Disaster Reduction Cycle. Use this information as an early warning for decision making by OACE, ODE, EN, CAP and CAM.
Task 8. Implement and control the adaptation and mitigation to CC measures, resulting from sectoral policy in the program, plan, and projects linked to food security, renewable energy, energy efficiency, urban and land-use planning, fishing, farming, health, tourism, construction, transport, industries, and the comprehensive management of forests,
Task 9. Strengthen the monitoring, surveillance, and early warning system to systematically evaluate the state and quality of the coastal zone, water system, droughts, forests, human, animal, and plant health.
Task 10. Prioritize the measures and actions to increase the perception of risk, and to increase the level of knowledge and the participation of all population in relation to CC and water-saving culture.

Task 11. Manage and apply all available international financial resources, both those from global and regional climate funds, as well as those from bilateral sources, to implement investments, projects, and actions that result from each of the tasks of the Plan of State

Figure 61-- How the GCF Project contributes to accelerate "TAREA VIDA".

4.1.2 National Guidelines and Plan for Development to 2030

244. The high priority given to Cuban State Plan for facing Climate Change ("Tarea Vida") and incorporation of climate resilient development in the main policy documents, in particular in the "Guidelines of the Economic and Social Policy of the Party and the Revolution" and in the "National Plan National for Social Development to 2030: Proposal of the Vision of the Nation, Axes and Strategic Sectors" demonstrate the importance of resilience to the GoC.

245. The "Guidelines of the Economic and Social Policy of the Party and the Revolution" were initially approved on April 18th 2011 and updated during the Seventh Congress of the Party (April 2016)[76]. These policies and strategies cover science, water, forests, soils, and other issues.

246. Guideline number 158 refers to the development of integrated research to protect, conserve and rehabilitate the environment, evaluate social and economic impacts of extreme events, and adjust environmental policy to projected changes in the economic and social context.

247. Guideline 107 refers to: "The accelerated implementation of the directives and programs of science, technology and innovation, aimed at tackling CC, in all organisms and entities, integrating them into territorial and sector policies, with priority on the agricultural, hydraulic and health sectors. Improve information and training to increase perceptions of risks in society as a whole".

248. Other important Guidelines include the following:

76 Moreno, C., et al. (2007): Ten Questions and Answers on Wind Power. Editorial Cubasolar, Habana, Cuba, 335 pp.
76 Rodríguez C., L. Favier, M. Abreu, and A. L. Pérez 2008: Study on the Dangers, Vulnerability and Risk for the Urban Planning and Land Management in Cuba. Institute of Physical Planning, Habana, Cuba, 99 pp.
76 Political, Economic, and Social Guidelines of the Revolution Party (Partido de la Revolución), approved by the VII Party Congress.

a) 101: Implementation of policies on science, technology, innovation and the environment;

b) 157: conservation, protection and improvement of natural resources;

c) 169: promotion of forest plantations with particular attention to watersheds;

d) 213: tourism sustainability

e) 236: planning of water resources

f) 237, 238, 240, 241, 242: program for the integrated management of water resource.

249. The "National Plan of Social Development to 2030: Proposal of the Vision of the Nation, Axes and Strategic Sectors", contains a number of relevant elements, in particular under the Strategic Axis on "Natural Resources and Environment", which defines three general objectives on guaranteeing the rational use of natural resources, the conservation of ecosystems and the care of the environment and national heritage, and improvement of environmental quality strengthening of national capacities for adaptation to CC. One of its specific objectives is "to effectively implement programs and actions for tackling CC, with emphasis on adaptation, reduction of vulnerability, mitigation of causes and the introduction of systemic and cross-sector strategies".

4.2 Relevant institutions related to Climate Change

250. In Cuba there are multiple organizations at national, provincial or municipal levels that are related to the management of natural resources and issues related to the impact of CC. The particular manner in which they are related has led to a sectoral approach to the national policies that guide the adaptation measures to CC in the country.

251. Considering the sophistication of institutional framework in Cuba, the institutional analysis describes two separate sections, one with the particularities and characteristics of the institutions that work at the national and provincial levels, as well as a description of the coordination mechanisms and structures of these same organizations at municipal or local level, since the project works in four scales, National, Provincial, municipal and communities. Later sections present the most relevant relationships at different scales in more detail.

4.2.1 National Ministries and key actors for the project

4.2.1.1 The Ministry of Science, Technology and the Environment (CITMA)

252. The Ministry of Science, Technology and the Environment (CITMA, for its acronym in Spanish), was created on April 21st, 1994, with the enactment of Law No. 147 of the reorganization of the Organisms of the Central State Administration. It was formed by the integration of the Academy of Sciences of Cuba (an institution with over 30 years of experience and had its background in the Academy of Medical, Physical and Natural Sciences of Havana, founded in 1861).

253. CITMA has the mission to lead, execute and control the policy of the State and the Government in the field of science, technology and the environment; the use of nuclear energy, standardization, metrology and quality control, promoting the coherent integration of these to contribute to the sustainable development of the country.

254. In the context of project design, CITMA has key information on issues of ecosystem conservation, protected areas, meteorology and the environment (marine and coastal ecosystems).

- The CITMA functions that are most relevant to the project included, but are not limited to:
- Propose and evaluate the strategy and the scientific and technological policies, in correspondence with the economic and social development of the country.
- Direct and control the process of preparation, execution and evaluation of technological innovation programs.
- Promote and facilitate the participation of the scientific community in the development and evaluation of science and technology strategies and policies.
- Propose strategy and policies for developing the plan and budget for science and technological innovation.

- Distribute and control, as appropriate, implementation of the approved national budget and territorial priorities.
- Direct, coordinate and control, as appropriate, the process of integration of scientific, technological, production and other factors.
- Establish regulations and standards for the transfer of technologies from abroad.
- Systematically evaluate the effectiveness and efficiency of the science and technological innovation.
- Propose or decide on the necessary measures for the development and improvement of research centers and institutions of scientific and technological services, including as regards its creation, modification, merger, extinction and subordination
- Develop, refine and control strategies, plans and programs for environmental protection, rational use of natural resources and ecosystems priority.
- Establish and monitor policies aimed at developing clean production, economic use of waste, promoting the use of renewable energy and the introduction of certification systems and other forms of environmental recognition.
- Supervise and require bodies and relevant organizations, to comply with the regulations established for the protection and conservation of the environment and the rational use of renewable resources. This function is closely related to the mandate of CITMA to lead the "Tarea Vida"in Cuba.
- Reconcile discrepancies between organs and other entities in relation to environmental protection and rational use of natural resources, taking appropriate decisions or raising the Government proposals for appropriate action in each case.
- Direct, evaluate and control the weather monitoring, the chemical composition and general air pollution; environmental monitoring and seismological service and risk studies seismic, meteorological and radiological hazard.
- Develop and manage programs and information projects in their areas of state responsibility.
- Prepare, propose, manage and control the policy of social communication related to science, technology, environment and use of nuclear energy.
- Propose and direct the policy files and documentation of permanent value retention.
- Direct and control, strategies and actions for international cooperation in science, technology, intellectual property, environment and use of nuclear energy.
- Coordinate national participation concerning environmental issues in organizations, and international treaties.
- Direct and monitor the implementation of measures to ensure compliance with international commitments made by the country's environment
- Direct and monitor the implementation of state policy on standardization, metrology and quality control.

4.2.1.1.1 Environmental Agency (AMA)

255. The Environment Agency (AMA), it is a Superior Management Organization of the Ministry of Science, Technology and Environment (CITMA) proposes and designs strategies related to the environment and natural sciences in the scope of its corporate purpose, manage and implements programs and projects of scientific research and technological innovation, is involved in the development of national and international policies and strategies for environment and the development of legal documents related to environmental issues. Directs, controls and coordinates the entities that are subordinated to it to fulfill its mission. The Environment Agency is integrated by the entities:

- Institute of Meteorology.
- Marine Science Institute.

- Institute of Ecology and Systematics.
- Institute of Geophysics and Astronomy
- Institute of Tropical Geography.
- National Aquarium of Cuba.
- National Museum of Natural History.

256. The Environmental Agency (AMA) is in charge promoting government strategies for environmental management through research and the active implementation of strategic projects and putting into practice environmental policy and providing key recommendations for the legislation on environmental issues. As a public agency, it receives an estimated USD 44 million annual funding from the GoC's national budget.

257. AMA as the institution in charge of coordination studies directed for the environmental protectin and rehabilitation has access to a network of Centres for Environmental Studies at a provincial level as well as at a municipal level through various municipal environmental specialists. The municipal specialist, in many municipalities, is also the designated head of Capacity Building Centres and is in charge of providing support to municipalities in integrating national environmental policies into local actions.

258. This makes AMA a strategic actor in bridging the gaps in EBA and adaptation expertise at a local level and in coordinating actors at a municipal level as required through Output 2 (See Section 6). As it has staff located in targeted municipalities, the project will leverage these resources.

259. AMA has expertise in implementing internationally funded projects in natural ecosystem management and has cooperated with UNDP for 25 years as the executing entity for 31 projects ($65 million) financed by the GEF, Montreal Protocol, Adaptation Fund, the European Union, Swiss Agency for Development and Cooperation (SDC), Government of Canada and Environment Ministry of Italy. This comprehensive project portfolio has contributed to cover the incremental costs derived from the commitments that Cuba has adopted, under multilateral environmental agreements. International agencies of the United Nations System, particularly UNDP, but also UN environment, FAO, WFP, UNESCO have served as implementers of these funds.

Table 11 - List of the recent projects implemented by AMA.

Project Title	Donor	Amount
Project GEF/PNUD Sabana Camaguey (3 stages)	Global Environment Facility	$ 10 000 000.00USD
Program PNUD/PNUMA/FAO/GEF "Support for the National Action Plan Implementation to Combat Desertification and Drought in Cuba"	Global Environment Facility	$10 000 000.00USD
Project PNUD/GEF "Preparatory activities for the proposal preparation for the 3rd. National Communication to the UNFCCC"	Global Environment Facility	$850 000.00USD
Project PNUD/FA "Reduction of vulnerabilities to coastal floods in the southern provinces of Artemisa and Mayabeque, through ecosystem-based adaptation"	Adaptation Fund	$6 067 320.00USD
Project PNUD/UE/SDC "Environmental Bases for Local Food Sustainability (BASAL)"	European Union/ Swiss Agency for Development and Cooperation	EU: $6 300 000.00USD SDC: $3 000.000USD
Project PNUD/GEF "A landscape approach to conserve threatened mountain ecosystems"	Global Environment Facility	$7 481 944.00USD
Project PNUD/GEF "National Plan for Biological Diversity to support the implementation of the Strategic Plan of	Global Environment Facility	$242 000.00USD

the CBD 2011-2020 in the Republic of Cuba"		
Project PNUD/GEF "Incorporating multiple environmental considerations and their economic implications in the management of landscapes, forests and productive sectors in Cuba"	Global Environment Facility	$9,580,365USD
Project PNUD/GEF "Integrating Rio global environmental commitments into national priorities and needs through the improvement of information management and knowledge for planning and decision making"	Global Environment Facility	$1 538 573.00USD
"Building coastal resilience in Cuba through natural solutions for Climate Change adaptation"	European Union	$5 000 000.00EUROS

260. AMA, with the support of its ascribed research centers, will act as the Executing Entity for this project.

4.2.1.1.2 Institute of Marine Sciences (ICIMAR)

261. On marine issues, one of the most relevant is ICIMAR (Institute of Marine Sciences) belonging to AMA. ICIMAR was founded on February 17th, 2017, through the merger of the Center for Marine Bio-products (CEBIMAR) and the Institute of Oceanology (IDO).

262. The ICIMAR, according to its constitution, has the mission to strengthen marine research in the country aimed at sustainable use of marine resources on a consolidated scientific basis. Its mission therefore includes providing solutions to environmental, social and economic problems in marine and coastal areas of Cuba, promoting research aimed at developing the scientific basis for knowledge management, rehabilitation and sustainable use of resources and processes in the coastal zone and the commercialization of goods and services provided by marine or coastal ecosystems. In this sense, the implementation of EBA mechanisms is an ideal example of the application of the mission of ICIMAR adaptation of the effects of CC in Cuba.

263. ICIMAR executes projects for development and innovation-oriented knowledge of biodiversity, monitoring and forecasting of ocean and coastal processes and the production and development of bioproducts for medical, industrial and environmental applications. In this sense, ICIMAR has the ideal professional staff to support the EBA measures promoted by the project, as well as the institutional profile and capacities for managing information and knowledge that the project will develop.

264. ICIMAR will provide support in the monitoring of coastal marine systems, the development of the knowledge management platform and the deveqzlopment and implmeenttio of capacity building programs on EBA and providing training to the provincial laboratories on the acquired technologies, among others.

265. In order to fulfill its corporate purpose, ICIMAR has the following functions;

- Contribute to the knowledge, conservation, prediction, integrated marine and coastal zone and its resources, by providing scientific and technological services management.
- Contribute to solving social, economic and environmental problems through products and services from science-based information.
- Design, organize and coordinate the environmental monitoring of the Cuban marine and coastal zone.
- Provide services in the fields of ecosystem rehabilitation, coastal engineering and the operation of integrated coastal, oceanographic and biological systems and others associated with the environment.

- To produce and market products resulting from the processes that develops expertise in coastal resource management. Contribute to the training of specialists and other people, linked to the management of the marine and coastal zone and its resources.
- Obtain new bioproducts up to pilot scale and its small and medium scale productions, as well as define its possible introduction for import substitution.

4.2.1.1.3 Institute of Ecology and Systematics (IES)

266. The Institute of Ecology and Systematics was created in 1986, by the merging of the Institutes of Botany, Zoology and Chemistry and Experimental Biology of the Cuban Academy of Sciences. The IES is a research center subordinate to the Environment Agency (AMA).

267. The institute fosters conservation and sustainable use in natural and replacement ecosystems, increasing the contribution to scientific and socio-economic development in Cuba and the Caribbean area.

268. Some of the project actions in which the IES will be involved are the following: validation of the coastal wetlands' status in the 7 intervention sites in order to adjust the designs of the interventions, trainings for the Centers of Environmental Studies (CEAs), monitoring of the coastal wetlands in the 7 intervention sites, among others.

4.2.1.1.4 Institute of Tropical Geography (IGT)

269. The Institute was created on February 9, 1962, as part of the Cuban Academy of Sciences. Since then, it has conducted a large number of investigations on the potential and rational use of natural and social resources, conservation, protection and improvement of the environment, regional and local development, cartographic modeling and the use of advanced technologies.

270. The IGT became part of the Environment Agency (AMA) after the creation of CITMA in 1997, reorganizing its research work in different National, Branch and Territorial Programs, with the inclusion of projects not associated with programs.

271. Some of the project actions in which the IGT will be involved are the following: moniotoring of the coastal wetlands with remote sensors and aerial photography with drones as well as trainings for the CEAs.

4.2.1.1.5 Institute of Meteorology (INSMET)

272. The Meteorological Institute, subordinate to AMA, has the mission of providing authoritative, reliable and timely meteorological and climatic information on the state and future behavior of the atmosphere. This information is and will continue to be aimed at ensuring the safety of human life and reducing the loss of material goods in the event of natural disasters of meteorological origin, directly contributing to the well-being of the community and to sustainable development.

273. The INSMET has a headquarters office where the general management is located, together with nine specialized research and service centers, 14 provincial meteorological centers, including the special municipality of Isla de la Juventud and a network of 69 meteorological stations throughout of the country.

274. Some of the project actions in which the INSMET will be involved are the following: monitoring of atmospheric parameters and monitoring of sea level and terrain movements.

4.2.1.2 Ministry of Agriculture (MINAG).

275. The Ministry of Agriculture (MINAG, for its acronym in Spanish) is the body of the Central State Administration responsible for proposing and implementing policy on the use, possession and sustainable use of agricultural land in the country; agricultural and forestry production to meet the food needs of the population, industry and export. By its nature the MINAG plays a central role in project because it involves the management of soils and forests and is the forest management.

276. MINAG objectives are presented below, based on their legal establishment:

- Objetive 1: Promote the growth of agricultural and forestry production through the proposal and implementation of agricultural policies that contribute to sustainable

development of the sector and government support to the productive base, especially the cooperative system.

- Objective 2: Increase the efficiency of agricultural land in compliance with protection measures, improvement and soil conservation in harmony with the environment.
- Objective 3: contribute to increased supply of animal protein toward sustainable development of the livestock and the implementation of appropriate policies in genetics, resources zoo genetic resources, animal health and the registration and control of the cattle.
- Objective 4: Support the increase of production, yields and diversification of agriculture, with the implementation of policies for seeds, plant health, mechanization, irrigation and drainage and industrialization of production.
- Objective 5: Support the increase in the forest area, ensuring sustainable forest management and conservation of wild flora and fauna.

277. Objectives 1, 2 and 5 are directly related to the proposed project intervention and establish the importance of working with this ministry and in particular its structures for forest management and capacity development.

278. Saline intrusion and direct onslaught of sea level rise affect the achievement of the MINAG objectives and goals. The management of Invasive Alien Species (IAS), their use and marketing are also under the regulation of MINAG. Forest management requires supervision, approval and certification of MINAG through the State Forest Service (SEF), which certifies and accredits rehabilitation, restoration or management plans for forest ecosystems, whether natural or planted. GCF investments on mangroves and swamp forest rehabilitation as well as Invasive Alien Species (IAS) removal, will require Forestry administration agencies participation, as stablished in the protocols of intervention in the following sections.

279. Within the structure of the Directorate of Agriculture of the MINAG is the Forest and Wildlife Direction that is a relevant structure for the implementation of the project.

280. The forestry sector is composed of the Forest Directorate of Flora and Fauna (DNFFFS) that is part of the Agroforestry Business Group that groups and directs 30 State Agroforestry Companies. These companies, administered by the state, in turn include local forest use companies that are also financed by the Cuban state. These have acquired expertise in forest management and reforestation specific to key areas. The project in the development of restoration activities will work with 6 agroforestry companies (site specific with one company covering Playa Florida and Santa Cruz) to leverage expertise in forest management and restoration actions and enhance capacity in EBA.

281. Several research institutes, including the Institute of Agroforestry Research (INAF) of the MINAG and several institutes of the Ministry of Science, Technology and Environment (CITMA) provide research for forest management with the support of the three Faculties of Forest Engineering existing in the country. These institutions will play a role in coordination with CITMA for the rehabilitation of Mangrove forests and swamp forests.

282. Mangroves and swamp forest rehabilitation require forestry companies to develop management plans that will be evaluated and approved by the National Forestry Institute, these rehabilitation programs will be certified later by the State Forest Service (SFE), so to endorse the effectiveness of the work done through independent agencies.

283. The National Company for the Protection of Flora and Fauna (ENPFF) that manages more than 80 Protected Areas and the Ranger Corps (CGB) of the Ministry of the Interior (MININT), have the responsibility of forest resources protection. Prevention and firefighting activities are carried out with the Ranger Corps (“cuerpo de Guardabosques”). In the case of unprotected conservation units or at risk the national flora and fauna this company supports them.

284. In 2005, the National Reforestation Commission was created, presided over by the Minister of Agriculture and replicated in the 15 provinces and 168 municipalities of the country. At these instances, the Commission is headed by the presidents of the provincial and municipal governments, respectively, and is made up by the organizations, agencies and institutions linked to the country's forestry development.

285. The National Fund for Forest Development (FONADEF), created in 2000, and that provides state financial support for the establishment of productive long-rotation forest plantations, including inputs such as seeds and seedlings; short-rotation plantations when relevant; and silvicultural treatments and restoration or enrichment of forests where management costs exceed the value of timber produced. The FONADEF provides an estimated 300M Cuban pesos annually for projects.

286. Because EBA activities proposed by this project are particularly important, it will require a broad coordination and participation of the MINAG and its institutions mentioned above.

4.2.1.2.1 Forestry Companies/Enterprises

287. The Ministry of Agriculture (MINAG), as an organism of the State Central Administration, is in charge of proposing and implementing policies about the use, tenure and sustainable exploitation of agricultural areas; the country's agricultural and forestry production.

288. The Agroforestry Business Group (GAF) is subordinate to this body, as the highest business management organization at the national level to manage the Cuban forest heritage through the Forestry Companies.

289. The Forestry Companies are state entities with their own legal personality, approved by the Council of Ministers representing the Cuban State as land holder. These Forestry Companies are part of the agricultural and forestry production system and are distributed throughout the country's provinces to satisfy the demand for goods and services provided by forests in a stable and growing manner, through their rational and sustainable exploitation and use. These entities have qualified technical personnel to supervise and prepare technical projects for forest rehabilitation, according to FONADEF's requirements.

290. In turn, the Base Business Units (UEB) are internal divisions with economic personality that are subordinate to the Forestry Companies and are responsible for the processes related to production of goods and provision of services at the municipal level. The UEBs are formed by Brigades of forest workers who reside in the municipalities where they are located; which are made up, on average, of about 30 workers. These workers are hired and paid by the UEB.

291. It is worth highlighting that the patrimony of equipment of forestry companies is limited and obsolete, most of them come from former socialist countries and have more than 40 years of exploitation. These companies have workshops where maintenance and repairs of their equipment are carried out. The companies allocate a part of their annual profits (obtained from national marketing and export of goods and services) to finance the acquisition of some of the supplies, pieces and spare parts to guarantee the service operation offered by these workshops. With its own technical capacity and workers' high level of creativity and innovation, it is possible to maintain the vitality of the equipment.

292. In the "Mi Costa" project, 6 Forestry Companies will be responsible for coordinating, executing and certifying the planned coastal wetland rehabilitation actions in 7 vulnerable coastal settlements (Component 1). These Companies are located in the provinces of Pinar del Rio (La Coloma Settlement), Artemisa (Cajio Settlement), Mayabeque (Surgidero Settlement of Batabano), Ciego de Avila (Júcaro Settlement), Camagüey (Playa Florida and Santa Cruz del Sur Settlements) and Granma (Manzanillo Settlement). There are 2 brigades in the province of Camagüey, and one brigade in the rest of provinces. Therefore, there are 7 brigades that will carry out this work.

4.2.1.3 Ministry of the Food Industry (MINAL)

293. The fishing activity in Cuba is governed by the Ministry of the Food Industry (MINAL), which is an Agency of the Central State Administration created in 2009 by the merger of the Ministries of Fisheries and the Food Industry. MINAL has the mission of executing, controlling and directing the application of State and Government policy in the development of the food industry, as well as research, conservation, extraction, cultivation, processing and commercialization of fishery resources.

294. In its specific role on fishing, MINAL is responsible for proposing policies to the Government and, once approved, implement and enforce it. In addition, the MINAL directs the harvest and conservation of fishing resources in the territorial sea, the exclusive economic zone and inland waters.

295. It is also the MINAL's power to grant, renew, modify and cancel fishing licenses, establishing the requirements and corresponding mechanisms for their granting and enforcement.

296. MINAL has the support of the National Office of State Inspection (ONIE), the Fisheries Research Center (CIP) and the Fishing Maritime Institute "Andrés González Lines" to support its work.

297. Although the project will not make specific investments in fisheries, the monitoring of certain fisheries or fish products that ensure the resilience of coral reefs and seagrasses is of interest for the implementation process

4.2.1.4 National Institute of Hydraulic Resources (INRH for its acronym in Spanish).

298. The management of ground water in Cuba is headed by the National Institute of Hydraulic Resources (INRH). It is the entity responsible for organizing and conducting, in coordination with the other competent bodies, protection of ground water basins, natural waterways, hydraulic works and installations against the dangers of pollution, siltation and other forms of degradation and deterioration, and systematic monitoring of water quality. At the provincial level, it is organized through Territorial Delegations of Hydraulic Resources.

299. This body is responsible for organizing and directing, in coordination with the competent bodies, the protection of terrestrial waters, basins, natural channels, works and hydraulic installations against pollution hazards, siltation and other forms of degradation, as well as, the systematic control of water quality.

300. In terms of project design, the INRH maintains and arranges information on the management of water resources and their quality, the monitoring of the condition of surface or underground waters and their monitoring. Therefore, it will be a highly relevant actor for follow-up works in relation with the impacts during the implementation of the Project. A

301. This agency is responsible for, in coordination with the competent bodies, organizing and directing protection of ground water basins, natural channels, hydraulic works and installations against dangers of pollution, siltation and other forms of degradation and deterioration and the systematic control of water quality. In terms of project design INRH maintains and provides information on management of water resources and quality monitoring of the status of surface and groundwater and monitoring, so it will be a very important player for follow-up work during project implementation.

302. INRH functions most relevant to the project include, but are not limited to:

- Organize and direct, in coordination with the competent bodies, the protection of terrestrial waters, basins, natural channels, works and hydraulic installations against pollution, siltation and other forms of degradation and deterioration, as well as systematic control of the quality of the waters.
- Determine the agencies that apply the regulations necessary for the protection of economic, social objectives and the natural environment of the harmful effects that could cause ground waters, establishing organizational actions, ensuring and controlling regulations to ensure the safety and proper functioning of hydraulic installations, of the flood protection works, and the ability and conduct of natural and artificial causes.
- Determine and update the hydraulic potential of the country on characterization data of the hydrological cycle on surface and ground water, rain and evaporation to be made available to the competent bodies.
- Propose water development strategy for the country and corresponding enforcement and regulate the activity of investment projects and hydraulic works.
- To plan, regulate and control water resources and operation, technical monitoring and maintenance of works and hydraulic infrastructure, equipment and facilities.
- Determine and update studies and assessments of hydropower potential and propose the participation of duly qualified agencies in its development strategy as well as regulate and control the projection, investment, operation and maintenance of hydroenergetic works.
- Regulate and control the activities of water, sewage and storm drainage.

- To organize and ensure the functioning of the national registry of ground water in concessions, assignments and permissions relating to water use and preservation, in line with what the law determines.

303. INRH as the institution charged with water management at all levels, is a key actor in calculating and releasing the ecological flow directed at ecosystems.

4.2.1.5 The Institute of Physical Planning (IPF).

304. The Institute of Physical Planning (IPF, for its acronym in Spanish) is the national entity subordinate to the Council of Ministers that directs the application of the policy of the State and the Government in matters of territorial order, urbanism, aspects of design and architecture related to the latter.

305. The Institute of Physical Planning, created in 1960, is in charge policies established by the State in terms of territorial planning and urban planning, through provincial and municipal Physical Planning. Among its functions are definition of location of production activities and services, preserving the soil as necessary for social use and the use of natural resources while protecting the environment.

306. The Provincial Directorate of Physical Planning is under the Council of Administration, governing the land use planning and urbanism state entity. The Municipal Departments are responsible for developing and implementing territorial plans and urban planning studies and location details; developing and adopting micro locations and other instruments of territorial control at their level, applying the measures established in the field of urban and regional planning and conducting inspection in these areas.

307. The IPF at the central level offers guidelines for the implementation of land management at all levels and sectors, methodological tools and also coordinates the issue of territorial planning at other levels. Therefore, it will have a relevant role in developing methods for integration among different sectors and scales facilitating the mainstreaming of EBA measures in planning processes. relevant functions related to the project are mentioned below:

- Develop and propose the national land use plan.
- Elaborate and propose schemes of territorial ordering on special topics, for example of productive or thematic activities of a particular sector.
- Integrate the general land and urban planning plans at the national, provincial and municipal levels, with the medium and long-term projections of the economy.
- Establish priorities and advise, review and technically approve the schemes and plans of territorial and urban planning of the regions, provinces, municipalities, cities and settlements of national interest.
- Establish and monitor standards for better functioning of urban and rural settlements.
- Design, manage and control information system on Physical Planning and its link with the Government Information System
- Organize and teach graduate courses, habilitation, seminars and conferences on topics related to land use planning
- National land use planning studies, including territorial disproportions, identifying critical municipalities considered and the impacts of sectoral development policies.

308. The IPF will play an important role in the project by establishing guidelines and guide for the preparation of municipal development plans, therefore, if the project reaches to incorporate the criteria, concepts and EBA practices through the IPF in the above mentioned guidelines and procedures for territorial planning will be much easier and more effective institutionalization and mainstreaming of EBA, among the various institutions in the country.

4.2.1.6 Civil Defense:

309. In July 1966, Law No. 1194 was promulgated, which established the Civil Defense System of Cuba as a result of the experiences of the aftermath of Hurricane Flora. The main objective of this new

body was to coordinate the efforts of the State and the political and mass organizations for the fulfillment of Civil Defense missions in time of war.

310. Then the role of the Civil Defense expanded with Law No. 75 of the National Defense, of December 21st, 1994, which defines in its article 111 that: "The Civil Defense is a system of defensive measures of a state nature, carried out in peacetime and during exceptional situations, in order to protect the population and the national economy from mass destruction of the enemy and in cases of natural disasters or other catastrophes, as well as consequences of environmental degradation. It also includes conducting rescue works and urgent repair damage to the foci of destruction or pollution". Finally, Decree Law 170 published in 1997 governs a process of evolution of civil defense to a broader view.

311. As a result of the analyzes carried out after Hurricane Kate in 1985, Directive No. 2 was drafted, which established the activation of defense councils at all levels and defense zones. In that year, the existing deficiencies in the preparation of the population in the face of disaster situations were studied and the need to extend it for all types of events was raised, which increased the participation of citizens and the governing bodies at all levels. Directive No.1 "for planning, organizing and preparing the country for disaster situations", approved in June 2005, marks a new stage in the development of Civil Defense System.

312. Subsequently, from the experiences of the confrontation to numerous events such as hurricanes Gustav, Ike and Paloma, in April 2010 Directive No. 1 was approved "For Disaster Reduction", which updates the criteria on the direction of the activity of Civil Defense, groups and synthesizes elements of other governing documents. Currently, the actions of Civil Defense are aimed at educating, preparing and training the population and the State agencies for the confrontation and reduction of risks in the face of such disasters. Equally, all the human and material resources of the territories are put in place to face the catastrophes and recover the damages caused.

313. According to its constitution, the main Civil Defense functions that are relevant to the project include:

- Identify and assess, in coordination with state bodies and agencies, economic and social institutions, risk factors, vulnerability and risk and determine the planning elements necessary to address them.
- Organize, in coordination with state bodies and agencies, economic and social institutions, compliance with measures of prevention, preparedness and fighting for the protection of the population and the economy.
- Enforce the process of harmonization of economic and social development of the country with the interests of the Civil Defense, established in the legislation.
- To establish the principles of preparation and equipment and forms of action of the forces involved in the enforcement of civil defense measures.
- To direct, on the basis of its structure and the participation of the selected state bodies and agencies, the National Direction for Post Disaster Cases.
- Monitor compliance system activities of civil defense measures.
- Create groups of experts to advise the National Civil Defense Staff in the study and analysis of specific measures and tasks of the Civil Defense.
- Approve programs, projects and plans for disaster reduction and in coordination with the Ministry for Foreign Investment and Economic Cooperation, in the first instance.
- In scientific and technological fields, carry out environmental protection coordination of programs, projects and plans, will be done in coordination with the Ministry of Science, Technology and Environment (CITMA).
- Represent the Cuban State to the organs, agencies, organizations and international agencies and to other governments, in everything related to the reduction of natural disasters or other catastrophes.

- Establish the hallmarks of people and civilian property subject to special protection under international conventions on civil protection in which, the Republic of Cuba is a party, and establish regulations disaster areas.

314. Civil Defense, which typically focuses on responses to disasters with a reactive character, will be a key user focused when desigining climate information products that will be prepared through Activity 2.2 (See Section 6).

4.2.1.7 GEOCUBA Business Group

315. The GEOCUBA Business Group is an association of state companies. It was created as a result of the mergin between the Cuban Institute of Hydrography and the Cuban Institute of Geodesy and Cartography, both of recognized prestige at the national level, with institutional backgrounds since the 1920s and 1940s respectively, and which accumulated an invaluable heritage.

316. Established on May 1st, 1995, the GEOCUBA Business Group aims to develop and commercialize information, technologies, products and services in the areas of: Geodesy, Photogrammetry, Remote Sensing, Hydrography, Marine Studies, Cartography, Studies Environmental, Graphic Arts and Aid to Maritime Navigation; to satisfy market needs related to the geographical environment´s study and use.

317. GEOCUBA will be involved in the monitoring of sea level and terrain movement throughout the project.

4.2.2 Local Governments and Legal Framework

318. Local Organs of People's Power (OLPP) are the governing or administrative bodies at provincial and municipal level, which constitute key actors for project execution in the local space. With their involvement, they contribute to the ownership of interventions.

319. Representation of the OLPP in the Organizational Structure of the Project will be ensured by including the Provincial Administration Councils (CAP) of the provinces involved in the with in the Project's National Steering Committee, as beneficiaries. It should be noted that that the different entities of the country's institutional organization are represented in the CAP, including those in the forestry sector, water resources, physical planning and environment (See section 4.1). Likewise, the entities that attend these sectors at the municipal level are represented in the Municipal Administration Council (CAM) (see section 4.2.2). The management of the entities that make up both the CAP and the CAM will designate representatives to be part of the Provincial and Municipal Coordination of the project. Within these entities at the provincial, municipal and local levels, national officials and experts are employed, who will work part of their time in support of achieving the objectives set forth in the project.

4.2.2.1 Provincial governments

320. Provincial Government of People's Power are formed by a Governor and a Provincial Council that represents the State and has as its fundamental mission the economic and social development of its territory, in accordance with the general objectives of the country, and acts as coordinator between the central structures of the State and the municipalities. The Governor, who organizes and directs the Provincial Administration, is the highest executive-administrative liable official in his province and is elected by the delegates of the corresponding Municipal Assemblies of People's Power, at the proposal of the President of the Republic, for a period of five years. The Provincial Council is the collegiate and deliberative body that fulfills the functions defined in the Constitution and laws. It is chaired by the Governor and integrated by the Vice Governor, the presidents and vice-presidents of the corresponding local assemblies of the People's Power.

321. The Provincial Government's fundamental mission is to work for the economic and social development of its territory, in accordance with the general objectives of the country, and acts as coordinator between the Government of the Republic and the municipalities, for which it directs, controls, guides and contributes to the harmonization of the interests of the province and its ministries, and exercises the powers and functions recognized in the Constitution and the laws; contributes to the development of activities and demands and controls development plans and territorial and urban planning.

4.2.2.2 Municipal governments

322. The Municipal Assembly of People's Power is the highest body of State power in its demarcation and, consequently, is vested with the highest authority in its territory. It is composed of the delegates elected in each constituency in which their territory is divided for electoral purposes, elected for a period of five years by means of the free, equal, direct and secret vote of the voters. The Municipal Administration Council performs executive-administrative functions and directs the Municipal Administration; it is chaired by the Mayor, who is appointed by the Municipal Assembly of People's Power, to which he is subordinated and accountable.

323. The municipalities are divided to facilitate relations with voters in popular councils composed of delegates themselves and chaired by one of them. The municipalities of Santa Clara, Camagüey, Holguín and Santiago de Cuba (municipalities with a large population) are further divided into districts, where several popular councils are grouped, in order to decentralize and bring the different administrative offices closer to the population.

324. At the municipal level, government structures of popular power are available (See Section 4.2), which establish the government plans at the lowest jurisdictional scale. It is in the municipality where the municipal plans and budgets are developed, these plans are then integrated into provincial and national plans. It is stipulated that Local Administrations in the exercise of their specific assigned functions have no national subordination to ministries and other national State institutions (OACEs), which only exercise a function of methodological guidance in relation to Local Administrations.

4.2.2.3 2019 Constitutional Reform Process and Local Governments

325. Cuba has recently undergone a profound constitutional reform process that resulted in the current constitution that was formalized by the National Assembly of People's Power in April10, 2019. The Consitution of 2019, amongs other objectives, reafirms the role of local governments particularly in the municipal level in environmental management and planning as well as in local economic development and investments.

326. The new text of the Constitution grants greater importance to the municipalities, from the recognition of their autonomy, which they exercise in line with the interests of the nation. It provides that the municipality is the local society, organized by law, which constitutes the primary and fundamental political unit of the national organization, enjoys autonomy and legal personality, proper to all legal effects. The autonomy of the municipality includes the power to decide on the use of its resources, in the framework of the strengthening of institutions in the country. This should favor the project objective as it will allow the incorporation of EBA practices into policies and tools for territorial planning, as well as their direct implementation at the municipal level.

327. Under the 2019 Constitution, the Municipal Assembly of People's Power has its own income and receives payments from the Government of the Republic. It prepares its plans and reports in terms of economic progress, social development of its territory and other state purposes. Municipal development plans must be prepared and approved annually, moreover compliance with the plan of territorial and urban development is monitored.

328. The 2019 Constitution thus provides a new framework that allows an opportunity for local actors through its municipal governments to have a greater role in decision making and process, a key mandate for adaptation considering its direct impact to communities and local economies. It also presents a challenge as local authorties, community leaders and economic sectors need to have the capacities for effective decision making and planning capacity to manage climate impact as it will be felt locally. This in turn allows for the identification of appropriate solutions to manage these impacts and ensure their long term sustainibility. The project looks to address these challenges while provide with capacity enhancements at all levels ensure that adaptation planning is embedded with institutional sustainability.

4.2.3 Local Intersectoral Coordination Mechanisms and Spaces relevant to the project

4.2.3.1 Capacity Building Centers (CBC) of the CITMA

329. Capacity Building Centers where conceived as a space for intersectoral coordination and knowledge management with the objective of contributing to the development of skills of workers in the tourism, fishing and agroforestry sectors, as well as local populations in matters of biodiversity

conservation, integrated coastal management and environmental management. CCCs where created as a result of the a GEF funded project located in the Sabana-Camagüey province in 2003.

330. Due to the success of the model, between 2005 and 2014 a Network of Centers for Capacity Building for Integrated Coastal Management (CBC/ICM) was consolidated throughout the Sabana-Camaguey archipelago. This experience was taken up by the project Environmental Bases for Local Food Sustainability - "BASAL" by its initials in Spanish, which has implemented the Centers for Capacity Building and Knowledge Management (CBC/GC) for Adaptation to Climate Change since 2013.

331. At the national level, the Environmental Education section of the AMA's Environmental Directorate provides guidance to the Centers. The Centers have become important focal points for environmental education, training, workshops/events, distribution of teaching material, dissemination of best practices, and research, enabling environmental issues to be integrated in the work of institutions, productive sectors and community members

332. CBCs are subordinated by CITMA and located in coastal municipalities in spaces provided by the municipalities themselves and that act as meeting centers and training areas (1 classroom and an office). In each municipality where a CBC is located there is a coordinating group made up of representatives from the prioritized economic sectors, from CITMA, local governments, education sectors, civil society organizations. This group has the function of determining the training needs and elaborating the training and environmental and education programs based on priorities identified by CITMA and the CBC/ICM. The CBC in turn facilitatates the coordination for the completion of prioritized actions to in an integrated way, thus favoring community participation and enhancing knowledge management through training programs77.

333. Considering the success of the CBC model and the existance of various of these spaces in coastal municipalities, the project considers CBCs as a key figure to enhance capacity's for local adaptation and adaptation planning by incorporating resilience measures and monitoring as well as linking environmental management of ecosystems as a measure of EBA and coastal resilience. Hence the project will look to evolve current CBCs in project intervention areas into Capacity Building Centres for Climate Change Adaptation.

4.2.3.2 The centers of environmental studies (CEA, by its initials in Spanish).

334. The Centers for Environmental Studies (CEA) are Entities of Science, and Technological Innovation (ECIT) anchored in the different territories of the country. They are administratively subordinated to the provincial CITMA Delegation (1 per province) and AMA.

335. In General, among other functions, they have to coordinate and methodologically guide research activities on biodiversity including but not limited to;

- Provide better knowledge about conservation, sustainable use and adaptation in a changing climate and economic environment; Provide scientific and technical services (SCT) in studies to face CC.
- Develop environmental education actions, supported mainly in the obtained scientific results, museographer activities, botanical gardens, protected areas and other areas of conservationist interest;
- Encourage institutional strengthening through international projects and formal relations with foreign institutions;
- Commercialize natural products or services that stimulate the sustainable use of biodiversity;
- Promote and develop undergraduate and postgraduate courses is all competition topics, both nationally and internationally;

336. The CEA operates through specialists located in the provincial governments of each of the provinces where the project will intervene. The CEA specialist will provide specialized technical assistance to the CBCSs. They contribute to the project through monitoring and evaluation of environmental investments as well as through the compilation and systematization of climate information products based on the territories where they are based. It will also serve as a technical liaison in the territories and contribute to inter-agency coordination to technically assist the

77 https://formacionambientalpnuma.files.wordpress.com/2017/11/resumen_2017_cuba5.pdf

communities where the project will intervene directly and exchanges of experiences with communities in neighboring municipalities to the areas of intervention.

337. The CEAs will perform various functions at the local level. Moreover, equipment purchased will be installed in 4 provincial laboratories. Some of the project actions in which the CEAs will be involved are the following: monitoring of physical-chemical parameters to assess the quality of seawater, monitoring of physical parameters to improve local weather forecasts, as well as the impacts of extreme meteorological phenomena, field expeditions to assess the health status of ecosystems

338. The following CEAs are close to the project's intervention stretches:

- Center for Research and Environmental Services (ECOVIDA). Pinar del Rio
- Center for Coastal Ecosystem Research (CIEC). Cayo Coco. Ciego de Avila
- Camagüey Environmental Research Center (CIMAC). Camaguey
- Center for Research and Environmental and Technological Services (CISAT). Holguin

4.2.3.3 Municipal Delegations of the MINAG

339. The mission of the municipal delegations of the MINAG are to implement and enforce the policies of the state and the Government on agricultural and forestry production; ownership and possession of land and its sustainable employment; the use, conservation and improvement of the soil; plant and animal health; the registration and physical and statistical control of the livestock heritage; the control of forest heritage and wild flora and fauna; mechanization, irrigation and agricultural drainage; animal genetics and animal genetic resources; seeds and plant genetic resources; as well as the promotion and development of the cooperative movement in the agricultural sector of the municipality.

340. The instances of technical assistance and community support of the MINAG, and in particular of its agencies, to support and supervise the forestry sector will be of great help in the integration of the best forestry practices. These practices may include the rehabilitation of mangroves, the eradication of exotic species in mangroves, swamp grasslands and swamp forests or the introduction of native forest.

341. Only as a reference, the main specific functions of the municipal delegations of the MINAG are listed below:

1. Implement and consolidate state policies that are approved on agricultural and forestry production to meet the food needs of the population, industry and export.
2. Register and control the ownership and possession of land, tractors and self-propelled agricultural machinery, the agricultural land fund and the jurisdiction over it.
3. Organize, execute and control measures for the conservation, improvement and sustainable management of soils and fertilizers.
4. Execute and control the protection against the introduction and diffusion of plagues and diseases of the plants, a good phytosanitary state and the registration and control of the use of chemical, biological and natural pesticides.
5. Execute and control protection against the introduction of diseases of animal origin to achieve satisfactory animal health status; register and control the use of raw materials, products and by-products for these purposes and of veterinary medicines.
6. Execute the control of the livestock patrimony; register and control livestock, pure breeds, crosses and the morphological standard of different species.
7. Execute and control the genetic development, the preservation of the “genofondo” of the animal species and of the domestic and wild fauna.
8. Execute and control the use and exploitation of agroforestry heritage, including fruit trees and the administration of the national forestry fund.
9. Execute the mechanization, irrigation and agricultural drainage systems, according to the regulations for their technical assistance.
10. Execute, implement and control policies on plant genetic resources, certification and registration of varieties of “gásmicas”, “agámicas” and biotechnological seeds.
11. Implement the policy for the process of promotion, development and consolidation of the cooperative movement in agriculture, forestry and sugar sectors, and exercise control over compliance

342. The participation of the MINAG locally will provide technical tools for the EBA and the coordination with the CBC of the CITMA will be key to the success of the investments made by the project.

4.2.3.4 Center Risk Reduction Management (CGRR for its acronym in Spanish)

343. The Civil Defense Center for Risk Reduction Management operates comprehensively both at the province and at the municipal level. The CGRR is a tool of local government that supports adequate decisions making to reduce vulnerabilities and avoid new risks. They guarantee the reception, the processing of information and the monitoring of the events that threaten the territory.

344. CGRRs have a constant link with the communities based on urban or popular consultations, the training that is carried out with the different community actors, through the dissemination of prevention measures to hazards, through action at the base of the Multidisciplinary Commission. In other words, communities constitute the basic geographic scope for their work.

345. The main functions are summarized below.

- Prioritize Prevention: through the monitoring and control of vulnerability reduction.
- Support During Response and Recovery: providing information for immediate actions, as a link in the Early Warning System (SAT), and providing follow-up to recovery actions.
- Coordinate the Operation of Early Warning Points (PAT) in Vulnerable Communities, as part of the SAT.
- Promote the Culture of Disaster Risk Reduction: through the preparation and dissemination, aimed at the actors of the territory and the community.

346. To develop these key functions, PVRs perform other functions, which support the success of the functions listed above, including:

- Support the Management of the Multidisciplinary Commission (CM), an inter-sectoral and inter-institutional group that facilitates the compilation, updating and analysis of information on the different thematic contents of the territory.
- Ensure the Update of the Hazards, Vulnerability and Risk Studies (PVR), which make the work of the CM viable, responsible for this task at the local level.
- Support the Update of Disaster Reduction Plans and Other Documents generated in the Center, which allow decision-making.
- Create an Information Base, and enable its processing and mapping with the support of Geographic Information Systems (GIS). The Multidisciplinary Commission is a fundamental link for the PVRs – Hazard, Vulnerability and Risk. From the seriousness of his work, his professionalism, the integration that exists between his actors and his scientific potential, depends the quality of the management for the reduction of the risk that we carry out and, therefore, results in an important benefit for the municipality.

347. The institutional strategy of the project at the local level proposes that the CITMA's CES and CBC work together with the civil defense centers to use and promote better management practices and location of their activities and infrastructures, as well as training based on an EBA strategy, so that at times of catastrophic events such as storms or hurricanes or tidal waves the local institutions and the communities themselves are better adapted to withstand the attacks of CC and better prepared and adapted to overcome them quickly and at lower costs.

4.3 Relevant International agreements signed by Cuba

348. Cuba is a signatory of more than 100 international and regional agreements and conventions, which are related to the environment. Table 12 reflects some of the key instruments, to which Cuba signed/ratified/adhered since 1992, which are most relevant to the GCF project.

Table 12 - International agreements of greater relevance for the project signed by Cuba between the 1992-2017 period.

Convention/Treaty Includes the date on which it was opened for signature and the date on which Cuba became a party.	Main Objectives
Convention on Biological Diversity (1992). **Cuba: 09/03/1994**	The objectives of the Convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, though, inter alia, adequate access to those resources and the appropriate transfer of relevant technologies, taking into account all rights to those resources and technologies, as well as through appropriate financing.
United Nations Framework Convention on Climate Change (1992). **Cuba: 05/04/1994**	It declares as its ultimate objective, and of any related legal instrument to be adopted by the Conference of the Parties, to achieve, in accordance with the relevant provisions of the Convention, the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to CC, to ensure that food production is not threatened and to enable economic development to continue in a sustainable manner.
United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (1994). **Cuba: 13/03/1997**	The objective of the Convention is to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa. This is achieved through effective action at all levels, supported by international cooperation and partnership agreements, within the framework of an integrated approach consistent with Agenda 21, to contribute to the achievement of sustainable development in affected areas. Achieving this goal will require the implementation in affected areas of integrated long-term strategies that simultaneously focus on increasing land productivity, rehabilitation, conservation and sustainable use of land and water resources, all with a view to improving living conditions, especially at the community level.
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar) (1971) **Cuba: 12/08/2001**	It aims to establish a framework for national action, and international cooperation, for the conservation and rational use of wetlands and their resources. It is the only environmental agreement that focuses on a specific ecosystem - wetlands. The three "pillars" of action on which the Convention is based are the rational use of all wetlands, the designation and management of wetlands of international importance, and global cooperation.
Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997). **Cuba: 30/04/2002**	It shares its objective with the Framework Convention on Climate Change, adding more specific commitments, particularly for a group of industrialized countries.
Cartagena Protocol on Biosafety to the Convention on Biological Diversity. **Cuba: 11/09/2003**	In accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development, the objective of this Protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.
International Treaty on Plant Genetic Resources for Food and Agriculture (2001) **Cuba: 15/12/2006**	The objectives of the Treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, consistent with the Convention on Biological Diversity, in accordance with sustainable agriculture and food security. These objectives will be achieved by closely linking the Treaty, with the Food and Agriculture Organization of the United Nations and with the Convention on Biological Diversity.
Stockholm Convention on Persistent Organic Pollutants (2001). **Cuba: 21/12/07**	Bearing in mind the precautionary approach enshrined in principle 15 of the Rio Declaration on Environment and Development, the objective of the Convention is to protect human health and the environment from persistent organic pollutants, recognizing that these pollutants have toxic properties, are resistant to degradation, bioaccumulate and are transported by air, water and migratory species across international borders and deposited far from the place of their release, accumulating in terrestrial and aquatic ecosystems.

Convention/Treaty Includes the date on which it was opened for signature and the date on which Cuba became a party.	Main Objectives
Convention on the Conservation of Migratory Species and Wild Animals (Bonn Convention) (1979) **Cuba: 06/02/2008**	It aims to conserve terrestrial, aquatic and flying migratory species and their habitats globally by providing for strict protection of endangered migratory species listed in Appendix I of the Convention, by concluding multilateral agreements for the conservation and rational use of migratory species listed in Appendix II, and by promoting joint research efforts.
Nagoya Protocol on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization. (2010) **Cuba: 16/12/2015**	The objective of the Protocol, under the Convention on Biological Diversity, is the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. This includes through appropriate access to genetic resources and through appropriate transfer of relevant technologies, taking into account all rights over such resources and technologies and through appropriate financing, thereby contributing to the conservation of biological diversity and the sustainable use of its components.
Paris Agreement, under the United Nations Framework Convention on Climate Change (2015). **Cuba: 27/1/2017**	The Agreement aims to enhance the implementation of the Climate Change Convention, including the achievement of its objective. It aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty.

4.4 Economic Planning in Cuba

349. Cuba is a country with a centrally planned economy. For this purpose, it uses two planning tools, one in the long term and the other in the short term.

- **Long term (perspective):** It is the Plan for Economic and Social Development to 2030. It is being developed from the Bases approved at the Seventh Congress of the Communist Party of Cuba (PCC), dated May 17, 2017, which were subsequently endorsed by the extraordinary session of the National Assembly of People's Power (ANPP) held on June 1, 2017.

- **Short term:** The National Economy Plan that is prepared annually and approved by the deputies of the Cuban parliament: the National Assembly of People's Power (ANPP), accompanied by the Budget, with a legal hierarchy of Law.

350. The Ministry of Economy and Planning (MEP) governs this process. For the preparation of the National Economy Plan, the MEP establishes Methodological Indications based on the "Government Guidelines for the preparation of the National Economy Plan", approved by the Council of Ministers. Two large information flows are defined (from bottom to top and vice versa):

- **From the grassroots to the national level:**
  - The plan/budget proposals are defined at the grassroots level of each entity. This information is compiled territorially in the municipalities and provinces, and also by the OACEs in relation to the entities that belong to their sectors. The figures for the draft annual plans and budgets of each institution, company or entity at both the municipal and provincial levels, including cooperatives, are discussed annually with all workers and members of cooperatives for their formulation. Once approved by the institutional bodies that apply: Municipal, Provincial and National Assemblies of People's Power, workers are informed of the figures in the budgets and plans approved, and workers' assemblies are periodically held to discuss compliance with the figures and plans approved.

  - The MEP prepares a proposal for an economy/budget plan, defining priorities according to the availability of resources existing in the country, and submits it to the ANPP for approval.

- **From the national level to the grassroots:**
    - Once approved by the ANPP, a process of disaggregation of the figures from the national level to the grassroots begins.

351. Government Guidelines indicate that the drafting of the National Economy Plan must take into account the financing needs to support the implementation of the State Plan for Confronting Climate Change (Task Life). This provides an opportunity for the project in ensuring that sectors and local governments include within their budgets and actions the incorporation EBA and the sustainability of coastal ecosystems as a measure of adaption fully in line with Tarea Vida.

352. **The Banking System in Cuba:** Representative offices of foreign banks in Cuba are part of the National Banking System. The 11 representative offices of foreign banks that exist in the country do not include the Banking Agencies recognized by the GCF as "Accredited Entities", several of which do not have or discontinued their relations with Cuban banks and entities due to the economic, commercial and financial blockade imposed unilaterally by the United States government against Cuba with effects of extraterritorial scope. (See in this link the Representation Offices of foreign banks and financial institutions based in Cuba: http://www.bc.gob.cu/sistema_bancario_y_financiero).

353. In addition, according to national legislation 78 "Representative offices of foreign financial institutions are prohibited to: 1. Perform active or passive operations in the national territory; 2. Manage operations or services that are not characteristic of the institution they represent; 3. Raise funds and invest them directly or indirectly in the country; 4. Perform exchange operations; and 5. Offer or invest securities and other foreign resources in the national territory". It is not possible in Cuba to execute this GCF project through a banking institution.

4.5 Practical Implications and Effects of the Economic Blockade of the United States against Cuba

354. Cuba has *sui generis* economic, commercial and financial circumstances, almost unique in the world.

355. For six decades, Cuba has been subject to an economic, commercial and financial blockade imposed **unilaterally** by the government of the United States of America. (MINREX, 2018)79 to which the international community, within the framework of the General Assembly of the United Nations, has overwhelmingly called for an end in 28 consecutive occasions, the last one on November 7, 2019 by 187 favorable votes, only 3 negative votes (United States, Brazil and Israel), and 2 abstentions (Colombia and Ukraine).

356. The blockade against Cuba is the most severe and prolonged unilateral sanctions system that has been applied against any country in the world80, and Cuba is the only country in the world for which the US Trade with the Enemy Act of 1917 (TWEA) is in force, the oldest of its kind, under which the Cuban Assets Control Regulations (CACR) were adopted in 1963, thereunder was established the prohibition of all financial and commercial transactions with Cuba, unless approved by a license; the prohibition of exports of Cuban origin to the United States; and the prohibition, to any natural or legal person of the United States or third countries, of carrying out transactions in US USD with Cuba, among other restrictions.[81]

357. Other blockade laws also prohibit subsidiaries of US companies in third countries from trading goods with Cuba or Cuban nationals; that ships from third countries that reach Cuban port enter the

78 Decree-Law 362 "On the institutions of the Banking and Financial System ", published in the Official Extraordinary Gazette number 58, dated October 12, 2018. (in Spanish)
79 Ministry of Foreign Affairs. Cuba report. Under resolution 72/4 of the United Nations General Assembly, entitled "Need to end the economic, commercial and financial blockade imposed by the United States of America against Cuba. Havana, 2018. 56 pp (http://www.minrex.gob.cu/sites/default/files/ficheros/informe_bloqueo_2018.pdf)
80 Report of the Secretary General of the United Nations "Need to end the economic, commercial and financial blockade imposed by the United States of America against Cuba," Document A/73/85, August 29, 2018, p. 29.
81 Report of the Secretary General of the United Nations, Document A/73/85, August 29, 2018, p. 33.

United States within 180 days, except those that are licensed by the Secretary of Treasury, as well as trips by Americans to Cuba for tourist purposes.82

358. Because of the US blockade laws and its extraterritorial application, which also negatively affects Cuba's economic, commercial and financial relations with banks and companies from third countries, Cuba has limited possibilities of internal and external financing from international cooperation and commercial banking, with the exception of United Nations agencies, including UNDP, and a group of institutions from several countries. The blockade laws prevent Cuba from entering international and regional financial institutions, and benefitting from the large concessional development credits received by other countries in Latin America and the Caribbean from the World Bank, the International Monetary Fund and the Inter-American Development Bank, among others. In that sense, the Green Climate Fund is an important financing option for Cuba.

359. UNDP is one of the few entities accredited with the Green Climate Fund with which Cuba can work. Cuba does not have a national direct access institution accredited with the Green Climate Fund and on the other hand, as part of the extraterritorial application of the United States Blockade against Cuba, several banks, some of them Entities Accredited with the Green Climate Fund, have ceased their relations with Cuba having been fined by the Government of the United States for conducting financial transactions in US USD with countries such as Cuba.

360. For example, in 2004 the US Federal Reserve Bank fined with 100 million USD the most important private bank in Switzerland for financial operations in USD with a group of countries subject to unilateral sanctions by the United States. 83 In November 2006, the two largest banks in Switzerland, Union Bank of Switzerland (UBS) and Credit Suisse, ceased all transactions with Cuba, as both institutions reported.[84]

361. Because of the significant losses annually caused by the US blockade against Cuba, the country has limited potential for domestic savings to finance on its own and co-finance the large investments required for climate change mitigation and adaptation. To give some notions of the impacts, the damages accumulated due to the blockade for almost six decades reach 922,630 million USD, taking into account the depreciation of the dollar against the gold value in the international market. At current prices, the blockade has caused quantifiable damages for more than 138,843.4 million USD. Only in one year, from April 2018 to March 2019, the blockade has caused losses to Cuba in the order of **4,343.6 million USD**[85]. The impact caused by the blockade to Cuba's foreign trade during the period amounts to 2 896 581 555 USD, of them 2 343 135 842 USD of income not received for exports of goods and services[86].

362. An increase in freight costs of shipping and insurance of commercial imports, and for international cooperation projects, has also been a practical result of the emabargo due to the need for geographical relocation of trade in distant markets, mainly Asian and European. Due to the geographical relocation of trade, Cuba lost 1,020.2 million USD in one year, from April 2018 to March 2019, which represents a growth of 18% in relation to the same period in previous years. To this is added the increase in the cost of country "risk financing" whereby creditors apply rates of approximately 5% above normal. These indicators are influenced by the lack of access to bank or soft loans; therefore, Cuban companies are forced to work with commercial loans granted by the suppliers themselves under more disadvantageous financial conditions.[87]

363. The blockade cause many difficulties for the execution of international cooperation programs and projects, due to commercial restrictions or prohibitions on acquiring inputs from US companies and their subsidiaries based in the United States or other countries. It also reduces the number of possible suppliers, increases the prices of freight, insurance and goods, technologies and services, compared to

82 Report of the Secretary General of the United Nations, Document A/73/85, August 29, 2018, p. 34.
83 https://www.swissinfo.ch/spa/multa-a-ubs-por-dar-d%C3%B3lares-a-cuba/3896962 May 11, 2004.
84 German-Swiss weekly "SontagsZeitung" cited on November 13, 2006 by http://www.cubadebate.cu/especiales/2006/11/13/los-dos-mayores-bancos-suizos-cesan-todas-las-transacciones-con-cuba/
85 Report of the Secretary General of the United Nations, Document A/74/91/Rev.1, August 19, 201 9, Page 26.
86 Report of the Secretary General of the United Nations, Document A/74/91/Rev.1, August 19, 201 9, Page 44.
87 Report of the Secretary-General of the United Nations, Document A/74/91/Rev.1, August 19, 201 9, Page 45.

those obtained by neighboring countries of the Latin American and Caribbean region in the United States and even in third countries, and limits the competitive process for the purposes of importing equipment, inputs and other supplies not available in the domestic market. (UN, 2017)88

364. According to the laws that impose the United States blockade against Cuba (1992 Torricelli Law, 1996 Helms-Burton Law), US companies and subsidiaries in third countries are prohibited from selling products to Cuba, under penalty of sanctions for those who violate the ban. This affects the purchase of most US-owned technologies, including ICT, and third-country technologies and goods that contain more than 25 % of US raw materials or components. These laws impose restrictions on companies for shipping placed in Cuban ports. In addition, shipping lines that arrive in Cuba have irregular itineraries, resulting in a reduction in the availability of ships. This becomes a challenge and has a negative impact on the delivery times of the contracted goods.

365. On a financial level, the blockade prevents transfers in USD. For this reason, and despite the fact that the budgets of all projects are registered in USD, all external transfers are made in a currency other than USD (usually in euros). On the other hand, and even when payments are made in a currency other than USD, banks randomly withhold payments to prepare additional information that may be requested by the Office of Foreign Assets Control (OFAC) of the Treasury Department of the United States.

366. The blockade has direct implication on project development as seen the following issues that need to be taken into account:

- **Need of imports for the implementation of international projects**: Availability for the purpose of sale or rental of equipment (measurement, transportation, computing), inputs and other supplies is very limited , in the domestic market for the same reasons of the economic blockade of the United States and its extraterritorial effects, noted above. Many of the limited existing heavy equipment and machinery are of American technology of the 1950s, of the former Soviet Union or of the former socialist countries of Eastern Europe; they have more than 3 decades of exploitation, lack spare parts since their production has been discontinued, suffer frequent breakdowns and are high fuel consumers, thus highly polluting the environment, because they are obsolete and therefore inefficient. Due to this reality, international cooperation projects require import processes for the purchase of equipment, inputs and other supplies not available in the country, which are necessary to ensure the achievement of the project objectives. Furthermore, this import process is developed taking into account the limitations of access to the international market imposed by the economic, commercial and financial blockade of the United States Government on the country, and which additionally prolongs and increases the acquisition, insurance and transport processes to the country.

367. In order to guarantee the efficient use of the resources acquired within the project framework, as well as the sustainability of project interventions once its execution period has expired and external resources have been exhausted, the country requires that national regulations for the import of goods be complied with. Correspondingly, the beneficiaries of international cooperation projects require prior approval in the National Economy Plan of the goods and services related to project execution. Other national permits are required in the case of a significant group of goods (IT, means of transportation, among others) that must be issued by identified government agencies. (MINCEX, 2018)89

- **Need for the acquisition of means of transportation in support of project execution:** In Cuba there are significant difficulties regarding transportation availability and stability. The development of the different activities planned at national and local level requires the efficient

88 A/72/94. Report of the Secretary General "Need to end the economic, commercial and financial blockade imposed by the United States of America against Cuba." Seventy-second session. UN, 2017. https://digitallibrary.un.org/record/1304108/files/A_72_94-EN.pdf

89 Resolution 30/2018 of the Ministry of Foreign Trade and Foreign Investment, dated January 25, 2018, establishes the Procedure for monitoring compliance with technical regulations on import and export products and indications for processing of the merchandise inspection procedure. Published in the Official Gazette of the Republic Extraordinary number 23, dated March 28, 2018.

provision of transportation services to meet the objectives set out in the project and in the established schedules, at the lowest possible cost. These services can be rented occasionally and with difficulties from different entities, either public or private individual carriers (See Options Analysis). Unlike other countries, in Cuba there are no agencies or dealers of the major international manufacturers of means of transportation, such as Hyundai, Volvo, VW, Mitsubishi, Nissan, etc., that offer rental plans (leasing) at reasonable rates, or purchase within the country.

368. Most means of transportation in the country have decades of use; in the case of private ones, they are from US origin with more than 60 years of operation, usually with high breakage rates, unexpected and unstable availability due to long periods of inactivity given the lack of spare parts, due to the US blockade, in addition to having a high fuel consumption that increase transportation rental costs, and are highly polluting to the environment because they are obsolete technologies. Prices are set by the law of supply and demand, and they are high due to low supply for a high unmet demand.

- **Need to factor in fuel costs:** External financing is required to carry out this adaptation project that is nonprofit and does not generate income from the sale of goods or services in the national or international market and, therefore, it will not have a source of self-financing in convertible currencies to cover the cost of the fuel it will consume. Given the multimillion foreign currency income losses and annual overdrafts due to the US blockade, estimated at billions of USD annually, the country does not have the resources in foreign currency to finance the fuel that will be consumed for the execution of the project.

369. The country is a net importer of fuels and their derivatives. All means of transportation and machinery in the country operate on imported fuel, which is purchased at high prices, with high costs of insurance and freight due to the economic blockade. The availability of fuels in Cuba is unstable and cyclical, and is often low at certain times for some types of fuels, which has worsened since 2019 as a result of the sanctions against international fuel suppliers, shipping companies and tankers from third countries that transport fuel to Cuba. For these reasons, fuels have higher prices than those in other countries and limited quotas of fuel are fixed for companies and organizations, according to their plan and budgets approved each year, because of the external constraints suffered by the country.

370. Due to the serious foreign currency limitations of the country's economy and the difficulties in importing fuels, fuel allocation is prioritized to productive companies generating incomes, particularly those that produce goods and services for export and, therefore, foreign currency incomes, in order to recover the costs of the fuel they consume to finance its import costs.

- **Need to make insurance payments in foreign currency and the acquisition of spare parts through international project financing:** The Ministry of Transportation (MITRANS) has a regulation establishing that the means of transportation acquired with international cooperation funds must be insured by the international source. Even if there is no such provision, the rules of Cuban insurance companies establish the need to purchase insurance in convertible currency for several reasons:
    - The Insured will only receive as benefit, a total or partial compensation in Cuban pesos (CUP), currency that cannot be used for the import or acquisition in the local market of the insured parts and pieces.
    - In Cuba, only standard vehicle parts and accessories are offered in the market to any vehicle (batteries, tires, oil filters and fuel, belts, spark plugs, etc.); only payments through accounts in USD (USD) are accepted.
    - Insurance contracts in convertible currency for legal persons include the insured value of the amount corresponding to the invoice for the purchase of vehicles and accessories, which would correspond to the real value of vehicles or other equipment imported.

371. It is not the international practice of insurance companies that the insurance covers payments for vehicle breakdowns or spare parts due to the normal use or deterioration of a vehicle or equipment, or those that must be replaced according to technical standards and schedules of useful life and safety of vehicle or equipment manufacturers.

372. Since in Cuba there are no agencies or representations of vehicle or truck manufacturers , due to the economic blockade, it will be necessary to import spare parts for cars and equipment acquired for the execution of the project from third markets, paying in convertible currency, since they will not be available in the limited local automotive parts market.

- **Need to make payments of telecommunications services for the execution of the project.** The Empresa de Telecomunicaciones de Cuba S.A. (ETECSA) is a public limited company. ETECSA's telecommunications rates for companies and institutions are in convertible currency (USD), as are the rates for international communications, even for natural persons. As this is an adaptation project, no income is generated from the sale of goods or services in the national or international market, therefore it will not have a source of self-financing that allows it to cover the foreseeable expenses of telecommunications in convertible currencies, being mostly long distance national and international communications, since the project is executed in several provinces distant among themselves and from the capital of the country, and because UNDP is the international entity accredited as the project's implementing agency.

V. National Capacities to Manage Climate Change Impacts

373. Traditionally, Cuba´s tropical storms response and management strategies have focused on emergency preparation and attendance rather than on planning for disaster risk reduction. In that sense, the GoC has successfully introduced early warning mechanisms and clear emergency protocols to reduce the impact of storms in the loss of lives. This has included networks for local mobilization such the Municipal Council Defense groups, under the authority of National Civil Defense, that mobilize actors at a community level when storms are predicted to hit ensuring that emergency resources are available to address storms' immediate impacts. While these are important steps in the face of an immediate emergency and provide a general framework for adaptive action, they are insufficient to manage multiple ongoing threats consequence of climate change.

374. Initial investments and national research have also been successful in identifying the country´s climate vulnerability, including drought and SLR vulnerability and hazard risk assessment maps. The development of the "Macro-project on Coastal Hazards and Vulnerability (2050-2100)", focused on these areas´ adaptation challenges including oceanographic, geophysical, ecological and infrastructure features, together with potential risks such as floods, saline intrusion and ocean acidification. Cross-sectoral information integration was a key tool to identify climate risks and potential resources (existing instruments, institutions, knowledge, etc) to manage it. This research provides an important foundation but has yet to be translated into concrete actions particularly at the municipal level.

375. International cooperation has also provded an important baseline of experience through projects that have further allowed the GoC to innovate on various institutional mechanisms as well as develop important best practices on ecosystem restoration, integrated coastal management, succesful capacity building and on integrating monitoring systems for enhanced environmental management particularly in the case of marine ecosystems. These projecst have been evaluated positively throughout their development and have created mechanisms such as the Capacity Building Centres that have been expanded and maintened through GoC funding, thus demonstrating the relevance of these projects in national capacities.

376. Table 13 summarizes the most relevant baseline projects and highlights key results, lessons learned, and gaps identified for EBA and coastal adaptation. The proposed project aims to address such gaps, to efficiently achieve efficient climate resilience in the target coastal sites

Table 13 - International and National Experiences with scaling up potential.

Key Results	Lessons Learned to be Scaled Up	Key gaps / Addressed in this project
Sabana Camagüey /GEF/UNDP		
Integrated Coastal Management (ICM)	An ICM approach facilitates addressing specific situations identified in the coastal zones of each intervention area of the project. The project demonstates the relevance of an integrated approach through the active participation of local governments in matters of environmental risk management and natural resources management The project highlighted the importance of achievieng institutional coordination at all levels, particularly in terms of financial planning and financial agreements/mechanisms and ensuring thi is addressed early in the project. This has been included as a result of Activity 2.3 (municipal workplans with budgets that incorporate EBA). As well as the	This practice has been validated widely in Cuba. 60% of the coastal territories of the country have ICM programs, certified by the National Environmental Authority, in accordance with the corresponding Ministerial Resolution. 40% (among those the most vulnerable to CC) have yet to adopt this tool. The approach to ICM failed to take into account EBA within its coastal management thus excluding a key issue for coastal management and vulnerability assessments particularly as it relates to zones at risk of disappearing under coastal flooding.

Key Results	Lessons Learned to be Scaled Up	Key gaps / Addressed in this project
	involvement of all stakeholders in a participatory manner.	
Coastal and marine ecosystems monitoring protocols	Developed and implemented monitoring protocols for coral reefs and marine ecosystems. These will be applied in the project in Activity 1. 2.	Exclusion of indicators of specific relevance to the challenges of CC adaptation, including ecosystem responses to pressures from CC, and the effectiveness of EBA measures in terms of ecosystem health and the buffering of coastal communities were not incorporated
Identification of the existing knowledge gaps related to environmental issues and sustainable natural resource management in the established target groups. Training and support materials.	The results of this project contributed decisively to changes in understandings, planning and actions by decision-makers and sector technicians. Ecosystems restoration guidelines for stakeholders´ awareness creation and training. Capacity building guidelines at a community level	This experience will contribute to the design of actions in Output 2 to extend the paradigm change proposed through the present project up to national level.
Capacity Building Centres: Joint instruments of ICM & capacity building. At CBC occurs the integration, conciliation and analysis of problems and opportunities in the decision-making process going beyond training, education and awareness-raising activities in communities.	Central points for the identification of hazards and climate change risks and vulnerabilities. This experience will be scaled up from an adaptation perspective in this project.	Training did not include CC-adaptation. The use of climate data, when available, is limited to extreme events responses, rather than a proactive approach to risk management. Curriculas and KM material need to be enhanced to approach these issues with trainings to local populations.
"Application of a regional approach to the management of coastal and marine protected areas in the region of the Southern Archipelagos"/GEF/ UNDP		
Monitoring programs were applied to Marine Protected Areas (MPAs). A publication on the status of the Southern Archipelagos coastal and marine biodiversity was produced.	Use of the protected areas monitoring and management tools produced will be of much relevance to the proposed project. Integration of lessons learned in protected areas the management applied to EBA.	The interaction of terrestrial and Marine systems and the influence of CC-threats were not considered. This is a key input required to measure EBA capacity for coastal resilience.
Prevention, control and management of Invasive Exotic Species (IES) in vulnerable ecosystems in Cuba/ GEF/UNDP		
	The methodological bases (on risk analysis, environmental impact evaluation and protective areas management programs) could be applied in the proposed project, together with the use of corresponding monitoring protocols and Information System for the management and eradication of IES. Monitoring activities aimed at assessing climate variability influence on species (invasive and native) behavior.	It mainly focused on biodiversity objectives, climate adaptation or coastal zones resilience were not an objective.

Key Results	Lessons Learned to be Scaled Up	Key gaps / Addressed in this project
	Methodological documents on risk analysis, environmental impact evaluation and the effectiveness of PA management programs, which are currently being applied nationwide. It developed black, white and grey lists according to the impacts and risks of these species and the protocols for their monitoring.	
Reduction of environmental vulnerability to coastal floods due to sea penetration through Ecosystem-Based Adaptation in the south of the provinces of Artemisa and Mayabeque (Manglar Vivo)		
Restored mangrove and swamp forest ecosystem to improve the resilience of the coastal belt and reduce the impacts of the coastal floods	This experience will be scaled up directly in particular for rehabilitation of mangroves ecosystem and swamp forests, as well as for the coordination and processes involved with forestry sectors. Numbers of hectares recovered by this project serve as baseline estimated in the proposed project log frame. Lessons include: Methodological bases for functional rehabilitation of coastal wetlands, including incorporating a wide variety of restoration efforts which can include: comprehensive reforestation, enhanced monitoring and control efforts, and the creation of detailed vulnerability assessments to better understand how climate change is affecting communities and their ecosystems. Working actively with local schools to create awareness and promote a strong link between coastal populations and their environment. Techniques for germination and seed treatment of native species to be used in mangrove rehabilitation Techniques for hidrological restoration of coastal wetlands Ensuring a high level of involvement of governments and coastal communities Approach to the creation and training of voluntary groups of members and communities for monitoring, cleaning, etc. Initial methodological bases for the study of the cost-benefit of EBA actions in mangrove ecosystems.	Limitations on in its EBA approach are mainly related to focusing only in mangroves and not on integrated ecosystems connectivity and functionalities restoration including a monitoring system to evaluate the impact that the rehabilitation of coastal wetlands has on the marine ecosystem (sea grass and coral reefs). The project did not consider developing more general capacities and user based information for adaptation and as such missed the opportunity to allow for the integration of adaptation measures within general local contexts. Implementation of a monitoring system adressing water quality and availability at the involved hydrographic basins. From the information generated at the local level, develop knowledge products and meteorological information to support local decision-making The development of methodological bases for CBA was considered by the project but at a late stage. More experience needs to be developed in incorporating this analysis within an EBA framework to value its results in terms that are more understandable to decision makers.

Key Results	Lessons Learned to be Scaled Up	Key gaps / Addressed in this project
The Country Partnership Program (CPP) on Sustainable Land Management (OP 15 GEF/UNDP/UNEP) (2008-2023) Developing capacities for addressing land degradation threats in Cuba		
Development of systems and capacities for the management of environmental information. Guidelines for climate related disasters prevention Increased capacities for water management.	Guidelines and approaches for information management and capacity building have the potential to contribute to CC resilience and are therefore relevant for this project. Strengthen meteorological stations network to improve an understanding of current climate variability and support decision making. In this particular case for droughts	It does not have a specific focus on adaptation, or on the specific threats facing coastal zones.

5.1 Baseline Projects

5.1.1 UNDP/GEF Sabana Camagüey Project: Integrated Coastal Management as a fundamental governance process in the coastal ecosystems of Sabana Camagüey

Launch:	1999
Conclusion:	2007
Technical and financial external contribution:	GEF
National implementation Agency:	Environmental Agency, CITMA
Total Investment	US$ 4,119,448

377. The Sabana Camagüey project focused on biodiversity protection and sustainable development in harmony with tourism development in the ecosystem that includes the Sabana Camagüey archipelago, which is characterized by high fragility. It has been implemented in three phases, starting 1993 with a total duration of 20 years. It started by supporting the priority Protected Areas (PAs) of the archipelago and concluded with implementation in terrestrial productive landscapes, in areas that had been subjected to intensive cultivation of sugarcane for centuries, while ensuring correct environmental management through Integrated Coastal Management Plans. The main contributions to the proposed project are institutional strengthening, conceptual innovations and practical experiences generated through the project, particularly with regard to the application of ecosystem, landscape and inter-sectoral visions to natural resource management. This is the case as the proposed project will also involve a landscape-wide approach and places strong emphasis in community involvement in ecosystem management.

378. In particular, the UNDP/GEF Sabana Camagüey Project, in its first and second stages (1993- 1998; 1999 - 2007) contributed to developing national capacities for the monitoring, collection and processing of information on coastal ecosystems. These capacities resulted in the generation of the first methodological protocols for monitoring, which have subsequently been improved. This experience has enriched national research centers (at national and provincial levels) and provided for technically trained personnel, who systematically evaluate the health status of these ecosystems, and formulate actions for their restoration.

379. Furthermore, the institutionalization of Integrated Coastal Management programs (a result of the project) in many municipalities resulted in annual municipal plans that needed to incorporate activities to implement the programs associated with the programs and ensuring that these had an associated budget. This has supported in the sustainability of the ICM methodology that was in turn supported in the use of financial planning tools.

380. A best practice developed through the project led to the creation/ consolidation of 20 Capacity Building Centers for Integrated Coastal Management (CBC) in municipalities, which surpassed the original project expectations (20 CBCs instead of 12). According to the interviews carried out during the evaluation, the CBCs constitute one of the most important project impacts. Through these centeres the project supported a very large number of workshops with representatives of key productive sectors,such as fishermen, fishing inspectors, agricultural workers, tourism managers and workers, as well as with institutional actors. At the community level, primary school children were educated on the values of the Sabana Camagüey ecosystem through partnerships with Circles of Interest. The final evaluation of the project is clear in stating that the strong emphasis on training, education and awareness raising through the CBC strategy led to a significantly higher level of awareness within the communities on the natural values of the Sabana Camagüey ecosystem and on sustainable productive activities.

381. The successful experiences in the execution of this project, and the protocols that have been derived from them, are lessons learned to be scale up in the present GCF project. Furthermore, they show that capacity and experience exist in the restoration of ecosystems, in particular monitoring of coral reef. While this project had an approach of conservation and recuperation of ecosystems and their biodiversity,

demonstrable co-benefits have been generated in the form of strengthening of resilience to impacts of CC. Based on this experience this proposed project goes further to implement an approach with the main aim of generating greater resilience to the impacts of CC in coastal zones through the EBA measures in coastal wetlands.

5.1.2 Awareness raising and training of key stakeholders as the basis for changes in behavior: UNDP Project "Capacity 21"

Launch:	1999
Conclusion:	2006
Technical and financial external contribution:	UNDP
National implementation Agency:	Environmental Agency CITMA
Total Investment	US$ 483,900

382. UNDP project "Capacity 21" was implemented as one of the components of the Sabana Camagüey project. It generated lessons that guide activities being proposed for the awareness raising and training of key stakeholders in the areas of intervention in restoration action as well as in investing in capacity building measures at a community level.

383. The project began by identifying the existing knowledge gaps in the established target groups (specific sectors in the municipalities, women, children, students of different levels, decision-makers, Governments, artists, teachers), regarding environmental issues and sustainable natural resource management, and the definition of the issues to be developed for the training of these stakeholders, together with the selection and preparation of trainers for each target group in each one of the 20 municipalities of the area of intervention of the project.

384. The support materials developed are part of a basic environmental training module containing 12 thematic bulletins, including a methodological bulletin aimed at the trainers, a manual of best environmental practices, 6 videos, and 9 information charts on different issues, all aimed at disseminating knowledge to fill observed gaps. The support materials were all produced with the participation of members of the communities and interventions of experts of the scientific institutions and sector professionals, both from the communities and from national institutions. In parallel, the communities were involved in local debates (neighborhood debates), which constitute a tool that will be applied in output 2 of the present project in relation to CC.

385. The capacity development process was implemented over a period of five years (2000-2005, in the 20 municipalities of the project. It benefited around 15,000 people, with priority given to the group of decision makers in local Governments, given the importance of the support provided by these stakeholders in response to the local problems associated with the effects of adaptation. This consideration is taken into account in the detailed design of the awareness-raising activities of the present project.

5.1.3 Application of a Regional Approach to the Management of Marine (MPA) and Coastal Protected Areas (PAs) in Cuba's Southern Archipelagos

Launch:	2009
Conclusion:	2014
Technical and financial external contribution:	GEF
National Implementation Agency:	National Centre for Protected Areas
Total Investment	US$ 5,710,000

386. This project was focused on conserving coastal and marine biodiversity of global importance in Cuba to counter threats including overfishing, eutrophication, sedimentation and the evolution of hydrological conditions. Its specific objective was to guarantee that marine biodiversity of global importance was conserved and utilized in a sustainable manner through an expanded, strengthened and integrated network of marine and coastal protected areas (AMP) in the region of Southern Archipelagos. The instruments and capacities developed by the project are of specific relevance to the actions of the GCF project in support of the sustainable management and conservation of coastal and marine ecosystems that provide CC resilience benefits.

387. The project aimed to deliver three results: 1) Increase in the coverage of priority ecosystems in MPAs, related terrestrial PAs and management units in terrestrial and marine productive landscapes, 2) MPAs in the area of the project are subjected to effective management effective in the framework of a regional subsystem PAs and 3) planning of businesses and associations with productive sectors increase the income of the MPAs and cost efficiency.

388. The project strengthened alliances with productive sectors such as tourism and fisheries and supported the improvement of the financial management of the PAs. Sustainable tourism products were developed for different PAs, with the provision of training on sustainable tourism for tourism guides and local communities.

389. Preliminary economic valuation studies were carried out of ecosystem services, which increased the understanding of the economic value of these services, especially in productive sectors and the Government. The studies served as a basis for the development of GEF project on the issue, which is currently under execution.

390. Because marine and coastal ecosystems are open ecosystems, with great interaction among them, resilience models to the effect of CC require the incorporation of protected areas to achieve two purposes, (1) have representative samples of fully protected ecosystems and resistant to serve as seed sources in case of catastrophic effects and (2) as habitat for control monitoring systems proposed by the project. For this experience monitoring and management of protected ecosystems will be of great importance to the project, as well as opportunities to integrate lessons learned from EBA in the management of protected areas.

5.1.4 Improving the prevention, control and management of Exotic Invasive Alien Species (IAS) in vulnerable ecosystems in Cuba

Launch:	2011
Conclusion:	2016
Technical and financial external contribution:	GEF
National Execution Agency:	National Centre for Protected Areas, CITMA
Total Investment	US$ 5,018,182

391. This project constituted a significant contribution to the strengthening of the policy, judicial and regulatory framework for environmental activities in Cuba. It filled in the gaps existing in the National Program of Biological Diversity and the National Environmental Strategy, in relation to knowledge for implementing the prevention, management and control of the IES at national level. The capacities developed through this project are of special relevance for the GCF project because the IES contribute to reducing the resilience of the ecosystems that make up the Coastal Wetland, besides there is the possibility that they present greater risks to health and the resistance of human and biological communities in the coastal zone.

392. The project covered 7 terrestrial intervention areas and the coastal–marine zone of the main island of Cuba, and 60 working sites made up of protected areas, natural areas in terrestrial, coastal and marine

ecosystems and productive ecosystems linked to the livestock, agriculture, fisheries, tourism and forestry sectors. 13 species of flora and 16 of fauna were covered by the project. The project had nationwide coverage, including all of the provinces belonging to the western, central and eastern regions of the country.

393. Lessons learned on the management of coastal species will directly inform restoration actions envisioned within the first project output in particular in relation to the eradication of Invasive Alien Species (IAS).

5.1.5 Reduction of environmental vulnerability to coastal floods due to sea penetration through Ecosystem-Based Adaptation in the south of the provinces of Artemisa and Mayabeque (Manglar Vivo)

Launch:	2014
Conclusion:	2020
Technical and financial external contribution:	Adaptation Fund of the Kyoto Protocol
Total Investment	US$ 6,067,320

394. This initiative aimed to reduce vulnerability to coastal floods in the South of two provinces (six municipalities) located in the Northwestern part of Cuba (Artemisa and Mayabeque), through EBA, addressing both coastal erosion and saline intrusion. This project has generated enormous experience in mangrove management and recuperation, which will be directly applied by the GCF project.[90]

395. The intervention covers 84km of coast, with the aim of protecting the ecosystem against coastal floods, and consists of three components: 1) recuperation of the mangrove ecosystem to improve the resilience of the coastal belt and reduce the impacts of the coastal floods, 2) participation of sectors and communities in the planning of the coastal zone and 3) strengthening of institutional capacities and the provision of information to promote the effectiveness and sustainability of adaptation measures.

396. The project re-established the coastal belt of red mangrove *(Rhizophora mangle*) in two geographic sectors (Surgidero de Batabanó and Punta Mora) together with important actions such as the evaluation and monitoring of the mangroves and swamp forests, the restoration of 1,145ha of mangrove and 1,401.3ha of swamp forest; the identification of 20 invasive exotic species per site, with proposals for control and management; the spatial delimitation of the types of coverage in the initial stage of the project (mangrove, swamp grasslands, swamp forests); realization of space-temporal analyses of the types of coverage (scrubland, crops, mangroves, forestry plantations, swamp forests, swamp grasslands, artificial areas, water); the monitoring of vegetation indices and the evaluation of the functioning of freshwater currents.

397. As a result of the project, protocols for the restoration of mangroves have been developed with important results including the assessment of restoration periods and growth, the capacity for resilience to coastal stresses as well as their impact on the immediate ecosystem[91]. Planting methods that have demonstrated the survival rate of the mangrove at above 85% in areas where coastline erosion has been

[90] https://undp-climate.exposure.co/splendor-of-the-living-mangrove

[91] Manglar Vivo (2019). Metodos de intervención para la recuperaion de la Salud del Ecosistema de Manglar en el Sur de las provincias Artemisa y Mayabeque. CITMA. Cuba p.15-16 and 25-28;

Almeida LD, JM Guzmán, J Abreu, M Vales (2020). Cajío, lo que el viento se llevó y el mangle protegerá. Colección de Estudios de Casos "Experiencias en el enfrentamiento del Cambio Climático". La Habana, Cuba, 19 pp.

significant is a key lesson learned from this project that will be put in place in the targeted vulnerable areas.

398. Lessons include the incorporation of rehabilitations measures that initiate through the transformations in the conditions of the substratum through water management and correct water circulation to favor microbiane activity in the organic decomposition porsees followed by enrichment actions through red mangrove propagules. In highly deforested areas “island” restoration methos where used based on Central and South American experiences. This measures allows the focalization of preparation work in site and planting in small spaces withn the deforested areas with the objective of optimizeing the substrated process and the interspecific development amongst the propagule, this method allows a simulation of the natural regeneration process within the degraded area.

399. In terms of ensuring the resilience of the restoration methods, particular attention was made to the restoration interventions sites. For example, in mangrove plantings near the sea borded (with submerged roots), the project innovated through the estanquillo process that allowed the mangrove planting to withstand increased wave activity until achieiving the stability required to manage this pressure (4 years estimated). The implementation of this method resulted in a high survival rate of the mangrove at above 90% (see picture below).

400. In terms of managing drought like conditions within an area, registries kept by the Forest Entripise demonstrate the success of restoring the hydrology. In 2015, the first experiences of niches and plantations were applied in one of the target areas that had been facing an extreme drought event with consequences on mortality and lack of establishment of the red mangrove propagules. Hences the project worked to to open channels and ditches to refresh the planting areas with sea water (of lower salinity thana the marsh) and lower the salinity levels while refreshing the plantatings and the establishment of new propagules. This technique was further enhanced with the speckling of forest nursery species that favored the achievement and survival of areas planted in 2015 that were affected by the drought conditions. This work was later complemented by the manual clearing of targeted ditches 2 years later to increase the freshwater flow[92].

401. Results taken during the project lifetime in planting sites demonstrated a reduced salinity rate particulatly in areas where hydrological restoration took place and imporoving the natural regeneration of mangroves. Data from logs at each project site recorde a decrease in the interstitial salinity from more than 50 ppm to approximately 40 ppm at some sites. In the areas near channels where rehabilitation was

[92] Registries from the Mayabeque Forest Enterprise and also cited within Manglar Vivo (2019). Metodos de intervención para la recuperaion de la Salud del Ecosistema de Manglar en el Sur de las provincias Artemisa y Mayabeque. CITMA. Cuba.

undertaken there was a more marked decrease in salinity, evidenced by the difference in height of the plant individuals planted near the channel, with heights of between 3 m and 4 m, while those away from rehabilitated areas only grew to between 1m and 2m.

402. Imaging from the project has also shown promising results in the impact of mangroves in managing coastal retreat as can be seen in the below images taken in Cajio prior to the project and in 2020. These demonstrate mangrove expansion towards the sea hence providing services in sediment trapping and in providing an increased buffering zone to the population.

403. Information from the project has been consolidated into learning products and scientific publications that will be published and have also served to inform the restoration protocols that will be implemented through the project (see Footnote 91).

404. This experience will be scaled up directly through Output 1 in particular for rehabilitation of mangroves ecosystem and Swap Forest ecosystem, as well as for the coordination and process involved with forestry sectors. Numbers of hectares recovered by this project serve as baseline estimated in the proposed project logic framework.

5.1.6 The Country Partnership Program (CPP) on Sustainable Land Management (OP 15 GEF/UNDP/UNEP)

Launch:	2008
Conclusion:	2023
Technical and financial external contribution:	GEF
Total Investment	US$ 10,000,000

405. The CPP has been developing capacities for addressing land degradation threats in different contexts in Cuba over the last decade. It does not have a specific focus on adaptation, or on the specific threats facing coastal zones, but many of the approaches that it has promoted have the potential to contribute to CC resilience particularly in terms of their impact in ecosystems and are therefore relevant for the GCF project. These include the development of systems and capacities for the management of environmental

information, measures for preventing disasters related to extreme climatic events, and capacities for water management.

5.2 Cooperation Projects under "Tarea Vida"

406. As mentioned in the previous section, in 2017 the GoC approved the State Plan "Tarea Vida" to counteract the damage that could occur in Cuba due to CC in the next years. This plan was a result of the research developed by the Academy of Sciences of Cuba in 1991, as well as on the analysis of vulnerability in coastal areas of Cuba against the expected impacts of climate change in 2030, 2050 and 2100 published by Iturralde and Serrano (2015). These analyses concluded on the increasing risk of the entire archipelago from climate change.

407. Considering the nationwide risk, the implementation of "Tarea Vida" has promoted and developed actions focused on the protection of soils, water resources, marine-coastal ecosystems and on reducing the vulnerability of its coastal settlements through multiple initiatives that contribute to the differentiated attention of the vulnerabilities identified in each coastal zone. As such, interventions within the strategy, have taken into account the the physical geographic, socio-economic and vulnerability characteristics of each coastal settlement in the country (about 5 thousand km of coastline, including 94 coastal municipalities) all which are considere vulnerable to some degree in the current and future climate scenario.

408. In recognition that the implementation of the ambitions and immediacy suscribed within "Tarea Vida," required technical capacity support beyond that currently existing in Cuba, the plan included Task 11 set to manage and apply international financial resources to implement investments, projects, and actions that result from each of the tasks included within the State Plan. This has included the design of complementary cooperation projects that through the international support provided to upscale and integrate best practices, to innovate new approaches on natural based solutions and to provide support to key economic sectors will address the main objectives for the implementation of Tarea Vida. These have also been designed to address current national vulnerabilities related to coastal resilience and livelihoods and ensuring the mobilization of key actors in a coordinated manner for effective adapation actions and planning.

409. **FAO/MINAG/GCF**: 'Increased climate resilience of rural households and communities through the rehabilitation of production landscapes in selected localities of the Republic of Cuba (IRES)' which has been appoved for implementation to address the impact of drought in agricultural production in Las Tunas, Villa Clara and Matanza provinces in line with actions 3 and 4 of "Tarea Vida" focused on agricultural and livelihood production and incorporates ecosystem based solutions as a source of livelihood protection to increase the climate resilience of agricultural production and ensure food security through improved ecosystem services from landscape management using agroforestry, silvopastoral systems, reforestation and assisted natural forest regeneration.

410. **UNDP/AMA/EU**: 'Building coastal resilience in Cuba through natural solutions' has been designed to focus on Strategic Actions 1 and 2 and tasks 1,5,7,9, which is being implemented in 4 northern central coastal municipalities (Villa Clara, Sancti Spíritus, Ciego de Ávila y Camagüey) to provide support to the Risk Management Group by enhancing local Disaster Risk Management Centers in an effort to integrate disaster risk management and adaptation into the vulnerability assessment and planning tools of these territories. The project is also innovating with limited nature-based solutions to provide support ot local populations.

411. **UNDP/AMA/GCF**: 'Mi Costa' (Current project under consideration): As has been mentioned this project has been designed to on Strategic Actions 1,2 and 5 under "Tarea Vida" that prioritize the

protection of communities, populations and households through informed and cost effective adaptation solutions and enhanced coastal planning, including marine coastal ecosystems. The project has focused on the Southern Coastline considering their vulnerability to coastal flooding. The current project is largest in territorial scale (encompassing the majority of the southern coastline) and integrates various of the successful approaches and best practices in restoration and natural resource management focusing on their interrelated services with an emphasis on coastal defense and resilience from the hazards of saline intrusion and flooding. As such it is centered on upscaling and integrating to provide an important basis of information on EBA thus respresenting a progressive scale of work that is represented within the length of the project (30 years) that at its end will result in the full-scale, integrated and sustained application of EBA.

412. All projects prioritize ecosystem and nature based solutions in accordance to the GoC's NDCs and will complement each other through lessons learned in the implementation of EBA as a source of livelihood protection, coastal defense and integrating DRR within a wider adaptation framework thus providing strategic support to the GoC in managing CC principle impacts. The paradigm shift promoted by the present project under review, may feed into the conceptual framework of the Landscape Resilience Fund that is being developed through the IRES project to support adoption and implementation of agroforestry, forest grazing and forestry systems in support of landscape resilience, by providing metrics and information into the management of mangrove and wetland restoration processes. The experience of EU project on integrating RRD and ACC, will be an important element that Mi Costa will take into account within its information development and on the intregration of a broad national framework. In turn it will also provide key information from the project's environmental monitoring of the EBA to provide lessons learned to the EU project and share within the larger knowledge management framework developed by the project.

413. The results of these projects are being coordinated and monitored through the GoC by the Inter-ministerial Coordination Committee (CCI).

5.3 National Baseline Research and Experiences

414. A large body of knowledge and information has been generated and accumulated through the national and international projects that have been developed in Cuba over more than 30 years. This experience will feed into the project directly by informing the adaptation and EBA techniques that are included in the proposed project.

415. Of particular importance as the basis for the proposed actions is the "Macroproject on Coastal Dangers and Vulnerability (2050-2100)", which consists of 12 research projects focused on issues of specific relevance to the challenges of adaptation in coastal zones, namely mangroves, geomorphology and coastal dynamics, sea level rise, marine currents, beaches, reef ridges, floods, coastal settlements, saline intrusion, bathymetric services, ocean acidification and information integration. Information for the development of this project has been collected from these research projects to ensure correct targeting based on climate vulnerabilities. The EBA approach has also been considered to be sound as a result fo the information collected from the research projects linking climate vulnerability to coastal areas depending on the state of degradation of coastal ecosystems (Macroproject, Iturralde y Serrano).

416. Other research initiatives and areas of attention, of relevance to the project, include the following:

417. **Mangrove management:** mangroves, which constitute the first line of defense against extreme climatic events as well as acting as a filter for contaminants generated in terrestrial areas, are the most studied ecosystem in Cuba. The project will has included results of these studies and best practices derived from successful pilot projects as part methods for actions for protecting and restoring coastal wetlands and their contribution to resilience to CC.

418. **Coral Reef Monitoring and Restoration:** The GoC has innovated and produced various practical studies on coral monitoring and restoration (led by CITMA, MINAL, University of Habana). These efforts have been enhanced by information pertaining from the Voluntary Early Warning Network for Coral Reefs in Cuba that was established in 2003 and has become a vital source of information on the rate of coral bleaching.

419. Cuba has also been working since 2015 on a coral restoration project within the marine areas in the National Park of Guanahacabibes. The project has been developed with support of international coral experts within The Nature Conservancy (TNC) and local experts and marine biologists from National Aquarium with the aim of restoring the coral population in this highly vulnerable area. For this project 24 coral (*Acropora cervicornis*) nurseries were developed, with coral being then planted through artificial structures in two sites (Laberinto and Cabezo de Marcel). Results have been successful and have replicated similar successful international experiences within the Caribbean (Mexico, Dominican Republic and USA). The project will include support for the restoration of corals damaged as a result of extreme weather during the project's lifetime and it it is expected that interventions in other ecosystems of the coastal wetland will support coral regeneration. Monitoring of coral reefs is included in this proposal as a measure of coastal resilience.

420. **Aquifer Recharge and Monitoring:** there are traditional practices that have been used in the country in an isolated but successful manner, in particular those involving an autochthonous technological output related to the recharge of aquifers. These include experiences in Cayo Lago del Sur and Ciego de Ávila.

421. In Cayo Largo del Sur, in the extreme east of the Canarreos archipelago, measuring 37.5km² in area and 25km in length, a geophysical survey was carried out with the aim of establishing the depth, thickness and volume of the lenses of freshwater derived from centuries of rainfall accumulation, and whether they could be exploited without being affected by saline intrusion as a result of the extraction. In addition to the existing volumes, taking advantage of the geological constitution of the cay, which is made up of very permeable sandy rocks, 2m deep trenches were dug to capture rainfall water, including runoff from hotel roofs. The trenches were linked to the subterranean water lens and, for the extraction of this water; they were treated as if they were horizontal wells.

422. In the province of Ciego de Ávila, efforts were focused on capturing excess water from a reservoir and the superficial runoff of the Southern catchment of the province, by means of a battery of wells, knowing that the water stored in this way follows its normal channel underground, which self-cleans during variable periods of time, and helps to detain saline intrusion. These actions included the construction of other wells to determine the concentrations of chlorine and total soluble salts, to collect samples of water at different intervals in the same day, from top to bottom, and to find out the variation of the values of these two parameters to determine the salinity curves of the coastal zone and the effectiveness of the recharge.

423. In Cuba, within the project intervention areas there are already 56 established aquifer recharge wells. In the GCF project 30 of these wells will be used to monitor well water quality in some of the Project's regions. These wells will be used by the current project and the responsible state agencies to monitor the status of groundwater, its variation in quality and especially in the content of salts so that the impact can be evaluated on saline intrusion or the salt wedge. The proposed project will support the purchase of equipment (pluviometers, pluviographs, bathometers, electric hose) to determine the saline concentration and a water level monitor device to be included in some of these wells to allow for better quality of analysis and a greater frequency of monitoring with which national and municipal authorities can make water management decisions and can stimulate action on adaptation measures based on ecosystems. and its impacts on the quality and quantity of water available.

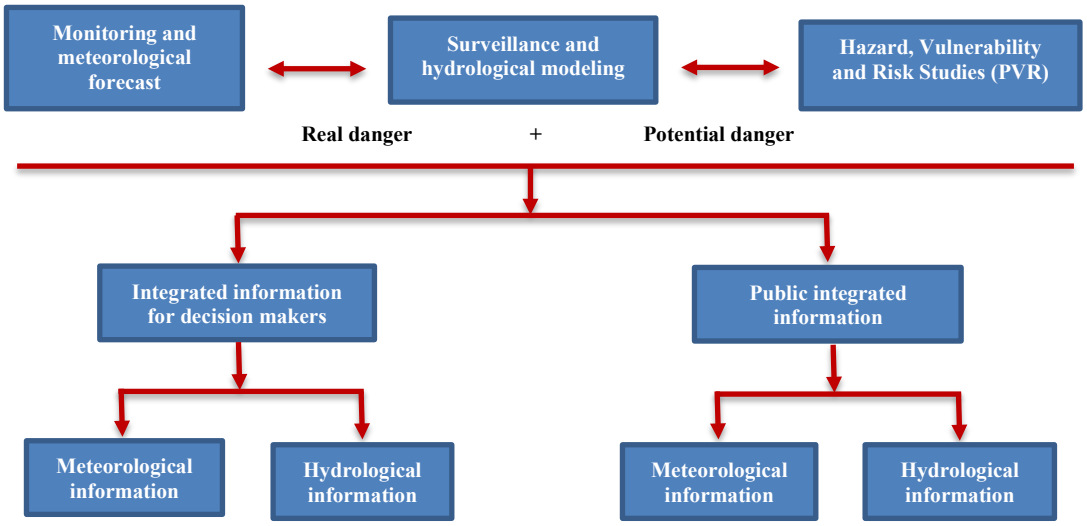
5.3 Early Warning Systems in Cuba

424. The proper functioning of the Early Warning System (SAT) in Cuba has been the fundamental support for the effective protection of people against the impact of extreme hydrometeorological events that have affected the country in recent years. Due to its successful results, the World Meteorological Organization (WMO) has selected it as one of the best practices in the world in this area. (http://www.eird.org/cd/fortaissance-del-sistema-de-alerta-temprana-pnud-cuba/fscommand/PROCEDIMIENTO/procedimiento_operativo_integral_ES.pdf)

425. The improvement of its four components (surveillance and forecasting, risk assessment and decision-making, dissemination of public messages, and timely protection measures) has been developed from the analysis of the experiences accumulated during the response to these phenomena through of the years. These components are briefly described below:

426. During the surveillance and forecasting component, several institutions work together to monitor possible dangerous hidrometeorological events. Moreover, this component also incorporates information about the potential danger detailed on the disaster risk studies which exist at the provincial and municipal levels. As a result of this interaction, integrated meteorological and hydrological information is generated, aimed at decision makers, specialized entities and the population, as illustrated in the following diagram:

Figure 62– SATs in Cuba; surveillance and forecasting



Source: Comprehensive Operational Procedure for hydrometeorological early warning system operation in the Republic of Cuba. https://www.eird.org/cd/fortalecimiento-del-sistema-de-alerta-temprana-pnud-cuba/fscommand/PROCEDIMIENTO/procedimiento_operativo_integral_ES.pdf

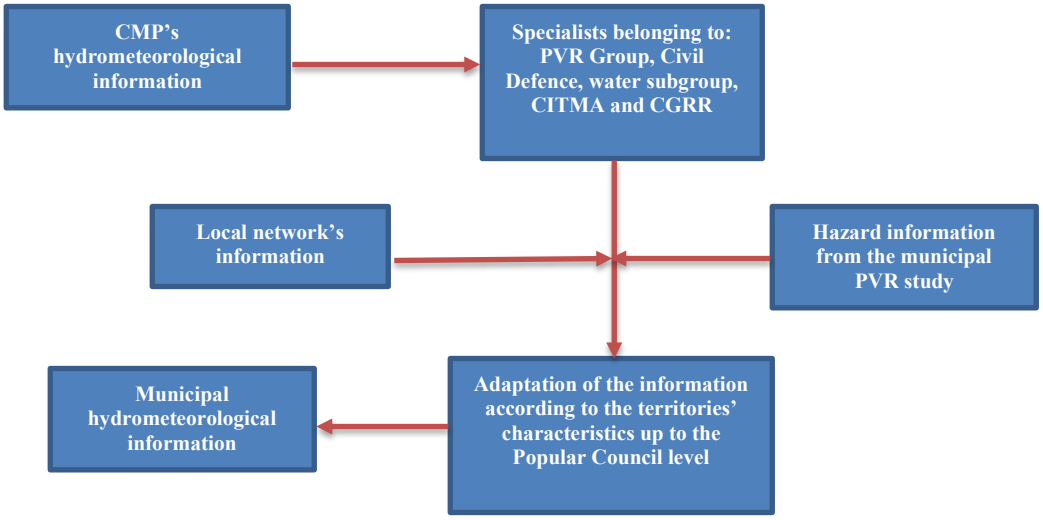
427. The forecast groups of the Provincial Meteorological Centers (CMP) make their assessment of the hydrometeorological event's possible effects in their territory, from the information received from the National Forecast Center (CNP), satellite images, numerical models, and other available data, as well as with knowledge available in the provincial disaster risk study's hazard report. This information contains more accurate assessments of the event's impact and is aimed at the Management centers of the Provincial and Municipal Defense Councils and the hydrological service of the territory, and to the Management Center for Risk Reduction (CGRR) where the Hazard, Vulnerability, Risk Study Group (PVR) is located.

428. In the EWs risk assessment and decision-making component, meteorological and hydrological information is analyzed in the Defense Councils' management positions at all levels with the advice of specialists from the meteorological and hydrological services of the PVR Study Group. The level of integration of the potential and actual hazards, as well as the modeling of probable scenarios, facilitate more reasoned and timely decision-making. The integrated information from surveillance institutions brief decision-making authorities about the probabilities and severity of the event's impact in the territory. However, they also need to know the places and sectors in the municipalities where the main damages

are expected, in correspondence with the PVR study. Therefore, decision-makers must combine hazard information with risk information to make more timely and reasoned decisions.

429. In the EWS' component of dissemination of public messages, PVR Study Group specialists in the municipalities adapt the provincial information, through the results of the territorial risk study's hazard information, in order to brief people living in the different areas of the municipality about event's effects. These reports are broadcasted by the local radio station and the municipal PVR study groups adjust this information to make it available - through VHF radio equipment - to mountain communities and other places that are difficult to access, including for dissemination by loudspeakers and other alternative means in order to ensure that the messages reach all those threatened by the event. This flow of information is illustrated in the following diagram.

Figure 63– SATs in Cuba; dissemination of public messages



Source: Comprehensive Operational Procedure for hydrometeorological early warning system operation in the Republic of Cuba. https://www.eird.org/cd/fortalecimiento-del-sistema-de-alerta-temprana-pnud-cuba/fscommand/PROCEDIMIENTO/procedimiento_operativo_integral_ES.pdf

430. Even with more than 10 successful EWS some gaps have been identified, mainly related to the articulation of the institutions that participate in surveillance and forecasting, which also requires technological strengthening, mainly in terms of complementing the equipment of the early warning points. The coordination mechanisms that will be developed by the project will provide support in articulating the role of institututions, mainly in the role of providing valuable information.

431. Regarding risk assessment and decision-making, Directive No. 1 of the President of the National Defense Council for Disaster Reduction of 2010, establishes that disaster risk studies at the territorial and institutional level are organized and led by the National Risk Assessment Group, with the participation of specialists from scientific institutions in the country, together with the National General Staff of Civil Defense, by developing specific methodologies for each disaster hazard. Under this regulatory framework, different natural, health and technological disaster hazards have been defined, where studies are carried out at the level of the people's council, municipality and province.

432. The following table shows the status of execution of the hazard, vulnerability and risk studies in each of the territories where the project will be conducted, these risks studies will take into account information from the project to enhance the development of information products that will be developed.

Table 14 - Status of Hazard Vulnerability Risk Studies in Target Areas

PROVINCE	FINISHED STUDIES	IN PROGRESS
Pinar del Río	Flooding by Intense Rains (2010), Flooding by sea penetratrion (2010), Strong winds (2010), Rural fire (2010), Earthquake (Ciudad Pinar del Río) (2015), Landslide (2015), Drought (2016), Epizootic (2018)	Precipitation Update (Ends 2020), Sea Update, Wind Update, Technological (started Sept 2019), Epidemic (Starts 2021)
Artemisa	Flood by Intense Rains (2012), Flood by sea penetration (2012), Strong winds (2012), Epizootic (2014), Drought (2016)	Technological, Epiphytotic disease, Precipitation update, Fire (Starts 2021)
Mayabeque	Flood Intense Rains (2012), Flood by sea penetration (2012), Strong winds (2012), Epizootic (2013), Drought (2016)	Technological, Epiphytotic disease, Precipitation update, Fire (Starts 2021)
Ciego de Ávila	Flood by Intense Rains (2011), Flood by sea penetration (2011), Strong winds (2011), Drought (2011), Epizootic (2013), Fire (2014), Technological (2018)	Epiphytotic disease, Sea (Starts 2020), Precipitation Update, Drought Update (Starts 2021)
Camagüey	Flood by Intense Rains (2011), Flood by sea penetration (2011), Strong winds (2011), Fire (2013), Drought (2012), Technological (2014), Epizootic (2014), Epiphytotic disease (2016), Earthquake at Camagüey city (Ends 2020)	Epidemic (Ends 2020), Technological Update, Precipitation Update, Sea (Starts 2021), Drought Update (Starts 2020)
Las Tunas	Flooding by Intense Rains (2012), Flooding by sea penetration (2012), Strong winds (2012), Drought (2011), Fire (2015), Epizootic (2017), Technological (2017)	Epidemic (ends 2020), Epiphyotic disease (ends 2020), Rain Update, Earthquake (Starts 2021), Drought Update (Starts 2020)
Granma	Flood by Intense Rains (2011), Flood by sea penetration (2011), Strong winds (2011), Drought (2013), Earthquake, Bayamo Municipality. (2013), Landslide (2012), Earthquake Manzanillo (2014), Incendio (2018), Epizootic (2019)	Precipitation update, Technological (Ends 2020), Epiphyotic disease (Starts 2021), Epidemic (Starts 2021)

433. A multi-risk EWS will be possible based on the technological and methodological strengthening of local actors for a better understanding of risk in the intervention areas (of which coastal vulnerability is an important part). In this sense, it will be essential to introduce the new multi-risk methodology that the National Risk Assessment Group is designing, which will allow the quantification of interactions between multiple hazards, as well as vulnerabilities in their different dimensions. This work is being done in parallel by the country and will be informed form information and experiences derived by the project.

5.4 Barrier Analysis

434. Considering the impact of CC a national strategy is required so the protective role of ecosystems is mainstreamed as a stronghold, while integrating local communities and enabling inter-sector coastal planning to reduce the high vulnerability of Cuba's coast to climate change.

435. Existing ecosystems have in fact been linked to the resilience of coastal areas and research has demonstrated their capacity to provide support in managing the impacts of climate change. However, for adapatation strategies to be successful these must look into specific actions at a local level to migitigate what will result initially in local impacts that need to be considered in local planning. Hence, generating community awareness and buy in is a key process for decisive decision making and resilience capacity in the face of climate change.

436. While climate change adaptation has been marked as a priority in Cuba through "Tarea Vida", it has mostly been very punctual and localized or within a disaster emergency preparation and attendance framework, excluding measures to enhance community resilience or to integrate it into formal

development and territorial planning. The 2019 Constitutional provides opportunities and an enabling framework to better to local governments more thoroughly in adaptation planning and mainstreaming.

437. Knowledge, tools and capacities have been lacking to enable the development and implementation of actions with a longer-term vision focused on adapting to the full scale of challenges posed by CC. An enhanced view of the protective role of ecosystems, rather than solely predicting and reacting to the impacts of individual events has also been pending.

438. This project will shift the paradigm in climate resilience in coastal areas in Cuba, resulting in the full-scale, integrated and sustained application of an EBA approach together with building capacity and awareness among direct beneficiaries and government institutions at all levels.

439. This has in the past has not been achieved as a result of the following barriers:

5.3.1 Limited experiences with the effective and sustainable application of EBA:

440. A solid base of knowledge and expertise has been developed on natural resource management, coastal wetlands restoration, sustainable land management, biodiversity and conservation, but there is a generalized lack of knowledge and practical understanding on how to integrate this diverse portfolio/visions of environmental management initiatives into a coastal adaptation strategy, with interventions across multiple coast and within government and productive sectors.

441. For example, the "Manglar Vivo" project (with an EBA approach) failed to integrate the value of adjacent ecosystems such as grasslands or their contribution to general coastal resilience, including the importance of establishing a territorial water management framework to take into account specific water needs required for the ecosystems. This is due to the limited experience that many institutions have in allocating key resources required for effective EBA, such as identifying the minimal and maximum ecological flow of water for coastal ecosystems.

442. EBA approaches and interventions are more successful when landscapes and systems are integrated and their nexus and functionalities understood, among these water flow management and hence integrated water resource management (IWRM) is crucial, particularly for disasters prevention. In terms of national initiatives, this is further exemplified by the limited experience that many institutions such as the INRH and the MINAG have in allocating key resources that are required for effective EBA, such the allocation of the ecological flow of water for coastal ecosystems within a larger water management framework. While water monitoring in key aquifer and reservoirs is performed it currently, it fails to capture and value the hydrologic requirements needed for coastal ecosystems to deliver ecosystem services in favor of the overall water balance as a strategy for managing climate impact.

5.3.2 Physical barriers that reduce natural ecosystems response capacity

443. Through time, infrastructure has been built within, neighboring or near mangroves and wetlands changing the natural dynamics, particularly those related with sediment trapping and water flow. There are infrastructure barriers -roads, dikes, walls, embankments etc.- upstream reducing sediment and water flow, there is also infrastructure within the ecosystems altering the natural dynamics and flows as well as infrastructure along the shoreline and offshore (See Annex 1).

444. It has long been reported globally that nearshore terrestrial ecosystem affects the health of submerged ecosystems, Land conversion, deforestation, increased sedimentation, pollution, changes on freshwater discharges can have cascade effects in mangroves, seagrasses and coral reefs. Impacting not only the ecosystems but also their connectivity and functionalities, including those related with coastal protection. Cuba is not different and actions along the shoreline have affected marine ecosystems (FA section 2.4).

5.3.3 Limited knowledge in vulnerable communities of CC drivers/threats and adaptation options

445. Though Cuban scientific and technical institutions have generated large amounts of information on the characteristics of coastal and marine ecosystems, trends in climatic conditions, and the magnitude and nature of CC drivers/threats affecting the ecosystems and local populations there is limited information and general understanding on CC adaptation.

446. Climate information, when available, has mostly been used for disasters preparedness and attendance. Furthermore, this highly scientific material is not accessible to key decision makers at the local level, nor presented in the required manner for its effective application. Hence, knowledge has not yet evolved into actions that bridge sector gaps particularly at a local level. This technical information on CC adaptation needs to be translated for adequate communication and streamlined into development planning to reduce communities´ vulnerability to climate change.

447. Community consultations indicate that communities perceive climate change as a future issue instead of an ongoing process that already poses immediate threats to lives and livelihoods, thus limiting their buy-in to adaptation strategies and planning. While the socialization of Tarea Vida has begun to change this perception, information has not flowed equally to all community members and remains highly technical, failing to generate local understanding of how climate change impacts them in the short term. This is particularly salient in rural coastal communities.

448. Actions at community level have focused on preparation, attendance and reconstruction to individual events and not disasters risk reduction per se, or to continuous relative changes such as SLR, hence communities feel adaptation is a reactive strategy to extreme events during which information flows top down making them reactive actors to immediate threats. To achieve climate resilience, communities ought to become active participants and adaptation solutions require enabling community knowledge and ownership.

449. Further, a limited number of local communities have first-hand practical knowledge of the range of adaptation options that exist for achieving cost-effective and sustainable resilience to CC, a situation which, if unaddressed, will result in an overreliance on cost-ineffective forms of adaptation, such as hard infrastructure or reactive responses to extreme events without a careful analysis of coastal dynamics. This was made particularly evident during national consultations to municipal governments that looked to implement hard infrastructure solutions to manage saline intrusion. These did not consider coastal dynamics and ecosystems nor a full picture of climate change impacts. Hence solutions that failed to consider that these could generate further stress to vulnerable ecosystems currently providing them protection. Upon field visits the construction of hard infrastructure along vulnerable coastlines was particularly salient demonstrating the need for informed physical planning.

5.3.4 Inadequate cross-sector provisions and capacities for CCA:

450. Although inter-governmental coordination has been progressively strengthened in recent years, there is still an entrenched tendency for institutional actors –environment, social, production- to work in silos, and for taking decisions at national level with a limited involvement from local authorities. This is particularly evident at a local level, where there is an expectation to follow national sectoral directives adopted at the national level. In addition, there is insufficient information and data from national to local stakeholders.

451. This top down approach translates into a limited capacity to take decisions locally, and such decisions are often decided by one sector alone (e.i deciding on hard solutions vs nature-based solution). This has resulted in limited capacities to incorporate adaptation, and natural resources management in decision-making at the territorial level. While a legal framework has been established at constitutional level- to promote territorial decentralization, it has yet to be made effective.

452. Hence, it is important that information is provided and standarized to key stakeholders at all levels in a manner that is relevant and usuable to allow for the incorporation of CCA in key decision making in matters of physical planning, natural resource management and local development.

5.3.5 Limited Investment Capacity for Adapatation Actions

453. Climate change adaptation has been hindered by limited availability of funds for investment. Though baseline investments exist, more investments are needed to overcome the barriers in the target areas. The current international economic context faced by Cuba limits the government´s capacity to access hard currency from the international capital markets and most international development agencies (See Section 4.5). This results in higher costs and difficulties in acquiring and importing equipment and materials. Hence, the identification of sustainable solutions that favor national capacity is crucial, particularly as hard infrastructure solutions have demonstrated to provide partial results and demand extensive amount of investment in imported equipment which can become financially unsustainable. Furthermore, the GoC is struggling to balance the budget and is resorting to domestic bond issuance to finance the budget deficit that has arisen as a result of the current economic blockade (sovereign bonds are sold primarily to domestic state-owned banks, as Cuba has a limited private banking sector).

454. While international cooperation projects in the past have been successful in achieving results, these have often failed to incorporate themselves into formal national or local structures for economic development. Among the several causes for the above failure in the sustainability and long-term vision on the projects can be highlighted, and a limited appropriation at the sectoral level, because of the wrong perception of projects and their outcomes being independent entities with no influence on public policies. This is a key barrier that needs to be addressed through this project to ensure that interventions are not isolated investments but are embedded within budget planning processes/mechanisms and formal legal frameworks for long term sustainability.

5.6 Adaptation Alternatives

455. Change on storms known patterns (path, intensity and frequency) and rising sea levels and make flood risk reduction expensive. Adaptation solutions require flexible measures that can adapt to the changing external conditions. These issues where discussed and analyzed in in the design of the project considering potential solutions to manage climate impacts in the projet's targetted areas. These included identifying potential infrastructure solutions against areas facing increased coastal flooding as a result of intense storms and erosion (sea walls), saline intrusion aggravated by to SLR and drought (underwater breakwater and levees). The benefits of grey infrastructure being their immediate impact in coastal protection where compared with the general benefits provided by ecosystem restotarion demonstrated through the Univerisity of Cantabria study [93] in terms of coastal protection from storms and coastal flooding as well as additional benefits related to increased water filtration an general system resilience.

456. Coastal and marine ecosystems, like sea walls and all infrastructure, are impacted by climate change and extreme events, however provide further benefits and a wider set of responses than the mere act of protecting against one threat (flooding or saline intrusion), more than 26 other ecosystem services with a value of almost 20 million USD per Km^2/year have been attributed to mangrove forests (figures from 2007 – when blue carbon was still largely unaccounted) (Mehvar, S. et al 2018).

457. The geographical characteristics of the targetted coastlines where also taken into account as coastlines are in soft bottom low-lying areas (at mean sea level) fringed by mangroves with coastal lagoons and estuaries followed by wide and shallow shelf area. These have in the past proven to be difficult sites for the construction of grey infrastructure (Figures 47 and 48) and when built at a local scale have demonstrated to have a short life span as was witnessed and discussed with municipal and local

[93] Instituto de Hidraulica Ambiental. 2018. Valoracion de los Sistemas de Proteccion de los Corales y Manglares de Cuba. Universidad de Cantabria.

authorities during site visits. In these cases, protection services from these structures where offset due to their quick deterioration as well as to their general environmental impact on existing ecosystems (See Section 5.3.2). Construction of grey infrastructure within these areas would require extensive drilling and subsequent filling with concrete materials to ensure its longevity or would require building much further inland causing increased ecosystem fragmentation.

Figures 64 and 65- - demonstrate low concrete barriers built for coastal protection and has now been overtaken due to erosion and coastal flooding

5.6.1 Comparative analysis of the investment for the establishment, maintenance and monitoring of green and gray works

458. The project developed an alternative analysis on achieving project objectives of coastal resilience in Cuba to identified climate drivers as detailed in Section I (coastal flooding and saline intrusion). Alternatives included adopting an EBA approach and development of engineering solutions (construction of sea walls) along targetted coalsines.

459. To perform these analyzes, the fundamental parameters of each intervention site were calculated (due to their proximity the values of the El Cajío and Batabanó sites are presented unified) which are shown in the following table:

Table 15 - Paramaters for coastal protection options EBA and Seawall

Sites	Effective mangrove area (ha)*	Total Area (ha)	Coastline (km)	Length of Seawall (km)	Observation on seawalls
La Coloma	938	6,253	33.562	3.36	10% of coastline would be protected for protection of urban and productive areas
Cajío - Batabanó	349	2,327	29.227	3.51	50% of Coastaline in Cajio would be protected (Southern Dike) and 10% of Batabano (productive and urban areas)
Júcaro	673	4,487	85.823	2.22	10% of coastline would be protected for protection of urban and productive areas
Florida	1,760	11,733	33.946	8.58	10% of coastline would be protected for protection of urban and productive areas
Santa Cruz	4,125	27,500	137.758	3.39	10% of coastline would be protected for protection of urban and productive areas
Manzanillo	3,582	23,880	259.283	13.78	10% of coastline would be protected for protection of urban and productive areas
Total	**11,427**	**76,180**	**579.599**	**60.77**	

460. The effective mangrove area is the one that will be the object of the restoration and constitutes 15% of the total area (76,180 ha) that represents approximately the forest area that will be rehabilitated. It is important to note that in the case of gray solutions, normally budgeted per unit of linear coastline, comparisons are made per km of coastline looking to provide protection to key areas.

461. The alternative scenario involves the targeted construction of seawalls for coastal protection totaling an estimated 61km of extension. As shown in the table below, the stretches of coastline where mangrove restoration is envisaged by the project have a cumulative length of approximately 580 km.

462. The estimate of 61 km of seawalls necessary to replicate the coastal protection benefits that would be achieved through mangrove restoration is very conservative. It assumes that seawalls are built only on 10% of the coastline in all sites apart from Cajio, where the percentage is set at 50%, considering the need to protect large sources of drinking water present in that area.

463. A cost comparisons for the engineering solutions took into account costs (both capital and O&M) based on various literature reviews[94] relevant for the Caribbean for the coastal protection including

[94] Simpson, M.C et al (2010) Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean (Key

Simpson, M.C et al (2010) that calculated coastal protection costs of 19 major cities in the Caribbean an included a range of costs for seawalls between USD 4 mln/km to USD 14 mln/km. Based on this range, total construction costs for the 61km of sea walls in the targeted areas would stand between USD 243 mln and USD 851 mln. The lower end of the range was used in the economic analysis. Construction of seawalls is assumed to take place in equal instalments in years 2 to 6 of the project period, with the first year being dedicated to planning.

464. Operation and maintenance costs were taken from Simpson and are estimated at annual costs within the ranges of USD 370,000 and USD 420,000 per km. The lower end of the range was used in the economic analysis. Costs are phased in according to the construction schedule of the seawalls. The useful life of the seawalls, with proper maintenance, is assumed to be 30 years, in line with the lifetime of the proposed mangrove restoration project.

465. Costs also considered investments for managing saline intrusion and providing general capacity building at a local level. For this purposed, it was assumed that the entirety of the proposed project's budget for Activities 1.3, 2.1, 60% of Activity 2.2 and 20% of the budget for Activity 1.1 would also need to be spent in the alternative scenario.

466. Benefits were assumed to be the same as those provided by the restored mangroves in terms of coastal protection. See "INFRA | Benefits" sheet. When the infrastructure is 100% built, these benefits would be equivalent to the $3,900/ha/year benefit of mangrove over the total restored mangrove area of 11,427 ha, or a total of $44.6 million annually. These benefits, however, would kick in earlier in the alternative scenario, as sea walls start producing their coastal protection effects right after they are built.

467. While grey infrastructure creates negative externalities, for instance at ecosystem level, these were not quantified and, therefore, the benefits of grey infrastructure utilized in the economic model are implicitly optimistic. Also, unlike mangrove restoration, seawalls do not produce any carbon sequestration benefits.

468. The base case economic model, based on the assumptions above, results in an EIRR of 7.1%, below the 10% return threshold conventionally used in economic analyses and well below the EIRR of the proposed project. The NPV at a 10% discount rate is -$66.8 million.

469. As previously noted, these results are obtained assuming a very limited extension of the seawalls and bottom-of-the-range estimates for both construction and O&M costs, while at the same time not reducing the benefits for any negative externality of infrastructure. The sensitivity analysis shows that a 20% increase in costs (for instance as a result of the increase in seawall extension) and a 10% decrease in benefits (for instance as a result of negative externalities on the eco-system) would push the EIRR of the alternative infrastructure project to close to 0%. Any further increase in costs and decrease in benefits would push the EIRR clearly into negative territory. The NPV is negative in all scenarios.

Table 16 - Infraestructure Base Case and Outcomes of Sensitivity Analysis (NPV $ millions; IRR %)

Points and Summary for Policy Makers Document), United Nations Development Programme (UNDP), Barbados, West Indies. And Rangel-Buitrago, N., et al (2017)., Hard protection structures as a principal coastal erosion management strategy along the Caribbean coast of Colombia. A chronicle of pitfalls, Ocean & Coastal Management, http://dx.doi.org/10.1016/j.ocecoaman.2017.04.006

	Costs							
	Base case		+20%		+30%		40%	
Benefits	**NPV**	**EIRR**	**NPV**	**EIRR**	**NPV**	**EIRR**	**NPV**	**EIRR**
Base case	**-38.6**	**7.1%**	-102.6	3.1%	-134.7	1.3%	-166.7	-0.4%
-10%	-66.8	4.8%	-130.8	0.7%	-162.8	-1.2%	-194.8	-3.2%
-20%	-94.9	2.2%	-159.0	-2.2%	-191.0	-4.6%	-223.0	-7.4%
-30%	-123.1	-0.9%	-187.1	-6.6%	-219.1	-10.8%	-251.2	#NUM!

470. In the case of EBA, the investment project would rehabilitate degraded coastal wetlands along 1,300 kilometers of the Southern coast line, with specific interventions being made in 7 key sites in the areas of La Coloma (stretch I); El Cajio (stretch I); Surgidero de Batabano (stretch I); Jucaro (stretch II); Santa Cruz del Sur (stretch II); Manzanillo (stretch II) and Playa Florida (stretch II). Investments will be made in the rehabilitation of mangroves, swamp forests and swamp grasslands. Costs, as detailed in the FP stand at the following.

Table 17 - Total Cost per Output per Year

	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Output 1	**32,502,765**	**1,476,519**	**14,411,356**	**6,078,307**	**4,396,589**	**2,122,677**	**1,787,673**	**1,363,251**	**866,393**
Output 2	**9,436,227**	**1,024,622**	**1,604,401**	**1,810,811**	**870,792**	**1,329,087**	**1,352,800**	**701,045**	**742,668**
Mgment cost	**2,360,237**	**314,728**	**436,741**	**420,624**	**356,160**	**235,289**	**219,136**	**203,020**	**174,539**
Total	44,299,229	2,815,869	16,452,498	8,309,743	5,623,541	3,687,053	3,359,609	2,267,316	1,783,600

471. Operation and maintenance costs have been calculated and projected based on the project's OM analysis and have been considered within the model (See Project's Economic Analysis).

472. In terms of coastal protection benefits, it is assumed that mangrove rehabilitation will take place in Year 2, 3 and 4 in the same proportion of the capital investment in those 3 years. It is assumed that the quantity of mangroves rehabilitated in any given year out of a total 11,427 ha follows the same annual percentages. It is assumed that rehabilitated mangroves provide no benefits for the first 5 years following rehabilitation, where it may not have sufficient structural stability to offer significant coastal protection. Hence, mangroves rehabilitated in Year 2, 3, and 4 will start to offer benefits in Year 7, 8, and 9 respectively. Finally, after this initial period of 5 years, it is assumed that the benefits from coastal protection gradually increases over a period of approximately 8 years from an initial value of 30% of their full potential, increasing by 10 percentage points per year, until it reaches 100% of the protection value 7 years later. Hence the above two assumptions imply that a hectare of rehabilitated mangrove will provide its full potential in terms of coastal protection only 13 years following its rehabilitation.

473. The study from the University of Cantabria assesses the quantity of land flooded, the number of people flooded, and the total stock of assets lost for extreme weather events of a different return period, both with and without mangroves. The difference between the scenario with and without mangroves provides an estimate of the benefits of mangroves. Taking into account the economic value of the rehabilitated mangrove area for each return period using the values presented in the Cantabria study, the following calculations are made.

Table 18 - Mangrove benefits

	1-in-100 return	1-in-50 return	1-in-25 return	1-in-10 return	Expected value
Benefits per ha	3,910	1,735	891	346	236
(from Cantabria study)	1%	2%	4%	10%	100%
Benefits of intervention	44,679,570	19,825,845	10,184,314	3,956,599	2,692,487
Annual expected benefit per ha	2,078				

474. In order to avoid the potential of double-counting, the flow of benefits is assumed to arise solely from the rehabilitation of mangroves, thereby ignoring the potential benefits which may arise from the rehabilitation of swam forests and swamp grasslands independently from the rehabilitation of mangroves. In so doing, the benefits included in the economic analysis are in all likelihood under-estimating the true economic benefits of the project of restoring the capacity of ecosystem services provided and detailed in Section II of this Study.

475. Further, a potential environmental co benefit for EBA is relies in carbon capture that while not a principle objective of the project can be considered to be an important factor to be considered. Caclucations for annual carbon sequestration at full regime has been estimated at94,844 tCO2eq. If using an approximate CO2 pricing per World Bank Guidelines for Pricing of Carbon[95], potential carbon benefits stand at an average of USD 6,022,718 per year.

476. In the base case, and only considering the benefits of coastal protection, the net present value (NPV) of the proposed intervention is estimated to be $49.85 million with an economic internal rate of return (EIRR) of 18.6 % demonstrating the overall economic efficiency of the proposed investment project.

477. Taking into account the potential for carbon capture, NPV during a 30 year period is estimated at USD 72 million and an EIRR of 21.2%.

478. These results confirm the economic attractiveness of the proposed EBA project not just in absolute terms (positive EIRR of 21.2%) but also relative to an alternative scenario based on the construction of seawalls.

479. A final analysis was also considered of a scenario without the project , taking into account a situation in which coastal ecosystems are not rehabilitated and climate change impacts remain as projected and detailed within the project's Funding Proposal and Feasibility Study (See Section III in the Feasibility Study including Figure 27 on the vulnerability of Cuban shoreline associated to climate change; Figures 38 and 40 Main Vulnerabilities in Coastal Stretches 1 and 2; and Figures 39 and 43 Human Settlements in Coastal Stretches 1 and 2 that will be Flooded as a Result of Hurricanes).

480. This scenario considers that benefits through the project as a result of the restoration of 11,427 ha of mangrove forest are not obtained. Furthermore, for the present analysis it also considers that the rate of progression of erosion within the target areas continues in its present course, causing an added loss of benefit that would be avoided through the project

481. As stated, in Sections 3.1 and 3.2 of the Feasibility Study, rate of coastal erosion have been identified in target areas at an average rate of 1.2 m/year. Starting from the principle that in the project's

[95] World Bank (12 November 2017). *Shadow Price of Carbon in Economic Analysis – Guidance Note*.

targeted intervention areas practically the entire coastline is covered by mangroves then we can assume that that area lost by erosion was covered with mangrove.

482. This analysis allows to calculate an average rate of mangrove loss estimated at 156 ha/year (Table XII 11). This allows us to consider the cost of the loss of these mangroves during the 8 year period of the project to total of 1,248 ha that would not occur had the project taken place and at 4,680 ha during the project's 30 year lifetime.

483. Considering the calculations established through the University of Cantabria (Table XII 8 and 9) that establish annual benefits at approximately USD 2,078 per ha, 4,680 ha of mangroves during the period of the project's lifetime present an estimated economic value of USD 52 million that would be lost without the project intervention, providing a reduction in the protective services provided by currently existing mangroves.

484. Hence through the restoration of the 11,427ha of mangroves the project will also prevent further erosion which over 30 years would cost,4680 ha of mangrove ($52m value of mangroves) that could be added to the economic analysis. When taking these considerations into account the project's baseline NPV stands at USD 100 million with an EIRR of 25%.

5.6.2 Options Analysis for Adaptation: EBA vs Grey Measures

485. Past experiences in Cuba have demonstrated that that gray measures are accompanied by environmental and social collateral effects, by contributing to the deterioration of ecosystems, promoting changes in sedimentation patterns in the coasts, causing erosion in some areas, excessive sedimentation in others, and possible changes in currents and ecosystem structure in marine areas. An impact of particular concern is related to the development of infrastructure in targetted coastal areas are those related to the changes in the movement patterns of freshwater ecosystems, causing salinization and alteration of plant or animal populations. A large part of these changes observed in Cuba produce unforeseen additional costs, and environmental degradation exacerbates climate change effects on the coasts, thus requiring new investments to correct them. The use of EBA measures seeks to avoid these additional costs.

486. Further, it should be considered that risk mitigation strategies based on hard engineering measures are not adaptive and might have additional negative impacts.

487. An integrated EBA approach can adaptively withstand a widening range of increasing water levels and wave heights, what would help achieving more robust, cost-effective, and climate proof designs.

488. Cuba´s geographical characteristics and its marine and coastal ecosystems conservation status (as described in sections I and II of this document) represent an optimal opportunity for wide scale ecosystem-based adaptation. The island's shape and orientation (from east to west), does not allow the existence of long and flowing rivers. Surface drainage is divided into two watersheds (one that drains to the North and the other to the South) and rivers are superficial and rapidly discharge to the sea. There is a direct link between mountains and marine environments, between fresh and saltwater and karstic processes and deep aquifers. The geomorphological processes have led to a very interconnected and diverse landscape in which different ecosystem flourished. The coastline is very irregular and diverse, including steep cliffs, sandy beaches, extensive low lying and swampy coastal plains, fringing coral reefs, marine terraces, inlets, deltas and bays. Low-lying coasts are fringed by mangroves with coastal lagoons and estuaries followed by wide and shallow shelf area with abundant seagrasses and fringed by coral reefs.

489. This geographical context added to strong institutions, political will and a solid understanding within the government that in a changing climate hard infrastructure is no longer a viable solution for the majority of Cuba´s coastal zones given the high costs, the punctual short-term benefits, the environmental damages and further vulnerability these structures have created or accelerated. The EBA approach that

will be favoured by the project is backed up by scientific knowledge and congruent with the UN GDS(6, 11, 13, 14 & 15), RioCCAdapt (adaptation assessment review in Latin America, Spain and Portugal), the Convention of Biological Diversity (CBD Technical guideline 93), and the current pathway of the Sendai framework for Disasters Risk Reduction and the IPCC recommendations.

490. The selection of the EBA-approach is based on an assessment of the following decisive aspects:

- Restored existent ecosystems act as natural defences against wind and waves, reduce coastal erosion, flooding and salt intrusion.
- Mangroves and marshes contribute to reduce salt intrusion by enhancing water filtration.
- Mangroves and marshes protect sea grasses and coral reefs from land stresses (such as contamination and sediments).
- Hard constructions such as longitudinal dikes are not effective in these coastal areas due to their low lying and swampy nature. Longitudinal dikes implemented in the past in similar coastal areas in Cuba to protect certain areas from erosion or to reduce salt intrusion have caused coastal erosion elsewhere and further degradation of the ecosystems.
- Conditions provided, mangroves are very resilient ecosystems and can enhance accretion even with SLR.
- The rehabilitated ecosystem will be able to self-repair after certain extreme events.[13]
- EBA approaches are more cost-effective than "hard" constructions, given the fact that the ecological infrastructure already exists, and the project will focus on repairing and/or addressing those aspects that could affect its functionality as a defence barrier. Once ecosystems have reached the desired protective functionality derived from rehabilitating and strengthening specific ecological processes, ongoing maintenance costs are much lower compared to hard infrastructure.

491. The project recognizes that to address climate change challenges and its related uncertainties scientific advantages need to be achieved both in coastal hydrology and understanding better the links with coastal wetlands and on the role of ecosystems and their interactions during disturbances. According to Michael et al 2017 achieving coastal resilience will require interdisciplinary scientific collaboration, open communication between scientists and the public, and strong partnerships with policymakers, all of which will be directly addressed by the project.

492. Furthermore, the project has been designed to build on seven of the Cairo principles for coastal zone management which the Murray et al (2012) recommended as a route for resilient coastal zones in the Americas:

- Reducing risks to human health and safety
- Maintaining functioning and healthy coastal ecosystems
- Reducing exposure and vulnerability of the built environment;
- Using engineered protection measures only after other options have proven ineffectual or Impractical;
- Avoiding transference of costs for private risks to the public Purse
- Securing public access and use
- Maintaining and diversify livelihood options and opportunities; and
- Strengthening governance frameworks for coastal adaptation

5.6.2 Options Analysis: Leasing and Hiring of Services vs Acquisition of Project Inputs

493. Considering the practical implications stated in section 4.5, the project analyzed various options for cost efficiency in the impemenation of the project outputs. This included the procurement of services for specific project actions (rather than on the acquisition) such the leasing of vehicles and the hiring of laboratories for specialized monitoring.

494. The development of the different activities planned at national and local level requires the efficient provision of transportation services to meet the objectives set out in the project and in the established schedules, at the lowest possible cost.

495. Mobility to the project's seven target areas is required to fulfill the main objective of the project and to guarantee the participation of multiple stakeholders at national and local level and develop the monitoring and communications systems that are part of the project's theory of change. Transportation services can be rented occasionally (though with difficulties) from public or private individual carriers.

496. As stated in Section 4.5, partner institutions (AMA/ICIMAR/MINAG) have a limited amount of transportation means to be able to develop their work at a national scale and in fact has resulted in scheduled delays in various occasions. The majority of vehicles in the country available to insititution have decades of use; with more than 60 years of operation, usually with high rates of breakage, unexpected and unstable availability due to long periods of inactivity given the lack of access to spare parts, in addition to being high consumers of fuels that increase transportation rental costs.

497. An analysis was made considering the rates of transportation services and the prices for the acquisition of a vehicle (see Table 19 below). This analysis took into account actual costs from past projects considering the distances that would be required to be made by the project actors for the development of project investements including supervision, implementation and monitoring.

Table 19 - "Cost analysis of hiring transportation services vs procuring a vehicle"

Vehicle category, according to its function	Estimated Km in 7 years	RENTAL COSTS	PURSHASING COSTS (CONSIDERING CURRENT FUEL COST)						
		Rental (1 Km = 19 CUP = 0.79 USD)	Purshasing (including mantenance kit for first 100,000km)	Spare parts and maintenance	Fuel costs, considering current value (1 lt = 25 CUP = 1.042 USD)	Insurance, register and inspections	Driver cost (2,400 CUP/ month)	Total cost per vehicle in 7 years I = D + E + F + G + H	Rental Vs Purshasing per vehicle J = I - C
4x4 field vehicle, for Provincial Delegations of CITMA. (Estimated kilometers: 104.19 km/day * 24 days * 12 months * 7 años = 210,050 km)	**210,050**	165,940	50,000	18,410	21,887	18,550	8,400	117,247	-48,692
4x4 field vehicle, for permantent environmental monitoring of coastal and marine ecosystems developed by ICIMAR/AMA and for the transportation dedicated to the assembly and later maintenance of the permanent meteorological stations and tide gauges. (Estimated kilometers: 137.58 km/day *24 days *12 months * 7 years = 277,370 km)	**277,370**	219,122	50,000	23,395	28,902	18,550	8,400	129,247	-89,875
4x4 field vehicle, for the assembly and maintenance of hydrological stations, the systematic monitoring of the quality and availability of superficial and underground terrestrial waters and to develop aquifer recharge actions. This vehicle will be provided to the National Institute of Hydraulic Resources and will result in contionous monitoring ofthe 40 hydrographic basins in seven provinces along the southern coastline. (Estimated kilometers: 137.37 km/day *24 days *12 months * 7 years = 276,950 km)	**276,950**	218,791	50,000	23,395	28,858	18,550	8,400	129,203	-89,587
4x4 Field vehicle, for the PM to ensure the monitoring, supervision and control of planned activities at the national, provincial and local levels. (Estimated kilometers: 75.08 km/day *24 days *12 months * 7 years = 151,362 km)	**151,362**	119,576	50,000	15,000	15,772	18,550	8,400	107,722	-11,854

498. It should be noted that once the project is concluded, any equipment purchased by the project will be used for the sustainability and long-term maintenance of project interventions and scale up.

499. In the case of leasing services for the development of monitoring activities (laboratory work for water monitoring), the option was also explored for the project. However, the lack of access of stable suppliers willing to work with the GoC does not present it to be a feasible alternative for long term implementation and can in fact become a source of potential delays for project implementation and long-term maintenance.

500. In the context of an increased risk of sanctions, the participation of companies in the procurement processes of the UNDP Cuba CO has been discouraged. Particularly, the use of most of the corporate LTAs of UNDP and other UN Agencies has been affected. The office has managed this situation with a market and supplier search strategy, with the dissemination of tenders on UNDP global website and also using supplier sources identified by national companies with which there has been a strong relationship over many decades.

501. The activation of Title III of Helms-Burton Act in May 2019 reinforced the extraterritorial character of the economic and commercial blockade imposed by the USA on Cuba. As a result, new challenges arose for the implementation of development projects in Cuba. This action has had a deterrent effect on third countries whose individuals, companies, banks and institutions are now more fearful of sanctions. Several international banks reinforced their review policies to meet the new OFAC restrictions, from the sanctions that were imposed by OFAC. As a result, banks began to withhold and reject payments, thus affecting the ability of UNDP Country Office in Cuba to meet payments to suppliers within agreed deadlines and causing delays in shipments, in the case of suppliers whose liquidity was affected due to non-payment.

502. The blockade laws also imposed restrictions on shipping companies that reach Cuban ports, since they cannot enter US ports on their way forward or on their return, a limitation that also contributes to high transportation prices and delays in delivery. Shipping lines arriving in Cuba are irregular and difficulties with the availability of ships poses a challenge that negatively impacts on the time of delivery of the contracted goods. This situation in managed by UNDP by anticipating as much as possible the procurement processes to increase its safety margin, so that more time for implementation can be available and also by looking to avoid entry or passage through US Ports.

503. In summary, the procurement of services (rather than providing the national means of developing environmental monitoring systems) that will be required consistently for project implmenetation can results in a constant risk for project delivery as circumstances outside of the project can result in uncertainty in the delivery of results and information that will be required for during a 30 year period.

504. With this in mind, the UNDP CO in Cuba will provide procurement support to the project and has looked to develop procurement strategies to ensure that project delays due to these issues are avoided. This has included procuring early on, in the project timeline.

5.6.2 Integrated EBA Approach and Project Theory of Change

505. In a changing climate best practices for strengthening resilience in coastal wetlands, outlined by scientific literature, include: removing infrastructure and stressors, regulatory setbacks, sediment fluxes restoration, linking fragmented wetlands and waterways, enhancing particular functions, ensuring freshwater availability for ecosystems, functionalities rehabilitation, monitoring, training and education, land zooning, strategizing conservation priorities, reconnecting terrestrial-coastal-marine systems, improve governance and planning frameworks, embrace uncertainty and enlist public support (Burket and Kuslker, 2000, Erwin 2009, Koch et al 2015, Wiens and Hobbs 2016)

506. The project was designed under this focus and was built to address key barriers identified during consultation and baseline analysis and incorporate lessons learnt and fill in key gaps from past projects implementation while leveraging current constitutional and administrative reforms to mobilize national effort to address climate change.

507. This will be achieved through two project outputs: Output 1: Ecosystem-Based Adaptation (EBA): Rehabilitated ecosystems to enhance coastal resilience to climate change Output 2: Increased climate adaptation capacity in vulnerable coastal communities, governments and sectors.

508. This project follows the recommendation by IPCC to integrate the multiple coastal zones uses in planning for climate change[96]. Approaches to reducing local stresses are considered feasible, cost-effective and highly scalable. Combined with the advantages of using local knowledge to guide transitions, solutions can be more effective when undertaken in partnership local communities, cultures, and knowledge. In other words, the proposed project focuses on working together with the communities to enhance integrated ecosystem rehabilitation to enhance coastal resilience. The ecosystem rehabilitation practices have been chosen based on the integral functioning of the system[97] and lessons learned from previous experiences.

509. This project will allow communities to adapt proactively and enhance coastal resilience. The proposed community-based monitoring system and the data analysis is considered unique for Cuba. Data provided will be used to adjust the prognoses of the local CC-impacts/coastal drivers and to determine more accurately the role of EBAs in reducing CC related vulnerabilities. These data and analyses will also be relevant worldwide. A considerable contribution to global knowledge resulting from the monitoring system will be the systematically assessment of ecosystems contribution to coastal communities resilience by: i) estimating the recovery time of coral reefs and seagrasses after hydrological rehabilitation of mangroves and wetlands; ii) estimating the resistance of mangroves at different forest heights to extreme weather events and their recovery time; iii) estimating the processes and drivers within the integrated rehabilitated systems to withstand SLR; iv) estimating the combined effect of holistic systems approaches in reducing coastal threats.

510. This project will provide crucial quantitative data and knowledge to support the use of nature-based solution as flood defenses mainstreamed in territorial planning and disasters reduction strategies. The gained knowledge from activities in output 1 will be ready for application systematized and formatted in user-friendly products. Thus, making possible for EBA to be up scaled in Cuba and other countries and providing knowledge base support for EBA approaches.

511. The GCF involvement is critical to Cuba because it provides the financial resources to address climate related additionalities and overcome the key barriers to coastal resilience. GCF financing is leveraging on GoC funds to increase the scope and scale of CC baseline investments in Cuba. This project also builds on lessons learned from past and ongoing projects (such as 'Manglar Vivo', Table 1) to upscale successful interventions.

512. The project will mainstream EBA and community-based adaptation (CBA) approaches and foster new governance mechanisms adjusted to the local conditions and multi-stakeholder participation. Output 2 will introduce innovative concepts in Cuba leading to paradigm shift at a national scale enhancing local participation into natural resource management and general planning through the following figures: i) training; ii) creating a platform of knowledge management which integrates and manages local and national climate products and information, contributing to the national information system in development; and iii) ensuring mainstreaming of the EBA by strengthening regulatory frameworks.

513. Table 20 below summarizes the activities of the proposed project and explains how the activities will contribute to overcome the barriers leading to paradigm change.

96 IPCC **Special Report on Global Warming of 1.5°C**, October 2018 & Kelleway et al., 2017. Review of the ecosystem service implications of mangrove encroachment into salt marshes. Volume23, Issue10 October 2017

97 van Integrated Ecosystems "Valoración Socio Económica de los Humedales en América Latina y el Caribe" "Socio-economic Assessment of Wetlands in Latin America and the Caribbean" (Wetlands International 2006).

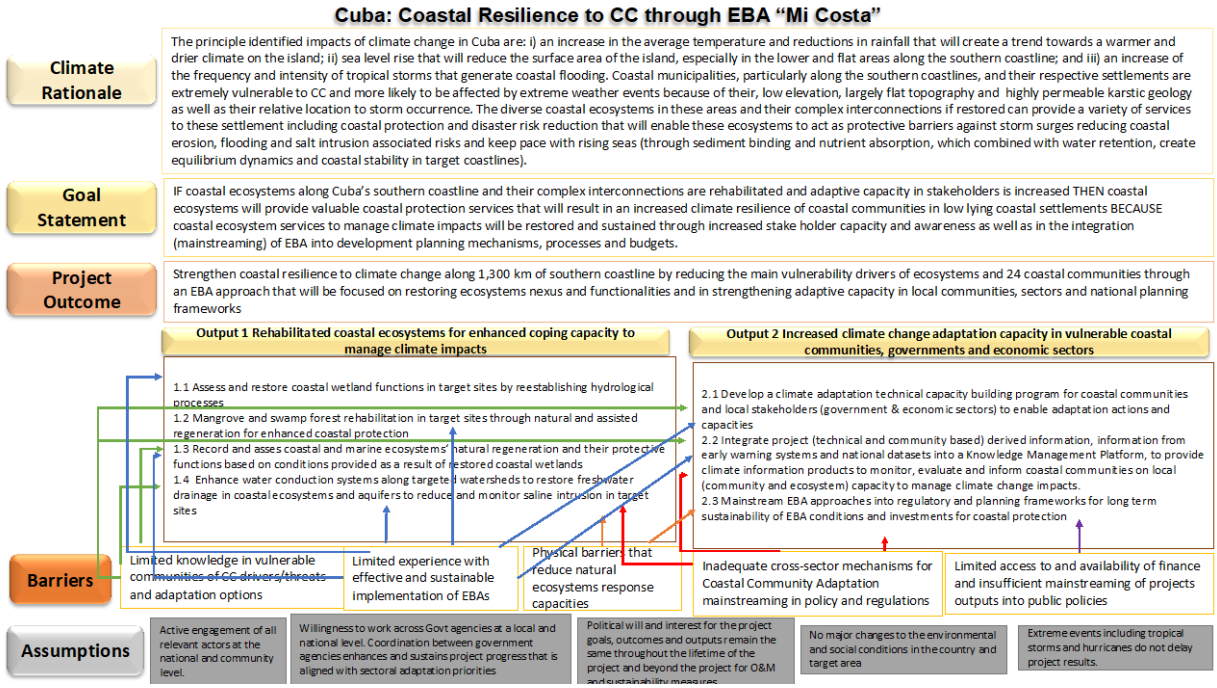


Figure 66-- Theory of Change and its baseline assumptions

Table 20 - Project response to identified barriers

Output 1	**Rehabilitated Ecosystems to enhance coastal resilience to climate change**
Activities	**1.1 Assess and restore coastal wetland functions by reestablishing hydrological processes and managing invasive species**
	1.2 Mangrove and swamp forest rehabilitation in target sites through natural and assisted regeneration for enhanced coastal protection
	1.3 Record and asses coastal and marine ecosystems' natural regeneration and their protective functions based on conditions provided as a result of restored coastal wetlands
	Activity 1.4. Enhance water conduction systems along targeted watersheds to restore freshwater drainage in coastal ecosystems and aquifers to reduce and monitor saline intrusion in target sites
Barrier 1: Communities will be involved in the monitoring of the CC impacts/threats, rehabilitated ecosystems and their responses. Knowledge on CC effects/threats and adaptation options will be increased. A climate change adaptation community monitoring system will be created and will be complementary to the environmental conditions monitoring to be implemented to achieve Output 1. Knowledge will not only be transferred to the communities, but the communities will apply it in the monitoring activities in their respective sectors. Information produced by the communities will be shared in a Knowledge Management Platform for Coastal Adaptation (KMPCA) that will integrate local monitoring with national monitoring information. The resulting information products will be shared in the Capacity Building Centres with user-friendly information products to be developed locally. The project will generate unique knowledge and practical experience on of ecosystems management and NBS integration into climate change adaptation planning. The project will generate during its lifespan of 30 years the needed knowledge to implement and evaluate the functioning of the EBA alternatives with a longer time horizon (till year 2100) and to assess complementary "Building with Nature" (BwN) solutions where needed. **Barrier 2**: The project will generate unique knowledge and practical experience on of ecosystems management and NBS integration into climate change adaptation planning. The project will generate during its lifespan of 30 years the needed knowledge to implement and evaluate the functioning of the EBA alternatives with a longer time horizon (till year 2100) and to assess complementary "Building with Nature" (BwN) solutions where needed. **Barrier 3**: The co-founding from the GoC will remove some of the infrastructure that is affecting the natural flow and sediments charge to the ecosystems. The monitoring system will also allow to stablish the minimum and maximum laminar flow required specifically targeting reservoirs in the upper watershed	

Barrier 5: Interventions proposed through this project favor cost-effective interventions, by rehabilitating existing natural infrastructure generating benefits in the short, mid and long term.	
Output 2	**Increased technical and institutional capacity to climate change adaptation in Coastal Communities, Governments and Economic Sectors**
Activities	**2.1 Integrate project derived information with information from ews and national datasets into a Knowledge Management Platform, to provide climate information products to monitor, evaluate and inform coastal communities on local capacity to manage climate change impacts.**
	2.2 Create a Knowledge Management Platform and Community Monitoring System for CC Coastal Adaptation
	2.3 Mainstream EBA approaches into regulatory and planning frameworks at the territorial and national levels for long term sustainability of EBA conditions and investments for coastal protection

Barrier 1: Capacity building through activity 2.1 will provide the tools needed at a local level for communities to understand not only the impact of climate change to their coastline but also adaptation alternatives. These will also be made evident through the enhanced Capacity Building Centres of Knowledge Management for Adaptation (CBCS). The project is designed to enable information to flow to and back to the communities promoting a change from a traditional reactive approach to risk management that considers communities as passive stakeholders, to a proactive approach for adaptation where communities are active and informed agents with capacities to adapt and generate coastal resilience.

To achieve a change of focus in the communities, the project will promote the exchange of climatic and environmental information generated between the national knowledge management platform and the trained communities, considering the empirical knowledge of coastal communities; as well as tailored information products to manage climate vulnerability. These will use technical information generated by the project and through national databases and translate them into climate planning tools that are relevant to local stakeholders.

The knowledge management platform for coastal adaptation will ensure that information flows from and back to the municipalities.

Barrier 2: The community monitoring system will complement the technical monitoring system of the coastal zone (Output 1) with the involvement of the community in the generation of information and knowledge of local interest for adaptation to climate change. The monitoring and data analysis will be presented to the communities in the form of contextualized climate information products to create a link between the EBA actions and the resiliency of their coastline. Therefore, knowledge exchange will take place by interactive learning (specialists and local communities). The project will tackle key motivation aspects for beneficiaries (community) to monitor their coasts and ecosystems by community such as: i) the knowledge of how they will benefit from the ecosystem protective services (though training); ii) promoting active participation and socializing with other participants.

Barrier 3: Activity 2.3 will integrate the role of ecosystems into Territorial Planning, Land Use Plans and Municipal Development Strategies as a key approach in achieving climate resilience. These revised instruments will be guided by technical standards and incorporated into respective local regulations ensuring that coastal development is consistent and mindful with coastal resilience based on strengthened ecosystem connectivity (including required water flow) and an important driver of degradation is eliminated

Barrier 4: Strengthening regulatory and planning frameworks for EBA will provide an opportunity to shift from a sectoral approach to coastal management into an integrated and cohesive policy based on informed decision making that can be translated at a territorial level for effective ecosystem based coastal adaptation. A key result of the project will be the development and use of a protocol to assess coastal resiliency at the local level, which will frame climate impacts in a manner that can be easily incorporated into sectoral and national planning. By linking this Protocol to an established approach to EBA, this model will have a clear pathway for national upscale and for its integration into national and local budgets.

Barrier 5: The project has looked to incorporate a cost-efficient solution to the extreme challenges being faced because of climate change. While GCF funds will invest in the initial capital investment, the GoC has the technical capacities needed to ensure their long-term sustainability. With the complementarity and synergies between its two outputs and related activities, the project will ensure that the necessary conditions are created for sustainability, and nationwide application. The data generated, will allow to make more accurate predictions on the cost-effectiveness of EBA-measures as adaptation solution to CC. This is a key output of Activity 2.3. Therefore, the knowledge generated on EBA by this project will allow designing viable, social and environmentally sustainable EBA solutions which minimalizes coastal adaptation investments in other coastal areas in Cuba.

VI. Climate-resilient investments for Cuban coastal areas.

6.1 Project Potential to Reverse the Situation (Paradigm Shift)

514. The capacity of the GoC in managing disaster and recovery efforts from the impact of hurricane hazards has been recognized as an international best practice and in has been exported to other insular Caribbean countries. Nonetheless, as the number of intense storm increases and becomes more unpredictable as projected in climate scenarios, these efforts will fall short of what is required. To effectively manage potential impacts, reactive national capacities for managing hazards needs to transform itself into an adaptation model centered around climate realities, including the potential to manage widespread coastal flooding.

515. Research has shown that best practices for strengthening climate resilience in coastal wetlands, include: removing infrastructure and stressors, regulatory setbacks, sediment fluxes restoration, linking fragmented wetlands and waterways, enhancing particular functions, ensuring freshwater availability for ecosystems, functionalities rehabilitation, monitoring, training and education, land zoning, strategizing conservation priorities, reconnecting terrestrial-coastal-marine systems, improve governance and planning frameworks, embrace uncertainty and enlist public support (Burket and Kuslker, 2000, Erwin 2009, Koch et al 2015, Wiens and Hobbs 2016)

516. With this in mind, outputs of project interventions include (1) the rehabilitation of coastal wetlands through the use of EBA methods, (2) establishment of a monitoring system to evaluate the impacts of interventions on quality of water, (3) recovery of coastal vegetation and the health of seagrasses and coral reefs. At the same time, (4) create capacities at the local level to manage environmental information and products based on climate information, and (5) incorporation of results into municipal planning. In this way, local governments will be able to address the threats of CC in a practical and strategic way.

517. Taking into account the ecosystem services provided by coastal wetlands, this proposed project will contribute to the resilience of the coastline and coastal communities of Cuba, to increased coastal flooding and saline intrusion. Specialized institutions acting jointly at community, local and provincial level will support the project, helping to reduce the vulnerabilities of the coastal communities.

518. The project´s objective will be to strengthen coastal resilience to climate change along 1,300 km of Southern Coastline by reducing the main vulnerability drivers of ecosystems and its 24 coastal communities. It will do so through an EBA approach, restoring ecosystems nexus and functionalities, and by strengthening adaptive capacity in local communities, sectors and national planning frameworks. The latter includes enhancing a greater understanding of climate change, its consequences and adaptation options together with mainstreaming ecosystems management within territorial and coastal planning instruments and frameworks. The long-term 30-year objective will be calibrated with information originated by two monitoring mechanisms: i) environmental indicators derived from the interventions improving ecosystems functioning and ii) community assessments.

519. Project interventions will enable a new paradigm from past national approaches to climate change adaptation and disasters risk reduction that will be achieved by positioning EBA directly into development strategies and actions as a means for integrated coastal zone management in a changing climate.Therefore enabling flexible risk management solutions for coastal populations through ecosystem based solutions.

520. To achieve this change of paradigm an integrated approach to EBA will be implemented including a focus on the full coastal marine landscape and ensuring that information and capacities are available for community and government buy in. This requires i) information to be available and accessible, ii) ecosystems to be rehabilitated and iii) communities and institutions' awareness of ecosystems role in adaptation to be strengthened along with their capacities to sustain it

521. Restoration activities will include 11,427 ha of mangroves, 3,088 ha of swamp forest and 928 ha of grass swamp, which in turn will improve the health of 9,287 ha of seagrass beds and 134 km coral reefs

crests. The interventions will also strengthen the adaptive capacity of communities, governments and socio-economic sectors by training on EBA, enabling the use of environmental monitoring and climate information in the decision-making process and in strengthening regulatory frameworks through a knowledge management platform for coastal adaptation.

522. GCF funds plus co-finance provided by the GoC will synergistically build the necessary resilience to the impacts of CC, through the integrated implementation of EBA across coastal ecosystem, creating the conditions to address the key concerns of "Tarea Vida" and provide a resilience model that can be replicated throughout the national coastline.

523. The GoC, will complement this project through co financing and parallel financing (already accounted to in national planning excercises) to include actions aimed at: 1) removing infrastructure barriers along the coastline 2) preventing the overexploitation of the aquifers, and 4) improving water flows to the wetlands through cleaning channels, drainage ditches and other drainage systems.

524. The GoC has developed a detailed analysis of coastal vulnerabilities to the effects of CC based on the experience of the passage of numerous hurricanes and tropical storms in the Caribbean that have directly and indirectly affected Cuba. Iturralde and Serrano (2015) have in turn analyzed and modeled the coastal vulnerabilities resulting from CC impact with milestones for the years 2030, 2050 and 2100, establishing the most vulnerable areas of the coasts in Cuba. Their results identify the two vulnerable coastal stretches selected as the project sites of the proposed GCF project.

525. The National Environmental Strategy of Cuba for 2017-2020, the Directives to Address Climate Change (2016), and the Nationally Determined Contribution have declared adaptation to CC as a national priority. Highlighting the threats to the Cuban coasts as the most important challenge derived from CC.

526. The project is thus centered in enabling national capacities to meet these directives, by putting into place best practices in natural resource management and coastal planning into a model for adaptation that is effective, feasible and cost effective.

6.2 Innovative Nature and Effectiveness of the proposed Interventions

527. The project will provide support in transitioning from a reactive disaster and emergency management approach to a preventive and holistic approach, considering adaptation as a continuous process, which in this case builds on maximizing natural infrastructure functionalities along coastal zones and is grounded on, and sustained through coastal communities and informed planning mechanisms.

528. Through the complementarity and synergies of its interrelated outputs, the project will ensure that the necessary conditions are created for nationwide application by addressing the baseline actions required for effective EBA (fully functional ecosystems, communities as active agents of adaptation and planning frameworks).

529. While Output 1 will enhance natural infrastructure as defense systems to mitigate climate impacts to coastal zones, Output 2 will promote a shift from a traditional reactive approach that considers communities as passive stakeholders into a preventive/proactive approach where they are informed active agents in natural resources and risk management. Through this output, the project provides an important opportunity in the country to enable information flow back to communities so that it can be integrated into local coastal planning mechanisms, moving beyond the implementation of top down directives, furthermore current EWS will also be strengthen by the data gathered. This will make the project a unique experience in the country which will be scaled-up within the framework of the long-term program "Tarea de Vida".

530. Hence, the principal innovation of the proposed interventions will be based on the full-scale, integrated and sustained application of ecosystem-based approaches together with building capacity and awareness among direct beneficiaries and government institutions at the local regional and national level.

531. The innovations and investments proposed through this project will occur within a structure of policies and institutional frameworks, all of which consistently prioritize addressing the challenges posed by climate change, especially in coastal communities, and the development of resilience and capacities for adaptation. With this in mind, the project has been developed to propose direct solutions for all priorities outlined in "Tarea Vida", supporting the GoC's plans to address climate change impacts, promoting adaptive actions in prioritized sectors and supporting enabling planning mechanisms for nationwide scaling up. Mainstreaming EBA into the local planning and regulatory frameworks will be a direct result this project.

532. A bottom up approach for the enhancement of regulatory and institutional frameworks is foreseen through the project. This enhancement will be supported by national mechanisms that will be developed with project funding, and that are regulatory in nature, including "Technical Standards" and "Legal Guidelines". There has been a lack of specific scientific information required for their formulation (as identified in Barriers 1, 3 and 4) and with will be provided by the integration of information derived from Output 1, into an accessible knowledge management platform and contextualized through information products (Activity 2.2) and then translated into specific normative frameworks that will allow for local action in the targeted municipalities and provinces.

533. The intervention proposal is based on the use of existing and proven successful capabilities in Cuba. First the rehabilitation of the ecological functions of coastal wetlands system whose integrity depend on the possibilities of adaptation to the impact of CC, the use of this soft or green strategy is very new in Cuba and throughout the Caribbean. Furthermore, it is proposed to improve and combine the capabilities for monitoring various government agencies in Cuba that manage data, soils, climate, hydrology, biological resources and emergency systems, to combine them, this is an unprecedented experience that will allow move from a sectoral and eminently reactive approach to an integrated and proactive planning approach for the prevention and attention of the impacts of CC, generating products and methods that will facilitate implementation at the municipal level.

534. By training local communities and authorities, while strengthening the Capacity Building Canters, the project is aiming to enhance ownership at the local level, and by promoting information exchange and letting local entities have an active role within the monitoring platforms and information management and exchange mechanisms the project is enhancing ownership of the decision making process thus ensuring proper adaptation in vulnerable coastal areas, which represent over 50% of the country.

535. The Project will also ensure the knowledge is disseminated through the Capacity building centers, where local stakeholders will also train on other topics directly related with adaptation (from territorial planning, to understanding the impacts of CC).

536. Through the application of an approach to CC adaptation based on a combination of ecosystem-based adaptation (EBA) and enhancing community capacity to cope with CC and a multi-sector approach. The different elements of this approach have been introduced and validated in the different baseline projects described above, but this will be the first time that a truly integrated paradigm will be applied, resulting in cost-effectiveness, environmental and social sustainability, and recognizing the interdependence across ecosystems and sectors.

537. The effectiveness of the project will be ensured by the fact that national institutions with strongly developed technical capacities and physical coverage at ground level will implement it; the adaptation actions proposed are founded in a solid base of scientific knowledge regarding the characteristics and functioning of the target ecosystems.

538. The proposed interventions will be carefully targeted at coastal communities which exhibit highest levels of vulnerability to the effects of CC, and at the same time present clear entry points for effective actions based on EBA; local communities will be fully involved in planning, implementation and follow-up, in order to ensure relevance and sustainability; and provisions will be made for monitoring, allowing

the investments to be managed adaptively to respond to lessons learned during implementation, or future changes in the assumptions on which the interventions are based.

6.3 GCF Project investments and proposed activities

539. The following section will provide detailed information on the activities to be implemented in each Output, which will subsequently achieve the project objective. This section includes methodologies for Output 1 and its related activities (direct interventions in coastland ecosystems) as well as a detailed description of actions related to Output 2 and its activities. Annex 1 included within the the current document presents a more thorough and site specifc description of the interventions foreseen in Output 1 within each of the targetted coastal stretches and intervention sites.

540. There is a strong complementarity between Outputs 1 and 2 to achieve the goal of improving resilience in coastal areas. The application of ecosystem rehabilitation through EBA measures will confer better conditions of resilience to the ecosystems, while the Output 2 develops the activities that generate enabling conditions to mainstream EBA measures and integrates participation of institutions and communities to achieve the final objective of the project.

6.3.1 Output 1. Rehabilitated coastal ecosystems for enhanced coping capacity to manage climate impacts

541. Output 1 will focus on rehabilitating coastal wetlands structure and functionalities along the wider marine-coastal landscape as presented in Figure 2 to address projected coastal threats consequence of relative sea level rise (coastal flooding and saline intrusion) and extreme events (increased erosion and coastal flooding) derived from climate change. Through the interactions of the four activities in this output, the project will effectively implement an EBA strategy for coastal resilience resulting from an increased capacity of coastal ecosystems along targeted areas to cope with sea level rise, extreme events and saline intrusion.

542. The proposed activities are aimed at strengthening coastal wetlands and marine ecosystems´ coastal protection services to the identified climate change impacts. This project follows the recommendation by IPCC that states that planning for climate change would need to be integrated with the use of coastlines by humans[98.] Approaches to reducing local stresses are considered feasible, cost-effective and highly scalable. The ecosystem rehabilitation methods to be applied have been chosen based on the integral functioning of the sea and coast landscape/system[99]. The proposed activities are aimed at strengthening coastal wetlands and marine ecosystems´ coastal protection services. Monitoring activities within this output will focus on assessing ecosystems´ responses (including their health, connectivity and reduced pressures) to rehabilitated conditions as indicators of increased coastal resilience[100].

543. Actions will be implemented in 7 specific sites in the areas of La Coloma; El Cajío; Surgidero de Batabanó; Júcaro; Santa Cruz del Sur; Manzanillo and Playa Florida. GCF will provide funding exclusively to inputs required for the improvements (additionality to overcome the barriers) required to restore and quantify the capacity of ecosystems to reduce climate change threats (erosion, flooding and salt intrusion).

544. The rehabilitation of coastal ecosystems of the coastal wetland will have at least the following effects:

a) Increase the water retention in coastal ecosystems, promoting infiltration and supporting the prevention of seatwater intrusion.

98 IPCC Special Report on Global Warming of 1.5°C, October 2018

99 van Integrated Ecosystems "Valoración Socio Económica de los Humedales en América Latina y el Caribe" "Socio-economic Assessment of Wetlands in Latin America and the Caribbean" (Wetlands International 2006).

100 Lacambra, C. 2010. Ecosystem-Inclusive Coastal Vulnerability Assessment in Tropical Latin America. PhD Thesis. Cambridge Coastal Research Unit. University of Cambridge. United Kingdom.

b) Increase the retention of rainwater or runoff, increase in water volume, release of ecological flow in upstream dams, and slow flow of water resulting from the rehabilitation of ecosystems. This will consequently result in greater retention of sediments and processing of organic material in the ecosystem, reflecting in an increase in their productivity and resilience.

c) The result of this increased capture of organic matter and sediment will contribute to improved resilience for both seagrass and coral reefs, reducing water turbidity and providing nutrients to the adjacent sea water.

d) Restore natural flow patterns of water and physical rehabilitation of swamp forests and mangroves to help increase the ecosystem resilience to face erosion as the effects of currents, waves and the impact of sea level rise.

545. The activities will directly strengthen the Cuban Coastal Wetland through the rehabilitation of coastal ecosystem, combining EBA techniques with integrated water and coastal management to reduce CC-impacts (coastal erosion, flooding and salt intrusion). As a result of the rehabilitated conditions, the ecosystems will more effectively face the erosive effects of wind, currents and waves on the coast (particularly during catastrophic events such as hurricanes and storms), improve the water quality and therefore improve the resilience of adjacent marine ecosystems, as well as reduce the impact of sea level rise on the geomorphology of the coast and the effect on saline intrusion. GCF funds will exclusively be used on improvements (additionality) to reduce climate change threats (erosion, flooding and salt intrusion) which are required to overcome the barriers to paradigm change in Cuba.

546. This section sets out the methodological details; (1) the evaluation of the specific intervention sites, (2) the intervention measures for the rehabilitation, (3) the protection measures to guarantee the effectiveness of the interventions once performed, (4) the monitoring of the ecosystems, (5) maintenance measures and equipment needed to carry out the proposed actions.

6.3.1.1 Activity 1.1. Assess and restore coastal wetland functions by reestablishing hydrological processes in intervention sites

547. This activity focuses on initial actions for the rehabilitation of coastal wetland functions by reestablishing the ecosystem's hydrological processes. This will include the clearing of existing water channels and favoring actions to restore the ecological flow of water along the ecosystem including the removal of invasive species. These actions will improve the ecosystems´ coping capacity to coastal flooding, climate extremes, and to saline intrusion by restoring water flows and water ways and -along with actions in Activity 1.2- rehabilitate the fluxes between ecosystems. GoC funds (Activity 1.4) will be used to eliminate manmade barriers that have degraded/changed the hydrological process including the clearing of physical waste from channels and eliminating polluted discharges into the coastal ecosystems.

548. This activity will also invest in the monitoring of coastal wetland functions to verify baseline conditions and monitor the effectivity of the restoration actions (rehabilitating water flows, new plantings, increased in foliage etc.), which in turn will allow the assessment of the impact of interventions and steering accordingly to ensure the ecosystem´s flows, nexus and functionalities for coastal protection are rehabilitated.

549. Interventions for rehabilitation across ecosystems will follow protocols which have proven to be effective through baseline projects and national research. These include a review and validation of project sites, re-establishing the hydrological flows within coastal wetlands, targeted ecosystems rehabilitation, reestablishing key species, restoring conditions for the sustainability of interventions including protective measures and management of invasive species, and monitoring and evaluation of these actions (data collection, analysis and evaluation).

550. Rehabilitation activities will be coordinated by CITMA's AMA and will be implemented by 6 forest enterprises (1 per site with two sites being attended by one cooperative) with in situ expertise in forest

management. Site selection for interventions was identified through a process that included community and municipal consultation and vulnerability-based mapping (Macro project report).

551. GCF funds for this activity will be specifically used for the acquisition of required equipment (for cleaning ditches/canals, for forest rehabilitation and for monitoring and evaluation) and technical capacity building. This includes:

- Equipment kits (one per intervention site) for the evaluation of forest' dasometry and biomass (weight scales, hypsometer, relascope, tree clipers, GPS, Phmeter, water quality multiparameter, salinometer, portable weather station, AMS Corer).
- Equipment for monitoring of rehabilitation actions including salinometers, hygrometers, stereo microscope, optic microscope, soil sample extractor, photometer.
- 5 Backhoe loaders (2 intervention areas will share this equipment) for the clearing of key channels to restore the hydrological flow
- International expertise to develop a short course on wetland rehabilitation for national specialist to standardize and share expriences in rehabilitation and management techniques.

552. Co-financing from the GoC includes technical assistance and specialist input (staff hired specifically for this project), labor directed for rehabilitation, maintenance and the protection of investments as well as purchase national insurance for the investment in mangroves rehabilitation during the 30 years of project implementation against climatic or accidental eventualities.

Mangrove Rehabilitation

553. The typical mangrove in the southern region of Cuba is a Fringing Mangrove (facing the coast directly) characterized by a coastal strip dominated by red mangrove (*Rizophora mangle*) that has a variable width of 50 to 150 meters. This is followed by a mixed mangrove dominated by black mangrove (*Avicenia germinans*) and white mangrove (*Laguancularia racemosa*) whose relative abundance and extent depends on the particular conditions of the sites. Finally, there a rather narrow strip of the non-permanent flood ecosystem dominated by Mangle buttonhole (*Conocarpus erectus*) (Menéndez and Guzmán, 2002)[101]. The mangrove ecosystem can be found by itself, however it is most commonly associated with other wetland ecosystems with varying degrees of flooding, dominated by freshwater and forests of swamps and marsh grasslands on the southern coast of Cuba.

554. The purpose of mangrove rehabilitation includes the reconstruction of the protection strip dominated by red mangrove as shown in Figure 69 below. However, other types of degradation of mangrove forests have been identified on the coast of Cuba by reducing structure height and density of mangroves. This requires other protective measures for rehabilitation of mangrove forest or anthropogenic effects in reforestation or changes in soils or hydrology.

Figure 67- Example of incorporation or rehabilitation of the protective strip formed in mangrove edge dominance *R. mangle*.

101 Menéndez L. and Guzman., 2002. Ecosistemas de manglar en el archipiélago cubano. Editorial Academia de Cuba. UY/2002/SC/ECO/PI/2 471 pp.

Source; "Manglar Vivo" PRODOC document.

Swamp Forest Rehabilitation

555. The swamp forests in southern Cuba occur in relicts of fringes and patches delimited on one side by agricultural, livestock and forest plantations, and on the other by swamp grasslands and mangroves. Among the native plant species that characterize them are: júcaro (*Bucida bucera*) ocuje (*Calophylum antillanum*), majagua (*Talipariti elatum*), oaks (*Tabebuia spp*.) Guamá (*Lonchocarpus domingensis*), royal palm (*Roystonea regia*), gray palms (*Sabal spp.)* yareyes (*Copernicia spp*.) and epiphytes several groups (Borhidi, 1996). Associated to these ecosystems are semi deciduous microphyll forests on poorly drained soil with similar characteristics and function. The swamp forests in the region exhibit high levels of degradation caused mainly by logging, invasive exotic plant species and climatic phenomena.

556. In the project the rehabilitation of swamp forests will focus on the recovery patterns of water flow, removal and control of invasive alien plant species, management of natural regeneration, planting of native plant species, along with the canopy thinning if required. The management of the water network in the region and the revitalization of streams, lakes, spring and streams are extremely important for the recovery of these forests. It is proposed that in areas with high density of invasive exotic plant species, there is establishment of various patches key native plant species and / or "umbrellas", act in turn as sources of seeds in the region.

Rehabilitation of Swamp Grasslands

557. The swamp grasslands are one of the ecosystems best represented in the wetlands south of Cuba and with considerable influence on the stability of coastal ecosystems. They are usually found among the mangrove forests and swamp forests, and are fundamental in connectivity and ecological relations in the wetland.

558. These grasslands are home to great plant diversity compared to the other ecosystems in the area. Among the plant species that make it up include: the cortadera (*Cladium jamaisensis*), macio (*Typha domingensis*) and ciperaceas in the herbaceous layer, and oaks (*Tabebuia spp.),* Yana (*Conocarpus erectus*) and palma cana (*Sabal maritimo*) in the shrub and arboreal stratum, in composition and quality that depend on the particularities of the area.

559. The channeling, drying and use of the land for agricultural, forestry and livestock production mainly affect the swamp grasslands south of Cuba. Reduction of freshwater and salinization of surface penetration by sea water, and the progress of seawater intrusion are also threats exacerbated by CC. It also affects the high frequency of fires where most are because of the negligence and poaching activity. Associated with these ecosystems they can present different types of herbaceous vegetation and flooded savannas with performances and similar characteristics.

560. Silviculture activity in parts of the swamp grasslands in the region has promoted the planting of Australian pine *(Casuarina equisetifolia).* This taxon is currently considered one of the invasive exotic plant species of greatest affectation in the swamp grasslands of the region, forming dense patches, transforming the natural conditions and displacing the native vegetation. The mattress of branches and leaves this species deposited naturally contaminates the soil, a promoter fire and limits the growth and development of native plant species.

561. In the project, the rehabilitation of the swamp grasslands will focus on the management of the natural hydrological network of the ecosystem, the elimination and control of invasive exotic plant species. The following summarizes the steps during the rehabilitation process proposed for swamp grasslands.

Sub-activity 1.1.1 Validate local conditions in intervention sites and verify ecosystem coping capacities to CC impacts through in situ and spatial temporal analyses

562. Once the project begins, field verifications will be conducted to determine whether the conditions that were assessed during project design are maintained or have changed. This will determine which are the most effective methods for the rehabilitation of the ecosystem and in particular measures to conserve their protection ecosystem services to mitigate the impacts of CC.

563. As a result of the field verification the intervention needs will be confirmed. The field verification for mangroves will be carried out through two complementary processes that will include;

- Refining the method of establishing quantitative data of the forest profile and its basic structure through the development of Transects with central point measurements.
- Establishment of qualitative analysis of the condition of mangrove forests through videos and photos with drones and their comparison with the data established through the profiles of the Transects.

564. In the case of swamp forests and grasslands field verification will be done through complementary processes that include;

- Updating map of landscape and ecosystem health.
- Spatial-temporal analysis of the ecosystem based on satellite images.
- Updating physical, chemical and microbiological parameters of soil and water.
- Update data on flora and vegetation of the area and analysis of its structure and composition by transects and fixed sample plots
- Update and status of major zoological groups
- Establishment of the causes of deterioration and evaluation of proposals for mitigation
- Qualitative analysis of the condition of swamp forests and grasslands through videos and photos with drones and their comparison with the data set profiles forest

565. Sampling and permanent plots will further allow comparison with initial data and assess survival conditions, species dominance and distribution, soil conditions and microbiota, and major zoological groups. Water salinity, flow, composition and quality into the ecosystems will also be monitored. These indicators are directly related to coastal ecosystems health and functionalities for resilience and will provide information to assess the effectivity of the restoration actions in strengthening coastal resilience and overall ecosystem sustainability. Hence these conditions will continue to be monitored during the project's lifetime.

566. Mangrove monitoring will be implemented through two alternative methods:

- Monitoring through the development of transects of 200 to 300 meters, perpendicular to the coast and sampling at the central point to determine the profile of the forest, its structure and dominance. This method will allow comparisons with the initial data from the initial assessment.
- Monitoring through systems of permanent plots that allow the description of the structure and composition of forest and their survival conditions, dominance, and distribution of species in the forest and also allow establishing timber volumes and forest growth data. The size of the plots will be established during the monitoring based on what is commonly used in Cuba.
- Measuring salinity of water in flooded areas. This is another important variable for the rehabilitation of the mangrove. It is measured with an optical salinometer locally collected

samples and the soil pore water to be measured through extraction interstitial water extracted mechanically from sediment cores.

- It is recommended that monitoring be accompanied by analysis of images or videos taken with drones to facilitate identifying changes in the short and medium term in the mangroves.
- Annual monitoring of the state of mangroves by remote sensing using images of SENTINEL 2 to determine changes in coverage and condition of the spatial distribution in the intervention areas compared to areas in good condition in adjacent areas.

567. The monitoring in the swamp forests and grasslands will be carried out from different areas of knowledge as a measure of integral evaluation of the project interventions. These will include:

- Monitoring through the development of 100-meter transects oriented randomly to determine the structure and composition of the ecosystem.
- Monitoring every 2 years with the system of permanent plots that allow the description of ecosystem rehabilitation processes and actions on invasive alien species
- Monitoring of zoological groups indicators of health and recovery of the ecosystem
- Monitoring of the composition, quality and flow of water in the ecosystem
- The monitoring should be accompanied by analysis of images or videos taken with Drones that facilitate the identification of changes in the short and medium term.
- An annual monitoring of the state of these ecosystems will be carried out through satellite images focused on determining the changes in coverage.
- Monitoring soil microbiota associated and the physical and chemical soil conditions.
- Monitoring of physical and chemical soil conditions.

Sub-activity 1.1.2 Restore the ecological flow of freshwater towards targeted mangrove ecosystems through cleaning of existing water channels and building small scale low impact infrastructure to facilitate the laminar flow of water during rainy seasons

568. An initial basic step for the rehabilitation of coastal wetlands in Cuba requires the rehabilitation of coastal wetland hydrology. This rehabilitation includes at least the restoration of freshwater flows from higher areas, the rehabilitation of water flow through the ecosystems and the habitat restoration in order to provide the ecosystem structure and spatial distribution that confers resilience to the ecosystem.

569. One of the management measures and initial steps for this rehabilitation is to restore the flow of freshwater. Based on the water law of Cuba (law 124, Decree 337 "Regulation of the Water Law"), the project proposes to establish the ecological flow required for the coastal wetlands. Actions hence will be focused on restoring these natural flows that have been obstructed.

570. Local actions in the ecosystem will include only specifically cleaning the obstructions (trash) of some ditches to guarantee the flow of fresh water from rivers or dams in drainage channels towards mangrove ecosystems, through a laminar flow. This activity will be covered by GoC co-financing. Actions to this end will be made in accordance to the project's ESMP.

571. In areas where natural drainage is obstructed, activities may include the manual rehabilitation of small ditches (known locally as "zanjeo") of limited width (30-50cm) and very shallow. These will pass through the natural meandering flow areas ("meandering" sinuous) thus allowing the laminar flow of fresh water to allow for a limited flooding of the swampland. This will allow for a flooding of the swamp land without causing erosion.

572. In areas where there is existing infrastructure for the retention of fresh water (such as dams, reservoirs or dams) measures will be established to allow for the discharge of the ecological flow of water,

hence increasing the flow of fresh water in the mangroves and other coastal wetlands. These actions will be framed within the provisions marked within Law 124 (as mentioned above). In the case of dams directly associated with coastal wetlands, actions will include the construction of earth-built speed bumps to facilitate the run off of storm water during rainy periods.

573. Finally, rehabilitation by planting mangroves or elimination of exotic forest species in Cienaga swamps will be enacted. This will, contribute to increased roughness on the floor, produced by grasslands and complex roots of forest species of swamp forest and mangrove in their respective ecosystems, thus allowing a greater accumulation of water, which ultimately contributes to feeding the aquifer and create an opposite pressure to saline intrusion. (see Figure 70).

Figure 68- Value of Wetlands on water infiltration

Source; Wetlands International,2006.102

574. Recovery of coastal wetland south of Cuba, requires actions to rehabilitate the hydrology of the region. In the swamp forests, the activities in this aspect focus on revitalizing the water currents that arise or cross the ecosystem.

575. Updating map of micro-relief will identify specific sites to run efficient cleanup actions glens, ditches, streams and waterholes based on ecosystem rehabilitation. These activities are limited to clearing some small accesses that have access through existing access roads and the waste from the cleaning of the causes can be used in local activities such as compost or disposed in existing local or municipal disposal sites.

576. The slow (laminar) and stable flow of fresh water will be recreated, as well as the natural periods of flood; will favor the recovery and stability of these ecosystems. The natural and meandering flow will be recreated in shallow systems with small circulation areas of no more than 50 centimeters wide and a maximum of 30 to 50 centimeters deep, according to micro-relief variations.

577. With regard to these actions, in cases where reservoirs or dams are present, CITMA and INRH determine the ecological flow to release it, allowing adequate freshwater flooding, in compliance with the provisions of the Water Law number 124 of 2017 established the mandate to release the ecological flow of ecosystems (corresponds to the same activity that is done with mangroves).

578. . The action then in the swamp grasslands should be aimed at restoring the natural courses of the water and not the artificial courses. In this sense the micro relief map update will identify specific sites for measures of efficient management based on ecosystem rehabilitation.

102 Wetlands International 2006. Valoración Socioeconómica de los Humedales en América Latina y el Caribe.Wetlands International, Wageningen. 36 pp

579. Natural storage capacity of freshwater ecosystems should be taken into account to ensure that goods and services should provide the wetland in coastal protection. It is proposed to contribute to the cleaning of obstructed natural ditches and to let the artificial channels siltation and disappear naturally, without doing actions in them. Rehabilitation of watercourses focus on achieving a slow flow (laminar flow) and stable reproducing patterns of micro relief, as well as allowing through the release of ecological flow natural periods of flooding, necessary for proper functioning of this ecosystem. In the water channels where natural conditions permit, the typical gallery vegetation will be restored through the management of natural regeneration and the sowing of native tree and shrub vegetation, as a measure of protection and sustainability of the actions.

580. The elimination and management of invasive exotic plant species in the ecosystem with emphasis on extractors and/or those that obstruct water flows, as well as those that contaminate the soil will take place. Those located in watercourses will be handled in a controlled manner with native plant species expansive behavior.

Sub-activity 1.1.3 Invasive species management in target sites to reduce pressures on the coastal wetland and enhance ecosystem coping capacity and resilience

Management of Invasive Alien Species (IAS) in Mangroves

581. The mangroves in Cuba have some species that are considered invasive because they are exotic species, e.g. Casuarina sp., locally called "Australian Pine", occasionally the almond tree *Terminalia catappa*. Other species occasionally found in mangroves include Majagua Florida (*Thespesia populnea*), gray Guacalote (*Caesalpinea bonduc*) and more recently the Asian colubrina. Other species that are rather typical of wetland marsh occasionally occur in the access roads.

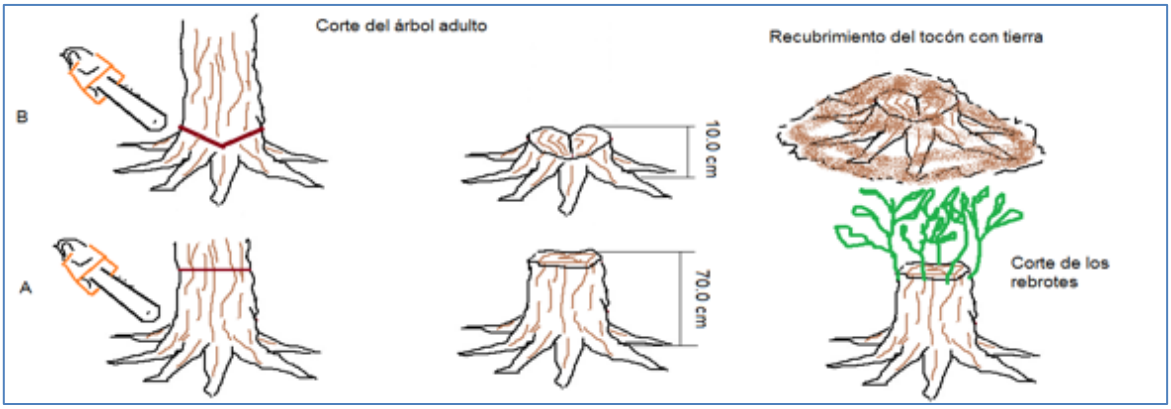
582. The proposed technique to be employed to manage these is the felling of individual trees and covering the base of the trunks to avoid regeneration or regrowth at stumps (as occurs, for example, with the Indian almond, *Terminalia catappa*). To minimize sprouts, the trunk is cut as close as possible to the ground with cuts angled towards the center. The stump (or the remaining part of the stump) is then covered with soil to prevent regrowth, as shown in Figure 52 below.

583. To minimize the possibility of bolters vertical cuts are applied with a machete from top to bottom, eliminating sprouts that can be formed with all the meristem tissue crust- also eliminating the natural regeneration; this action is applied every 15 days, until remaining without regeneration for 30 days.

584. Moreover, there are native species like the mangrove fern (*Acrosticum aurum*) that are not exotic but can be problematic. In places where mangroves have lost massive species due to deforestation or death, by fire or natural or artificial reasons, A. aurum (that has a very rapid growth) can suffocate the mangrove. In these cases, it is required to mechanically remove the fern to allow for the establishment of mangrove forests.

585. It should be noted that these techniques follow national and international best practice based on the protocols developed through internationally funded baseline projects and national legislation. The project's ESMP will be strictly followed in the development of these actions.

Figure 69- Correct method (B) for the elimination of arboreal IAS and incorrect method (A) that induces the formation of sprouts.



Management of IAS in swamp forest

586. The swamp forests of southern Cuba are severely affected by the presence of invasive exotic plant species. Almond *(Terminalia catappa)* and casuarina or Australian pine *(Casuarina spp.)* are species that affect swamp forests in the region The proposed actions are then oriented disposal and management of these species by logging race, girdling, removal of sprouts, removing natural regeneration and immediate planting of several pioneer native species and / or management native natural regeneration.

587. Then you can incorporate scryophilic plant species or that require this condition in the early stages of its development, which will allow re-establishing the ecological relationships in the region. In these ecosystems the almond exhibits alarming levels of invasion, so attention to this species will be a priority in the project.

588. Actions will be based on national and international best practices best on the above cited baseline projects funded through international funds (GEF and Adaptation Fund) and in keeping with national norms and legislations. The project's ESMP will be strictly followed.

Management of IAS in swamp grasslands

589. The swamp grasslands of southern Cuba are severely affected by the presence of invasive exotic plant species. Several threats have been identified, for example, that many of these species in the ecosystem of interest that extract water contribute to its drying, contaminate the soil, promote fire and obstruct natural water courses.

590. Proposals for actions in the project are then oriented disposal and management of these species by logging, girdling, removal of sprouts, removing natural regeneration for trees and shrubs, and extraction of aquatic herbaceous species.

591. The swamp grasslands of southern Cuba are severely affected by the presence of invasive exotic plant species. These include: the vine (*Ipomea alba*), water lettuce (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*), miriofilum (*Myriophyllum pinnatum*), Australian pine (*Casuarina spp*.), Leucaena (*Leucaena leucocephala*) and melaleuca (*Melaleuca quinquenervia*). These species are particularly harmful as these extract large water resources and obstruct natural water courses thus contribute to the drying of the swamp lands. These species also contaminate the soil and promote forest fires.

592. Proposals for actions include the disposal and management of these species by logging, girdling, and removal of sprouts, removing natural regeneration for trees and shrubs, and extraction of aquatic herbaceous species. Actions will be based on national and international best practices best on the above cited baseline projects funded through international funds (GEF and Adaptation Fund) and in keeping with national norms and legislation. The project's ESMP will be strictly followed.

Table 21 Detailed Stakeholder Table for Implementation Activity 1.1

Stakeholders with Active Participation in Implementing the Activity	Actions for Development of the Activity	Deliverables to be Provided	Existing Capacities (Co financing)	GCF inputs that will be provided to comply with the deliverable
Provincial Forestry Enterprises (Pinar del Rio, Artemisa, Mayabeque, Ciego de Avila, Camagüey and Gramna). In the case of Camaguey there are two (2) brigades, the rest have only one brigade. Thus totaling 7 brigades for the execution of this work. In addition, they will get scientific advice from the IES.	• Validation of coastal wetland conditions in intervention sites (7), to adjust intervention designs accordingly (anthropic pressure, coverage, structure and diversity of species, hydrology). • Ditch and channel clearing in intervention sites; • Hydrological flow conditioning in areas to be rehabilitated. • Invasive exotic species control and elimination in intervention sites (7).	• Technical projects for the restoration of coastal wetlands in intervention sites (7). • Approx. 1,300 Km of rehabilitated ditches and channels; • Approx. 15,000 Ha with restored hydrological flow; • Invasive exotic species controlled in approx. 15,000 ha; • Monthly activity progress reports.	• Qualified technical personnel, in each province (an average of 4), for the design of rehabilitation projects, as per FONADEF requirements. • Forestry Brigades (7). As an average each brigade has 30 workers who live in intervention areas. • Support personnel in the 7 intervention sites (office staff, drivers and executives). • Wages of all involved personnel (approximately 280).	A kit with the following equipment shall be delivered to each brigade in the concerned Forestry Enterprise (7): • Fuels and lubricants • Maintenance and insurance • IT Equipment • Office furniture • Equipment for biomass and forest dasometric assessment (Hypsometer, tree caliper, relascope, etc. • Channel and ditch clearing equipment • Personal inputs and tools for clearing works
State-run Forestry Service	Review of technical projects presented by forestry enterprises. Certification of hydrological flow restoration works	• Project Approval Certificates; • Certification of Budget allocation for Project implementation.	• Qualified personnel (at least 4 per province) trained in forestry project assessment; • Staff wages provided by MINAG cofinancing	• Kits to be delivered per province. • IT Equipment • Office furniture • Motorcycles
Institute of Ecology and Systematics (IES), CEAS,	• Validation of coastal wetland conditions in intervention sites (7) to adjust interventions'	• Reports on the initial condition of mangrove and swamp forests; • Maps, databases with mangrove and	• Qualified personnel in flora-and-fauna-related specialties (approximately 12) • Staff wages provided through	• Monitoring kit (5 microscopes stereoscopes, 3 optical microscopes, hygrometers, lab

	design accordingly; • Training to CEAS • Coastal wetland monitoring in intervention sites (7).	swamp forest health once initiated rehabilitation activities.	CITMA co financing	stoves, soil sample extractor, etc.) • IT Equipment • Office furniture.
Institute of Tropical Geography	• Coastal wetland monitoring using remote sensors; • Coastal wetland monitoring using aerial drone photography; • Training to CEAS	• Maps and databases on coastal forest abundance and health; • Progress maps showing changes in reforested areas.	• Personnel trained in the use of product development from remote sensors; • Staff wages (approximately 8 members) provided by CITMA cofinancing	• Drones equipped with multispectral cameras for aerial photography • IT Equipment

6.3.1.2 Activity 1.2. Mangrove and swamp forest rehabilitation in target sites through natural and assisted regeneration for enhanced coastal protection

593. This activity will result in the rehabilitation of 15,443ha of degraded coastal wetlands through natural and assisted regeneration in target sites focusing on mangroves, swamp forests and grasslands. This activity along with actions through Activity 1.1. will directly improve the coping capacity of coastal wetlands to flooding (by increasing sediment trapping, increasing ecosystems health and reestablishing seaward species that have been lost R. mangle), climate extremes (by strengthening the coastal system green structure and reconstructing its protective role with red mangrove) and saline intrusion (by restoring water /infiltration capacity).

594. Interventions for rehabilitation across ecosystems will follow protocols which have proven to be effective through baseline projects 103 and national research (Section B.2). These include targeted ecosystems rehabilitation, reestablishing key species, restoring conditions for the sustainability of interventions including protective measures.

595. Rehabilitation activities will be coordinated by CITMA/AMA and implemented by 6 local forestr enterprises with in situ expertise in forest management. Local forest enterprises, which are responsible for forest management practice in the area have strong technical skills in relation to forestry land will implement actions for wetland and mangrove restoration. Experience, in the last 4 years in mangrove reforestation and rehabilitation in the provinces of Mayabeque and Artemisa through the Adaptation Fund project "Manglar Vivo" have provided key lessons learned in terms of generating resilience factors and developing protocols for intervention in the rehabilitation of mangroves a form of coastal protection[104].

[104] Examples include but are not limited to:
Manglar Vivo (2019). "Métodos de intervención para la recuperación de la salud del ecosistema de manglar en el Sur de las provincias Artemisa y Mayabeque" CITMA. Cuba.
Torres Arias,Y. Sanchez Rendon,J. Pernus Alvarez,M. (2019). "Manual se Semillas para la Restauración de Ecosistemas Limítrofes al Manglar."CITMA.Cuba.
Sanchez, E. (2019). "Métodos Para El Monitoreo de Resiliencia, Seguimiento de las Labores de Mitigación y Adecuación." Manglar Vivo. Cuba
UNESCO (1999). "Bases Ecologicas para la Restauracion de Manglares en Areas Seleccionadas del Archiapelago Cubano." UNESCO. Cuba.

596. GCF funds for this activity will be specifically used for the acquisition of required equipment and software/hardware. Co-financing from the GoC includes the implementation of restoration actions as well as purchase of national insurance for the investment in mangroves rehabilitation during the initial 8 years of project implementation against climatic or accidental eventualities.

Sub-activity 1.2.1 Acquire forestry and evaluation equipment for restoration in target sites

597. This activity takes into account the integrated nature of GCF and co-financing resources as critical inputs for action as GCF funds will provide the necessary equipment (required due to incremental costs of adaptation) while co-financing funds will implement activities 1.2.2 and 1.2.3 with the provided equipment.

598. Hence, GCF funds will be used to acquire forestry and evaluation equipment for restoration actions in target sites. This includes the purchase of agricultural equipment difficult to access in Cuba (Feasibility Study Section 4.5) that will be provided to each forestry cooperative (6) and is required for the implementation of restoration investments, this includes the establishment of nurseries along each project site as well as mobilization equipment for access to difficult areas of access along the wetlands.

599. Equipment will be acquired through GCF funds during the project's first and second year and will follow UNDP's procurement process. Equipment will be provided to forest enterprises and will provide the capital means for the maintenance of coastal ecosystem interventions throughout the project's full life time (30 years) will directly enhancing national capacities for EBA. It should be noted that lack of this equipment has been listed as an important barrier in implementing ambitious EBA actions.

600. Cost efficiency for equipment has been ensured by looking to invest in the minimum required equipment required for the implementation of restoration actions. This includes identifying sharing agreements between forest enterprises for the use of the equipment when possible (case of backhoe loaders and tractor for land preparation). It should be noted however, that various interventions within the restoration process require careful timing[105] - timing being identified as an important factor in ensuring the success of restoration invesments in mangroves[106]. Hence, interventions will require some actions to take place almost simultaneously between sites making sharing agreements in these cases unfeasible.

601. GCF funds will be used for the following

- Specialized equipment for forestry rehabilitation per area (total 7) that includes sprinklers, chainsaws, water pumps and a portable power plant
- Tools for forestry works (1 per site) including equipment to build a forest nursery, protection equipment/clothes for workers and tools (hoes, measuring tapes, binoculars, sledgehammers, pruning shears, weaver curved hand saw)
- Agricultural equipment for forestry rehabilitation (total 7) including tractor (model TIGER 80) with tipper cart. Tractors will be used for activities wihin the wetlands where ground is irregular making access by other means impossible.
- 5 Krypton 110 Caterpiller Tractors with Front blade (2 intervention areas will share this equipment) for land preparation for reforestation in areas that have been identified as totally deforested.

105 UNESCO (1999). Bases Ecologicas para la Restauracion de Manglares en Areas Seleccionadas del Archipielago Cubano. Havana. p7

106Key aspects for success in mangrove restoration that have been identified include the correct identification of species, the timing and method of planting.

- Transportation equipment for monitoring and displacement of workers within the wetlands (plastic boats, bycicles, motorcycles, 4x4 vehicle) particularly to areas of more difficult access (see Annex 1 for characterization of intervention sites).
- Short course on wetland rehabilitation for national specialist to standardize and share expriences in rehabilitation and management techniques.

Sub-activity 1.2.2 Implementation of natural regeneration management measures in target sites

602. According to the available knowledge of the mangrove ecosystem and its ecological functions there are three types of rehabilitation measures that can be considered, these measures include; (1) Management of natural regeneration, (2) Mangrove forest rehabilitation and (3) Planting mainly of the red mangrove (***R. mangle***) (Activity 1.2.3).

Management of Natural regeneration.

603. One possible scenario regarding the fringe mangrove red (***R. mangle***) is the mangrove has decreased the width of the coastal strip and the number of adult trees of this species is no longer dominant, presenting a forest dominated by other species but with an abundant presence of ***R. mangle*** propagules naturally available. Under these conditions the thinning of the canopy removing branches or trees that impede the penetration of light in the mangrove is usually sufficient to promote the natural regeneration of ***R. mangle.*** as ***R. mangle*** is a heliophyte species which reacts positively to growing in the presence of light.

604. Subsequent monitoring of forest conditions after the intervention may be sufficient to determine forest responses to treatment and establish whether additional measures are required or interventions are sufficient.

605. In places where there are mangrove areas and spatial distribution and structure are similar to the ideal with relatively small-degraded areas, hydrological improvements and canopy tightening that allow rehabilitation in the short term will be established.

Rehabilitation of native vegetation in swamp forests and grassland

606. According to the available knowledge ecosystem of swamp forest and its functions there are three rehabilitation measures to consider: (1) Management of natural regeneration of native species, (2) Weed Control and clearing, (3) Planting of selected native plant species (Activity 1.2.3),

607. Natural regeneration in swamp forest is characterized by abundant plant diversity in relation to its composition. Usually in impacted areas dominance of regeneration of pioneer species limits the growth and development of other native species. In this case you must make a controlled extraction of these species at sites required and only as a measure to reduce its concentration. On the other hand, the controlled clearing of the vegetation cover up to 70% of its initial condition (in areas with 100% coverage), stimulates the growth rate of this natural regeneration.

608. In planted sites and those where natural regeneration is stimulated, should perform control activities and weed management which together with the controlled vegetation clearing up to 70% of its initial condition in areas with 100% coverage, stimulate the growth rate of individuals targeted. Forestry companies have developed and will follow a schedule of activities derived from successful past technical projects for the care of these plantations hence ensuring its success.

Sub activity 1.2.3 Red mangrove and native species planting in target sites for forest rehabilitation along the shoreline boundary of targeted coastal wetlands

609. Mangrove restoration efforts will rehabilitate the protection strip that used to be dominated by red mangrove along the coastlines (Feasibility Study Annex 1). Planting will be done in sections with very low mangrove density and with no evidence of sufficient presence of propagules.

610. Swamp forest rehabilitation actions will enhance native species diversity (often affected by illegal logging), with the objective of enhancing the ecological functionalities and connectivity for resilience and ecosystem services maintenance along the swamp forests that will in turn be monitored through Activity 1.1.

611. These actions will be implemented by forest enterprises that will make use of the equipment acquired in Sub activity 1.2.1 exclusively for these actions in target sites and their maintenance. Cost of implementation (labor, oversight, technical expertise) will be covered by the GoC as dedicated co financing for this project. All interventions will be managed following the project's ESMP, national legislation and protocols for forest management

Planting of Mangroves

612. In areas where the *R. mangle* density is very low and there is no evidence of sufficient presence of propagules established in the field, red mangrove sowing will be actively done.

613. Mangrove planting will also be done in areas where spatial distribution and structure are not idea. Monitoring data to verify baseline in target areas (Annex 1), will establish the intervention needs for rehabilitation through the use of field data systems. Interventions will favor natural regeneration, however in the very specific cases, small scale t planting of mangle will be done depending on local conditions.

614. For the plantation of mangroves, the following actions will be taken;

- The decisions about reforestation with propagules or with seedlings will be concluded during the field verification based on the availability of propagules and the stability of the ecological system.
    - Establish plantings of *R. mangle* propagules, directly where required. It is recommended to plant propagules at distances no greater than 30 to 40 centimeters from each other to stimulate intraspecific competition that allows faster growth of mangrove seedlings.
- Clearing of the Canopy through the pruning of branches or the cutting of trees to allow the penetration of light in the areas where the plantations are made, to favor the growth of *R. mangle.*
- "Estaquilleo" should be undertaken to limit the energy of the coast in areas where mangrove seedlings could be established in areas on the seashore and in those places where sedimentation patterns allow it. Estaquilleo involves the digging of wooden poles into the mud between the existing mangrove and the sea in order to reduce the impact of waves on new seedlings.

615. Efforts for the collection of propagules of red mangrove can be determined in the field, however it should be considered that it has a profuse flowering period the dry season, (although propagules can be obtained at any time of the year). Lessons learned from past projects have demonstrated that it is ideal to plant two months before the rainy season to find ideal conditions for the growth of seedlings.

Native species planting in swamp forests

616. The presence of tree and shrub species of precious woods in the swamp forests south of Cuba, has stimulated for centuries indiscriminate logging resulting fragmentation and loss of basic ecological relationships for resilience and maintenance of ecosystem services. Native plant species such as: Antillean mahogany *(Swietenia mahagoni),* black majagua de Cuba *(Thespesia cubensis),* ebony saithe *(Diospyros crassinervis),* black júcaro *(Bucida bucera*) among others, consists of its presence only in records of herbarium and floristic studies, or they are very scarce in these areas. The same behaviors show less represented herbaceous species and indicator of health in this ecosystem. In this sense, the actions are based on:

- Location of adult individuals of native species and seed collection of several representatives of their species to ensure genetic diversity.
- Implementation of methods to increase the rate of seed germination

- Establishment of nurseries for propagation of native plant species choose to plant in the rehabilitation work.
- Implementation of the native arbuscular mycorrhiza fungi to stimulate the growth development and survival of the seedlings.
- Rehabilitation with a mixed composition of native plant species in 2 steps without frames planting to deforested areas. Steps: 1) planting of pioneer species, 2) sowing of non-pioneer species. Plant species should remain in the nursery the period of time required until they reach a height of 2.5 to 3 meters ensure high percentages in the area
- Fortification certain native plant species in selected areas.

Sub-activity 1.2.4 Implementing external risk management measures in target sites to ensure perdurance of target restoration investments including fire control management, illegal logging surveillance measures and climate insurance

617. This sub activity is part of the established protocol for the restoration of coastal wetlands and must be considered. It will be mainly funded by the GoC through targetted resources.

618. Investments under this sub activity will protect restoration investments from outside forces (fires, illegal logging and loss from extreme storms) as they gain maturity and have enhanced capacity to self-manage. This will incorporate mitigation measures within the project to ensure that coastal ecosystems have the opportunity to develop during their initial years to provide long term services to coastal landscapes.

619. The monitoring and protection of coastal wetlands (mangroves, swamp forests and grasslands) is the responsibility of the forestry companies and the ranger corps, both with government direction. The periodic action of the specialists and workers of these institutions is to prevent poaching as an essential element, fires, and act immediately and in correspondence with the situation. The forestry law regulates and provides the means for the use of these forests. According to the "Tarea Vida" these protective ecosystems should be under national protection mechanisms.

620. Project investments in the mangroves, swamp forests and grass lands will include few protection measures to be considered. GCF funds will invest in enhanced capacities to enable monitoring (bycicles, ICT equipment for forest rangers) however all additional actions and work for fire preparedness particularly for the grasslands as well the purchas of insurance will be fully funded by the GoC with its own funds:

- **The protection system against forest fires.** Fire control systems through local fire brigade Ranger Corps. This output establishes and provides equipment to the ranger bodies, training, and the establishment and maintenance of fire trails in mangrove areas where relevant.
- Forest fires in the swamp forests are scarce and their occurrence is subject to its hydrological condition. Frequently the fires that occur have their origin in the grasslands of swamps or other adjacent herbaceous ecosystems. The firewall limits of these ecosystems trails prevent the passage of fire from one ecosystem to another. Local fire brigades and forest rangers manage control and eradication fire.
- Fires are very frequent in the swamp grasslands of southern Cuba, caused mainly by negligence and furtive activity. The building and the use of existing of water channels allow those ecosystems to carry water according to their natural dynamics preventing the expansion of these fires. These water channels to be effective should be about 30 cm deep and 50 cm wide with a slow and steady flow (laminar). However, these need to be better assed in the target areas to meet the rules of the firebreaks that must be established for the control of these phenomena. The project in accordance with the parameters for hydraulic rehabilitation in the areas of intervention, will conduct a review of the features and functions of the trenches and current channels that allows

for intervention proposals for the rehabilitation of the ecosystem and benefit adjacent ecosystems. It should be noticed that this was an important lesson learned from the Manglar Vivo Project[107] that resulted in the deviation of past practices of planting in these areas to increase forest coverage without taking into account hydrology, thus exposing plantings to potential fires.

- **Surveillance and Protection, is a measure for Ranger Corps of supervision and monitoring to prevent illegal felling of mangroves.** The monitoring and protection of coastal wetlands ecosystems is the responsibility of the forestry companies as administrators of the forest resource, and of the ranger corps; both with the task of safeguarding the government's assets. In Cuba there is a total ban on the use of the mangrove since 2012. The forestry law (law 85 July 1998) establishes that the mangrove is protective forest in its article 20. According to Article 27, the use of these forests is prohibited and requires that special conservation measures are taken. However, there are reports of illegal logging so the monitoring and enforcement of the law are necessary. Further, in Cuba the swamp grassland do not have a legal norm for its protection as an ecosystem, however they are a key part of coastal wetland functionality. As a result, from project activities (Output 2.3) a legal proposal for grassland conservation in the coastal wetlands of Cienaga will be promoted
- **Representation in the system of protected areas.** One of the measures for resilience of mangroves is to provide a broad representation of mangroves in the protected area system. According to the Millennium Development Goals, representation must include at least 10%. A broad representation of mangroves is available in the case of a catastrophic event, as it can regenerate naturally. The project intervention tranches currently selected include four protected areas with mangroves. It is estimated that this may be sufficient for resilience but requires support for the management of protected areas.
- The swamp forests selected within the project are included within 4 protected areas nationwide. This ensures the preservation of the formation of plants under the rules of the National System of Protected Areas of Cuba. In these protected areas there are plans for rehabilitation, monitoring and conservation, and there are species comprising identified as conservation targets because of their threat level, biological and ecological importance. The project will also promote the protection of soils and water in addition to forests in the swamp forests selected to intervene, to ensure that the rehabilitation actions implemented contribute to the overall functioning of the wetland sections.
- Wetland herbaceous and related ecosystems are found in the 4 protected areas included in the project intervention area. Hence these sites are protected indirectly by being part of these areas.
- **Purchase of national insurance for the rehabilitated mangroves** in project sites during the initial 8 years of project implementation against climatic eventualities (extreme weather). The Integral Forestry Companies that will carry out the interventions will establish an Insurance Contract with the the National Insurance Company (ESEN) to ensure forest plantations in the face of the occurrence of extreme weather events. By insuring these goods, they are protected against damages or losses caused by or as a result of cyclone, windsock, tornado, flood, heavy rains, hail and drought. The amount of these insurance policies is estimated at a total value ascending to: USD 4,000,000 to be paid in full with national co-financing.

General Maintenance of Interventions in Coastal Wetlands

621. Maintenance of interventions within the wetlands is included within the project and has been costed and detailed in the project's Operation and Maintenance Plan. Funds for maintance of the project

[107] Manglar Vivo (2020). Pp 4.

interventions during the project lifetime have been costed and will be funded in a mixture of cofinancing as well GCF financing. Maintenance costs beyond the project lifetime will be covered by the MINAG (forest enterprises) and CITMA/AMA as stated in cofinance letters and Operation and Maintenance Plan. Municipal support for these interventions will also be foreseen through the environmental management and development plans that will result from this project (Output 2.3).

622. GCF funds will be invested primarily in equipment required for the implementation of restoration actions. These will be procured following UNDP Rules and Regulations and following best practices including maintenance of the equipment and training of national staff, the purchase of spare parts. Furthermore, it should be noted that CITMA/AMA, forest enterprises have in house capacity (technical workshops and specialized staff) to maintain this equipment and ensure its long term sustainability.

Maintenance of interventions in Mangroves:

623. The implementation of intervention protocols includes activities ecosystem management that could be considered maintenance, however, in addition to implementing a series of forestry management activities standards that allow maintenance management actions and rehabilitation proposals for activities proposed described above. These maintenance activities include the following:

- Clean and maintain channels every two years.
- The method for cleaning and maintenance of appropriate cleaning ditches 2.0m wide by 50 centimeters to 1.0m maximum depth thereof and removing vegetation mangrove than 1.0m on each side thereof; the channels as a method or way of cleaning them proceed to 4.0 m wide by 10m deep, plating 2.0m on each side of them.
- Annual sanitary felling, exotic species are established or individuals are found in the forest with diseases or pests (described above in the intervention section of mangroves). Once established this measure is given maintenance once a year.
- During the plantation establishment the first 6 years is evaluated annually the possible needs of forest clearing to promote penetration of light on mangrove plantations where necessary.
- After the establishment of forests, thinning is required (selective cutting of individuals planted to stimulate growth especially in stands where the densities are very large). Thinnings must be performed at various periods after the establishment. Practice establishes at least 3 thinnings:
    1. First thinning; between 5 and 6 years
    2. Second thinning; between 10 and 12 years
    3. Third thinning at 15 or 16 years old.
- It also requires the development of fire trails that require annual review after the rainy season. Channels and trenches serve as anti-fire but surely other paths are required. For construction and/or maintenance of skid firewall as applied method it is implicit in the activity of trenches and channels, mostly because these fulfill the two functions contributes to better exchange of water in the ecosystem and serve as firebreaks.
- Finally, during the project life insurance that will cover mangrove plantations and other interventions against climatic or accidental eventualities provided as fire, flood or impact of hurricanes and storms in the areas of project intervention during the 8 years will implementation.

Maintenance of interventions in the Swamp Forest

624. The implementation of the intervention protocols includes ecosystem management activities that could be considered maintenance, however, in addition, it is proposed to implement a series of standard forestry activities that allow the maintenance of the proposed management and rehabilitation actions, these activities include the following:

- Clean and maintain channels every two years. The method for trench cleaning and maintenance proceeds by clearing 50 cm wide by 50 cm at a maximum depth of 1.0 m, and removing vegetation other than swamp forest and sowing sediment retaining species at 1.0 m each side of the same.
- Annual sanitary felling in swamp forest, exotic species are eliminated or individuals are found in the forest with diseases or pests (described above in the intervention section of mangroves). Once this measure is established, it is maintained once a year.
- During the plantation establishment the first 6 years is evaluated annually the possible needs of forest clearing to promote penetration of light on mangrove plantations where necessary.
- Management of natural regeneration is carried out annually to ensure that scarce but naturally occurring species within the Swamp Forest are regenerated.
- It also requires the development of fire trails that require annual review after the rainy season. Channels and trenches serve as anti-fire but surely other paths are required. For construction and / or maintenance of skid firewall as applied method it is implicit in the activity of trenches and channels, mostly because these fulfill the two functions contributes to better exchange of water in the ecosystem and serve as firebreaks.

625. Finally, during the life of the project, there will be an insurance that will cover the plantations of swamp forests and other interventions against climatic or accidental eventualities such as fires, floods or the impact of hurricanes and storms in the areas of project intervention during the 8 years of implementation. These will be funded through GoC funds.

Maintenance of the interventions in the Swamp Grasslands.

626. The protocol of intervention of the swamp grasslands requires; (1) Monitoring for removal of Invasive Alien Species (IAS), and (2) monitoring of the rehabilitation of hydraulic conditions and (3) monitoring determine permanent plots the ecosystem conditions (every two years).

627. During the period after 8 years of interventions GCF is expected to perform the same pattern GoC monitoring for 22 years for maintenance interventions according to the following protocol:

- Monitoring through the development of 100-meter transects oriented randomly to determine the structure and composition of the ecosystem.
- Monitoring every 2 years with the system of permanent plots, which allow the description of the processes of rehabilitation of the ecosystem and the actions on the invasive alien species
- Monitoring of zoological groups indicators of health and recovery of the ecosystem
- Monitoring of the composition, quality and flow of water in the ecosystem
- The monitoring should be accompanied by analysis of images or videos taken with Drones that facilitate the identification of changes in the short and medium term.
- An annual monitoring of the state of these ecosystems will be carried out through satellite images focused on determining the changes in coverage.
- Monitoring of the microbiota associated with the soil.
- Monitoring of the physical and chemical conditions of the soil.

Table 22 Detailed Stakeholder Table for Implementation Activity 1.2

Stakeholders with Active Participation in Implementing the Activity	Actions for Development of the Activity	Deliverables to be Provided	Existing Capacities (Co financing)	GCF inputs that will be provided to comply with the deliverable

Provincial Forestry Enterprises (Pinar del Rio, Artemisa, Mayabeque, Ciego de Avila, Camagüey and Gramna). In the case of Camaguey there are two (2) brigades, the rest have only one brigade. Thus totaling 7 brigades for the execution of this work. In addition, they will get scientific advice from the IES.	• Thinning to improve light outreach. • Elimination of immature trees. • Creation of nurseries; • Soil tillage; Planting of red mangrove and other native species.	Invasive exotic species controlled in 6,000 ha; Approx. 10,000 ha under plantation regime; Built firebreak gaps Monthly activity progress reports.	• Forestry Brigades (7). As an average each brigade has 30 workers who live in intervention areas. • Support personnel in the 7 intervention sites (office staff, drivers and executives). Wages of all involved personnel (approximately 280 ppl).	A kit with the following equipment shall be delivered to each brigade in the concerned Forestry Enterprise (7): • Invasive exotic species control equipment • Personal inputs and tools for invasive exotic species control works • Heavy vehicles and/or agricultural machinery. • Forestry work inputs and tools • Vehicles for field visits 1 • Firefighting squad gear (2 per intervention site).
State-run Forestry Service	• Field visits to inspect the work carried out.	• Work quality certification.	• Qualified technical personnel in each province (4 as average), to certify the quality of the work carried out as per FONADEF requirements.	• Vehicles for field visits 1 (same as 1.1) • IT and office equipment (same as 1.1)
Forest Ranger Corps	• Regular visits to identify potential forest fire hotspots and illegal activities in wetlands	• Forest fire incidents reports; Illegal activity incidents reports.	• Qualified technical personnel in each province.	• Firefighting squad gears (1 per intervention site). • IT and office equipment (1 PC. 1 printer, etc.)

6.3.1.3 Activity 1.3. Record and asses the coastal and marine ecosystems' natural regeneration and their protective functions based on conditions provided as a result of restored coastal wetlands

628. The main assumption for this activity is that a functional landscape approach in which interventions across and along the watersheds and coastal wetlands (as described in Activity 1.1 and 1.2) will have a positive effect on the health and coping capacities of seagrass and coral reefs. The interventions aim to reduce sediment loads, nutrients and contamination (key degradation drivers) thus providing an opportunity to naturally restore the health of seagrasses and coral reefs and enhance their protective

capacity against coastal threats. A volunteer network will also be created to support in the restoration of coral reefs in the case of damage from extreme weather.

629. The results from this activity will also provide practical and scientific information that will allow its replication at national and regional scales and strengthen the global argument for EBA in coastal systems. These include the following assessments:

- Coastal & marine waters´ monitoring & assessment. Physical, chemical and biological indicators will be monitored at specified areas and periods of time. Water and marine ecosystems´ continuous monitoring will allow to assess if coastal and marine ecosystems ´environmental conditions have improved as a consequence of the actions implemented in the wetlands (Activity 1.1), and hence improve marine ecosystem´s responsive capacity.
- Environmental conditions will be assessed, monitored and analyzed in order to evaluate the change due to the interventions. Baseline conditions are expected to improve, and degradation causes to diminish, hence will be monitored to assess the changes occasioned by the project activities. Fixed equipment placed on boats and in monitoring stations located on the main coast or along the keys will be crucial for the monitoring.

630. This activity will be led by CITMA/ICIMAR and will have the support of communities that will be trained through Activity 2.1.3 to support in the monitoring of seagrasses and coral reefs and their role in coastal protection. Information will be collected in the Knowledge Management Platform that will be created through the project (Activity 2.2).

Sub-activity 1.3.1 Acquire and install a monitoring system to evaluate enhanced water quality environmental conditions for seagrass and coral reef natural regeneration

631. This sub- activity takes into account the integrated nature of GCF and co-financing resources as critical inputs for action with GCF funds providing the necessary equipment (required due to incremental costs of adaptation) while co-financing funds will implement sea water quality monitoring and evaluation activities (including the installation of the acquired equipment). Together these actions will assess coastal and marine environmental conditions (measured through water quality) as a consequence of the actions implemented in the wetlands for enhanced marine ecosystem´s responsive capacity.

632. Monitoring capacity will be provided through the enhancing of 5 labs that will be dedicated to sea water monitoring within the target sites and will provide information on the conditions for ecosystem recovery. These laboratories will be set up at a provincial level in 4 Environmental Study Centres (CEA) as well as at a national level within ICIMAR. Physical, chemical and biological indicators will be monitored through these labs in by marine expeditions coordinated by ICIMAR/CITMA within the target sites to allow the assessment on improved conditions for coastal and marine ecosystems responsive capacity.

633. Actions will also include the installation of 36 marine monitoring stations (16 marine and oceanographic surveys, 10 weather stations, 4 wave stations and 6 sea level and terrain movement stations) to measure the marine ecosystem capacity for resilience and regeneration as measured through changes in water parameters. Equipment will be installed by experts hired by the GoC (including INSMET) based on best practices and international standards.

634. Marine monitoring in each section of the intervention will be carried out taking into account the three ecosystems that are the object of the project, in order to evaluate the response to the actions carried out from the hydrographic basins to the coastal wetlands in order to improve the resilience of the ecosystems.

635. The monitoring sites will be located along the coast in the submerged mangrove swamp, with an emphasis on the areas surrounding rehabilitation activities and on the biotopes of sea grass and reefs. The biological indicators of health of the ecosystems established in the monitoring protocols of seagrasses, reefs and submerged mangroves will be used. Likewise, in each of these sites the water quality indicators (chemicals and microorganisms) will be evaluated.

636. For real-time monitoring of oceanographic variables (physical, speed and direction of currents) and measurement of variation in wave amplitude and sea level, the stations will be located in coastal areas, fundamentally, adjacent to vulnerable coastal settlements and in the reef macro-lagoon where sea grass is present; as well as in the immediate vicinity of the reef ecosystems.

637. The water quality and oceanographic stations will be located close to each other to guarantee the simultaneity of the collection of abiotic and biotic data that allow the interpretation of the responses to the environmental changes that are expected to occur due to the actions of the project aimed at reducing anthropogenic pressures (sediment loads, nutrients and pollution) that are key factors in ecosystem degradation, thus providing an opportunity to naturally restore and enhance its ability to protect against coastal threats

638. Installation of the monitoring station will be done under two approaches to monitor the oceanographic conditions in transects coast-coral reef with a regularity to evaluate any change that occurs while allowing sufficient coverage and parameters: (1) the placement of stationary ocean stations to be located on the coast and along the keys "callerias" and (2) in the placement of stations within boats that operate under existing routes covering Batabanó-Isla de la Juventud and Júcaro-Cayo Anclitas (in the Jardines de la Reina).This will allow the use of measurements through transects located between the coast and the cays or islands (Figure 53 and 54).

639. The data capture will be continuous (every 30 mins), but can be set at will by users within standard parameters they determine the first phase. The data will be downloaded for analysis semiannually.

Figure 70- Sites and Transects proposed for the physical monitoring of seawater in Section I.

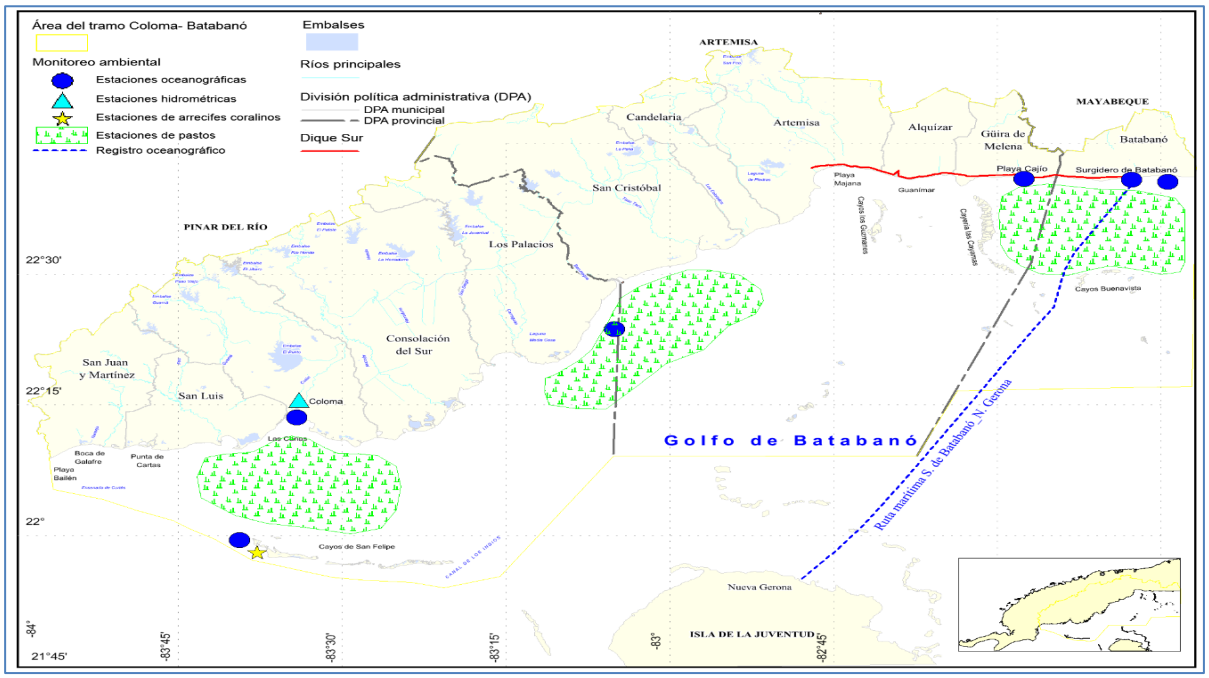
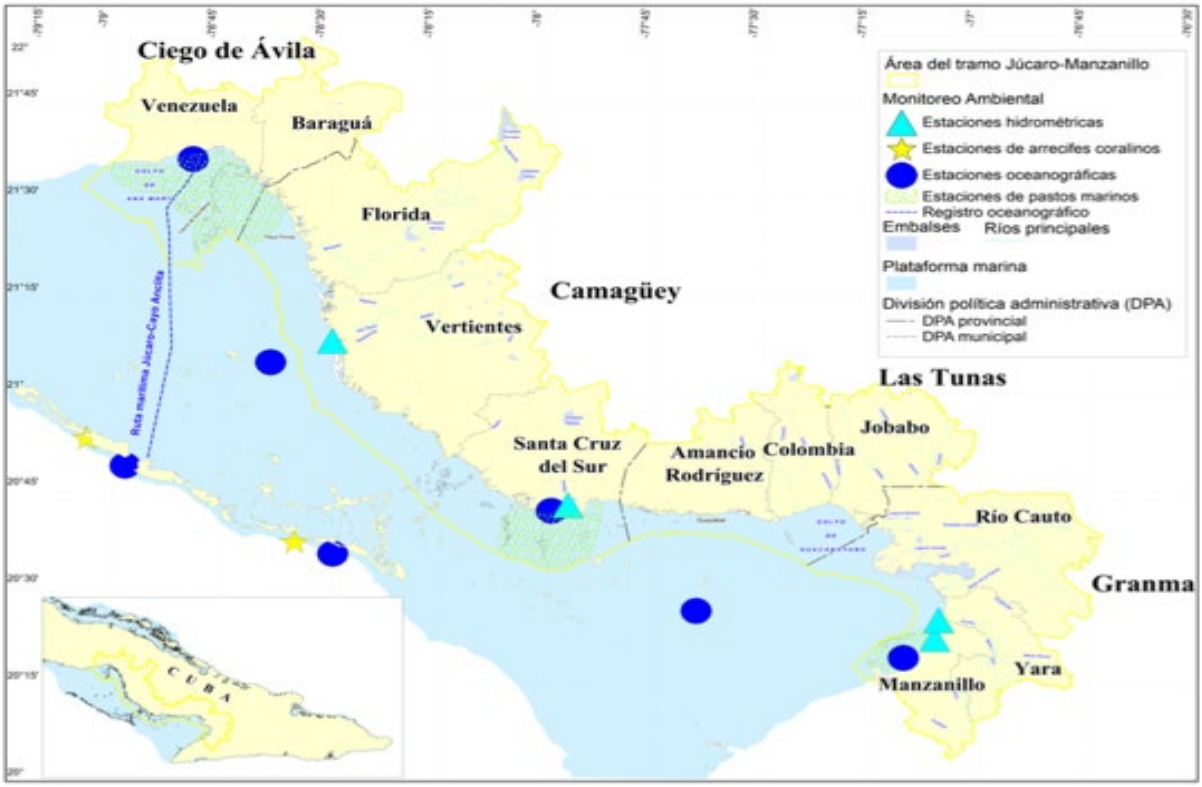


Figure 71- Sites and Transects proposed for physical monitoring of marine waters in Section II.



640. The GoC through co financing funds provided by CITMA will install the monitoring system including establishing the connectivity that will be required to connect them to the Knowledge Management Platform (Action 2.2).

641. Equipment acquired through the project using GCF funds will be procured during the project's first and second year and will follow UNDP's procurement process ensuring cost efficiency. This includes the procurement of services and training for equipment maintenance and the acquisition of any spare parts during project lifetime. CITMA/ICIMAR has the in house capacity (workshop and specialized technical staff) to ensure its long term maintenance.

642. Water and environmental monitoring equipment includes (For full detail see Table 23)

- Laboratory equipment to measure the quality of sea water including: vortex shaker, magnetic stirrer, laser sediment analyzer, autocalves, water baths, vacuum pumps, centrifuges, colony meters, water deionizers, electrophoresis chambres, spectrophotometers, incubators, laminar flow equipment.
- Laboratory equipment fo the determination of nutrient pollution (ammonium, nitrates, phosphates, silicates, nitrates)
- Mobile laboratory for in situ measurements of water quality (Microbus Toyota Hiace with laboratory infraestructure inside). It will be used in the monitoring activities of the impact of wetland rehabilitation on the quality of seawater and adjacent marine ecosystems (seagrass beds and coral reefs).
- Regeants for sea water analysis
- Atomic absorption spectrometer for the determination of metal pollution in seawater.
- HPLC equipment to determine organic pollutants derived from the use of fertilizers, organochlorine and phosophatized compounds, detergents and oil byproducts.
- Data capture equipment and tools for the assembly of 36 marine statations (Figures 46 and 47) including echo sounder; tide gauge, CTD sensors (conductivity, temperature and depth) coupled with sensors for physical and chemical data and current profilers; automatic weather stations, and tools and supplies for their installation

Sub-activity 1.3.2 Acquire and install a monitoring system to measure marine ecosystem capacity for resilience and regeneration

643. Actions under this sub-activity include enhancing capacity of ICIMAR/CITMA through GCF funds for the collection and processing of data samples through marine expeditions including a boat to support coastal and marine sampling operation and submarine data collection, autonomous diving equipment; safety consoles with gauge, compass and depth gauge; submarine data collection materials.

644. Monitoring systems for both coral and sea grasses will be established and coordinated by ICIMAR/CIMTA and fully funded through GoC co financing (making use of GCF acquired equipment specifically for these actions).

645. Coral reefs monitoring will be developed for all reef variables according to the standard AGRRA method that establishes three monitoring modules, (1) coral monitoring, (2) fish monitoring and (3) algae monitoring, as a whole to establish the conditions of the reefs and their health status. S

646. Seagrass monitoring will be carried out through three transects parallel to the coast, 50 meters long each, which have been previously geo-referenced.

647. The transects will be located at different distances from the coast on a perpendicular line. The transects will be located at different distances from the coast on a perpendicular line. In each transect 12 square frames of 25 x 25 cm will be used. The transects will be repeated at different distances from the coast to verify through them if the changes in the coastal wetlands are having the expected effect of reduction in suspended sediments, nutrients and turbidity are modified over time as a result of the

application of the EBA methods. Additionally, the monitoring of the physicochemical variables (Activity 1.2.1) is intended to explain possible alteration to the seagrass beds.

648. Investments for coral reef and sea grass monitoring include:

- Diving equipment for coastal and marine samplings
- ICT equipment and supplies to support the data processing and analysis, as well as, the generation of informational products from field sampling (includes drone, camera and GPS)
- Boat to support coastal and marine sampling operations (18 meters nautical length, power plant, navigation equipment, 150 horsepower engine, technical equipment (echo sounder, current meter, weather station))

Sub-activity 1.2.3 Implement a monitoring and surveillance system to measure coastal and marine ecosystem resilience and regeneration capacity to extreme events, including a network for coral recovery

649. The monitoring and surveillance system will include the implementation of sea water quality monitoring that will provide information on the improvement of seawater conditions as result of actions on coastal wetlands to assess the impact of these actions within the coastal seascape as well as record the environmental conditions that allow the natural recovery and regeneration of coral and sea grass to enhance ecosystem resilience and capacity. This will have a direct impact in enhancing the ecosystem's capacity for wave energy dissipation providing protection from extreme weather. The environmental conditions will be monitored through the monitoring stations installed that will include the use of oceanographic and marine meteorological measurements from coastal stations, ships, and satellites.

650. Physical-chemical water parameters to be monitored include

- Physical parameters: sea surface temperature (SST), sea surface salinity (SSM), turbidity, suspended solids, currents (direction and speed), sea level and waves.
- Chemical parameters: Concentration of dissolved oxygen (DO), percentage of oxygen saturation (SO), hydrogen potential (pH), total Alkalinity (AT), ammoniacal nitrogen (NH4), phosphate (P-PO4), silicon silicate (Si-SiO3) and the Chemical Oxygen Demand (COD).
- Biological parameters (marine microorganisms): Concentration of heterotrophic bacteria, cyanobacteria, chlorophyll and hygienic-sanitary quality.

651. **Physical:** sea surface temperature (SST), sea surface salinity (SSM), turbidity, speed and direction of currents, sea level and waves. These variables are obligatory references in CC studies for understanding fluctuations occurring in the marine environment, with effect on the structure and functioning of marine and coastal ecosystems, as well as the dynamic regime of waters (Manzano and Salinas, 2008)108.

652. The organic material and sediments supplied to the coastal zone diminish the transparency of sea water, which affects the penetration of sunlight for photosynthetic organisms planktonic and benthic and promotes sedimentation processes on seagrass and coral reefs.

653. **Chemicals:** Concentration of dissolved oxygen (DO), percentage of oxygen saturation (SO), hydrogen potential (pH), Total Alkalinity (AT), ammoniacal nitrogen (NH4), phosphate (P-PO4), silicon silicate (Si-SiO3) and the Chemical Oxygen Demand (COD).

654. Anthropogenic activities have disrupted the flow of nitrogen, phosphorus and silicon in the coastal area, central to the development of marine biota elements and whose contributions occur primarily through the terrigenous runoff and rivers, associated with precipitation. In studies related to the

108 Manzano, M. M. & Salinas, C. A. (2008). Variabilidad estacional e interanual de la concentración de clorofila a y temperatura superficial del mar en la región occidental del golfo de méxico: 1996-2007. Red de Revistas Científicas de América Latina, el Caribe, España y Portugal. ISSN (Versión impresa): 0378-1844.

environmental quality of marine coastal area, is of great importance to monitor chemical parameters related to the presence of dissolved oxygen, organic matter and nutrients, mainly ammonium and phosphorus as indicators of contributions of domestic waste, which high concentrations may favor the inorganic pollution and eutrophication processes in seawater (Kennish and McGuirk, 2007)109.

655. The Chemical Oxygen Demand (COD) with potassium permanganate is a direct indicator of the amount of organic matter in seawater and to determine whether conditions exist organic contamination. In these determinations oxidizes the organic matter and their values are not comparable with the microbiological oxidation (FAO, 1975)110.

656. The concentration of hydrogen ions H3O + (pH) in water systems is directly associated with the balance between the carbonate and hydrogen carbonate and is important for their relation to the processes of acidification of seawater, according to the availability of ions carbonate. PH measurements are made with a potentiometer

657. In situ dissolved oxygen, salinity, temperature and pH measurements were carried out using a multiparameter "Hanna". The chemical oxygen demand (COD) by oxidation of organic matter with potassium permanganate in alkaline medium and the concentration of ammonium (NH4) is determined according to analytical procedure of FAO (1975), total nitrogen (NT) by oxidation reduced forms of nitrogen to nitrates with potassium per-sulfate in alkaline medium (ISO 11905-1, 1997) and total inorganic phosphate (PO4) and (PT), according to the IOC-UNESCO (1983)111 and FAO (1975)112 manuals.

658. Total Alkalinity (TA) is determined from the temperature and water salinity and pH measurements, is measured Carbon Dissolved Inorganic (CID) and the concentrations of free carbon dioxide (CO2), bicarbonate (HCO3) and carbonate (CO32-) (Fermand and Brewer, 2007). The concentration of carbonate ion (CO32-) allow to calculate the degree of saturation of aragonite and calcite and estimate the solubility of these elements (Mucci, 1983)113; as well as calcium and carbonate concentrations (Mintrop et al., 1999)114. The partial pressure of carbon water dioxide (pCO2) is estimated by equation relating wind speed and atmospheric pressure (Wanninkhof, 1992)115, using a portable weather station.

659. **Biological (marine microorganisms)**: Concentration of heterotrophic bacteria, cyanobacteria, chlorophyll a and hygienic-sanitary quality.

660. The advantage of using microorganisms as indicators is the ability to have to respond quickly to changes occurring in the related waters with short times reproduction.

661. The temperature increase causes an alteration of metabolic rate of organisms, with increased respiration and hypoxic problems related to lower oxygen solubility in warmer water; as well as a decrease in generation times of the species (Domis, Mooij & Huisman, 2007)116

109 Kennish y McGuirk (2007). Atmospheric nitrogen deposition to the New Jersey coastal water and its implications. Ecological Applications. Supplement. 17: 31–41

110 FAO (1975). Manual of Methods in Aquatic Environmental Research part-1. Methods for detection and monitoring of water pollution. *FAO Fish. Tech. Paper*. 137. 237 p.

111 IOC-UNESCO (1983). Chemical methods for use in marine environmental monitoring. Manual and guides, No12. 52p.

112 FAO (1975). Manual of Methods in Aquatic Environmental Research part-1. Methods for detection and monitoring of water pollution. *FAO Fish. Tech. Paper*. 137. 237

113 Mucci, A. (1983). The solubility of calcite and aragonite in seawater of various salinities, temperature and one atmosphere total pressure. American Journal of Science. 283: 780-799

114 Mintrop, L., Körtzinger, A. & Duinker, J. C. (1999). The carbon dioxide system in the northwestern Indian Ocean during south–west monsoon. Marine Chemistry. 64: 315–336

115 Wanninkhof, R. 1992. Relations ship between wind speed and gas exchage over the ocean. *Journal of geophysical research*. 97: 7373-7382

116 Domis, L. N. S., Mooij, W. M. & Huisman, J. (2007). Climate-induced shifts in an experimental phytoplankton community: a mechanistic approach. Hydrobiologia, 584: 403-413.

662. Heterotrophic Bacteria Concentration**:** The abundance of heterotrophic bacteria in the marine environment is considered an indicator of the presence and abundance of labile organic matter, to be the main source of carbon for growth and reproduction. This criterion has formed the basis for the development of various numerical indices that assess the trophic status of marine waters. These microorganisms contribute to cycles of carbon and nutrients in two main ways: through the production of bacterial biomass (secondary production) and by the remineralization of organic carbon and nutrients.

663. Concentration of Cyanobacteria: The influence of CC and anthropogenic impacts is causing changes in species diversity in the pelagic ecosystem with a higher incidence of cyanobacteria (IPCC, 2007)117, which are microorganism's indicators of environmental degradation for their ability of adaptation to different stressors. There has been an increase in cyanobacteria, in relation to other phytoplankton groups, associated with high temperatures and nutrient phosphorus and ammonium (Bonilla y Conde, 2000;118) and Dobal et al. (2011)[119].

664. Chlorophyll a concentration**:** Organisms that contain are in the base of the food web so determination in water samples to estimate the phytoplankton biomass and the trophic status of ecosystems, as a measure of its condition (Espinosa et al, 2001)120.

665. Hygienic quality**:** total and fecal coliform bacteria are considered adequate indicators of hygienic and sanitary quality of coastal waters. In seawater, the presence of total coliforms works as a warning of contamination of domestic origin and within the fecal coliforms exclusively related animal feces. Approximately 95% of the group of coliforms present in feces, are formed by Escherichia coli and Klebsiella certain species.

666. **Monitoring and surveillance of marine ecosystem regeneration** and capacity for resilience will be done through coral and sea grass monitoring through equipment provided and installed in Activity 1.3.2**.**

667. Coral monitoring analysis and assessment will include the processing of criteria for resilience, developed through the TNC ground based research in Cuba (Figure 44). Coral reefs monitoring will be performed for all reef variables according to the standard AGRRA method that establishes three monitoring modules, (1) coral monitoring, (2) fish monitoring and (3) algae monitoring, as a whole to establish the conditions of the reefs and their health status.

668. In addition, a volunteer network for the surveillance and the recovery of corals damaged after extreme events will also be implemented, based on a methodology proven to be successful in past pilot projects in Cuba (Sabana Camaguey/GEF/UNDP (1999-2007)[121.] This network would be made up of professional divers, already performing tourist diving, marine protected areas technical staff, specialists from the environmental studies centers, and communities´ rangers and volunteers involved in the project. GCF funds will be allocated to training the network of divers and in the equipment for monitoring. Staff costs specifically hired for this activity will be co-financed by the GoC.

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117 IPCC (2007). Cambio Climático 2007. Impactos, Adaptación y Vulnerabillidad. Aportes del Grupo de Trabajo II al Cuarto Informe de Evaluación del Panel Intergubernamental sobre Cambio Climático. Cambridge University Press, Cambridge, Reino Unido. [En línea]. Disponible en: http://www.ipcc.ch/pdf/assessmen

118 Bonilla, S. y Conde, D. (2000). El Fitoplancton como descriptor sensible de cambios ambientales en las lagunas costeras de la reserva Bañador del este. Probides/UNESCO.No.31:63-70

119 Dobal, V., Loza, S. y Lugioyo, G.M. (2011). Potencialidades de las cianobacterias planctónicas como bioindicadores de estrés ambiental en ecosistemas costeros. Serie Oceanológica. No. 9: ISSN 2072-800x

120 Espinosa L.; Gaxiola, G; Robles J. y Nájera S. (2001). Temperatura, salinidad, nutrientes y clorofila a en aguas costeras de la Ensenada del Sur de California. Ciencias Marinas. 27(003):397-422**.**

121 Alcolado, P.M. 2004. Manual de capacitación para monitoreo voluntario de alerta temprana en arrecifes coralinos. La Habana. 80 p. ISBN 959-270-040-0 and http://www.cyted.org/sites/default/files/2014._1._experiencia_cubana_en_la_implementacion_de_una_red_de_monitoreo_voluntario_de_alerta_temprana_de.pdf

669. It is expected that activities along the coastal wetlands will increase the abundance, structure and composition of seagrass beds. Seagrass monitoring will be carried out based on three transects parallel to the coast, 50 meters long each, which have been previously geo-referenced. The transects will be located at different distances from the coast on a perpendicular line. In each transect 12 square frames of 25 x 25 cm will be used. The transects will be repeated at different distances from the coast to verify through them if the changes in the coastal wetlands are having the expected effect of reduction in suspended sediments, nutrients and turbidity are modified over time as a result of the application of the EBA methods. Additionally, the monitoring of the physicochemical variables (Activity 1.2.1) is intended to explain possible the seagrass beds.

670. Variables to be monitored include: species of marine plants present; relative abundance (in percentage of the framework covered by each species); density (by counting the number of stems); average height of the vegetation; type of substrate (coarse sand, sand, mud-sandy, muddy); abundance of the associated fauna (mainly marine invertebrates); biomass and presence of threats (erosion, turbidity, contamination, solid waste). Additionally, through the use of remote sensing systems, marine grazing distribution will be estimated if the distribution is compact and homogeneous or if patches and fragmentation of the ecosystem occur over time. The distribution in non-homogeneous patches is typically an indication of stress by limits in the penetration of light or by mechanical effects of waves and currents (obtained through Activity 1.2.1).

Sea grasses

671. The actions favoring the recovery of seagrass are: 1) Eliminating anthropogenic evidence in these ecosystems such as abandoned cages, anchors are other fishing gears and objects; 2) Elimination of invasive alien species as the lionfish; 3) Installation of mooring buoys for the fishing boats and tourist activities; 4) Review, update and establishment of regulations and good practices to reduce the vulnerability of the ecosystem impacts of fishing and tourist activities. 5) Strengthening of the system of surveillance and protection of the ecosystem.

672. The project design provides that the rehabilitation of ecosystems activities attends to the principal threats to seagrasses, such as sedimentation, the increment of nutrients and limiting the entry of freshwater ecosystem. Furthermore, the project will carry out interventions focused on measuring the status of certain variables of condition seagrass ecosystem and its relations with the benefits provided by interventions mangrove swamp forests and swamp grasslands.

673. Monitoring for seagrass will be carried out based on three transects parallel to the coast, 50 meters long each, which have been previously geo-referenced. The transects will be located at different distances from the coast on a perpendicular line. In each transect 12 square frames of 25 x 25 cm will be used. The transects will be repeated at different distances from the coast to verify through them if the changes in the coastal wetlands are having the expected effect of reduction in suspended sediments, nutrients and turbidity are modified over time as a result of the application of the EBA methods. Additionally, the monitoring of the physicochemical variables is intended to explain possible changes in the abundance structure and composition in the seagrass beds.

674. General information on seagrass beds will include data on structure, available biomass, species composition and epibionts in seagrass beds, all of them indicators of health. These samplings will be carried out twice a year and will collect the following information in each of the quadrants in the grid:

- Species of marine plants present
- Relative abundance (in percentage of the framework covered by each species.
- Density (by counting the number of stems)
- Average height of the vegetation
- Type of substrate (coarse sand, sand, mud-sandy, muddy)
- Presence of threats (erosion, turbidity, contamination, solid waste)

- Abundance of the associated fauna (mainly marine invertebrates)
- Biomass.

675. Additionally, through the use of remote sensing systems, marine grazing will be estimated if the distribution is compact and homogeneous or if patches and fragmentation of the ecosystem occur over time. The distribution in non-homogeneous patches is typically an indication of stress by limits in the penetration of light or by mechanical effects of waves and currents.

Coral Reefs

676. The project will look to measure impacts on coral reefs as measured through the resilience model that has been developed through the infield experimentation of TNC in Cuba to ensure that impacts are related to coastal protection.

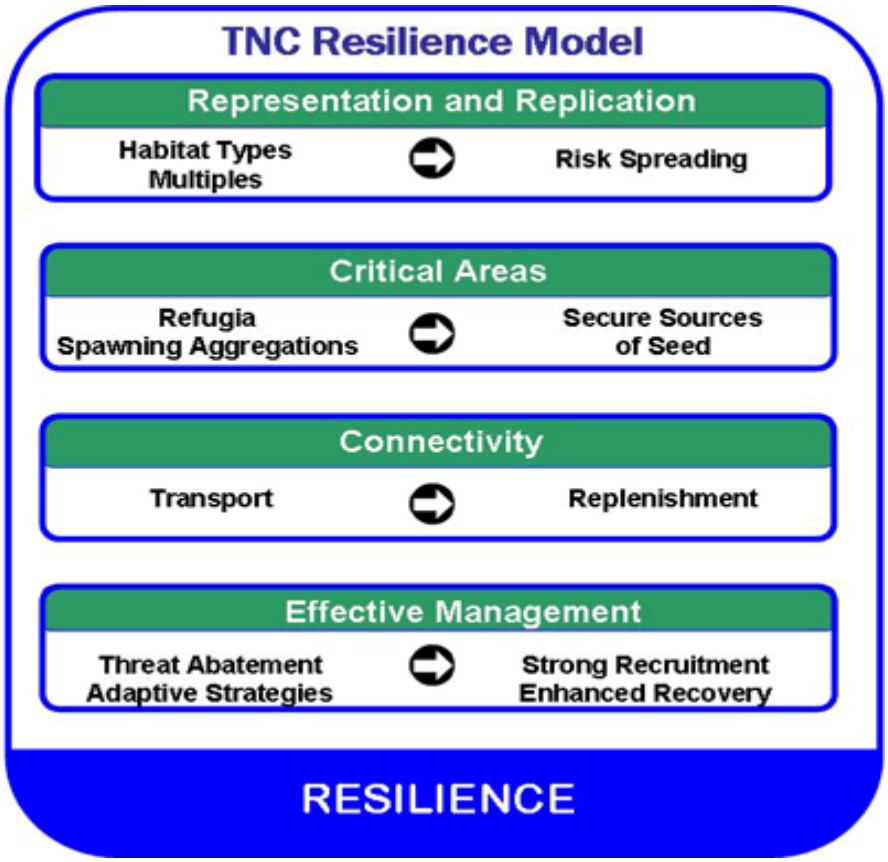
677. The elements of coral reef resilience are clearly determined in the coral reef resilience model developed by TNC[122] where certain conditions or variables are determined (TNC, 2013) (see Figure 45 below). The resilience model is presented in its simplest form in Figure 55. Where are observed particular characteristics that confer resilience.

678. The resilience model basically includes 4 components:

- Reduction of risk by increasing the representative samples of resistant reef systems within marine protected areas system.
- Establishment of refuge areas for key species, the most important elements that have been determined in Cuba are protectors of reef resilience, such as the protection of herbivorous species (Alcolado et al., 2003[123]), particularly the protection of aggregation areas. of herbivorous species such as fish, parrots, surgeonfish and sea urchins (*Diadema antillarum*), as well as aggregations of carnivorous species such as snappers and groupers in particular that contribute to maintaining a balance of biomass in the reefs.
- Safeguard systems resistant samples protected areas of reef species to the impacts of disease or bleaching and prohibit extractive uses these sites to serve as hotbeds in case some dramatic climate event produces high mortality, is permitted the natural repopulation. There are no rigorous genetic studies of reef recruitment in Cuba. However, it is estimated that self-recruitment is the main factor in the Island of Cuba based on recruitment modeling. In this context the management of their protected areas is very important.
- Improving conditions for management of marine protected areas in the stages of intervention, in order to maintain effective management to ensure proper conservation of protected areas. In this project there are two protected areas: National Park Jardines de la Reina and P.N. Cayos de San Felipe.

Figure 72- Reef Resilience Model.

122 TNC 2013, A Trainers Guide to Reef Resilience and Climate Change Training Workshop, 159 pp.
123 Alcolado, P. M., Martínez-Daranas, B., Menéndez-Macía, G., del Valle, R., Hernández, M. & García, T. (2003). Rapid assessment of coral communities of María la Gorda, southeast Ensenada de Corrientes, Cuba (part 1: stony corals and algae). En J. C. Lang (Ed.), Status of Coral Reefs in the Western Atlantic: Results of initial surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA).



679. Interventions in enhancing capacity of coral reefs will be focused on monitoring reef conditions that reflect improvements in their resilience as a result of interventions in the resilience improved because rehabilitation in coastal wetlands such as mangroves, swamp grasslands and swamp forests. Together this will provide a cost-efficient intervention for ensuring the capacity of coral reefs to provide protective measures while focusing on an ecosystem landscape approach.

680. Monitoring by the project will be performed for all reef variables using the standard AGRRA method that establishes three monitoring modules, (1) coral monitoring, (2) fish monitoring and (3) algae monitoring, as a whole to establish the conditions of the reefs and their health status. Monitoring will look to measure variables as measured through the resilience model that has been developed through the infield experimentation of TNC in Cuba and using the table of health indicators of coral reefs presented by MCField and Kramer (2007)[124.]

681. One of the working methods that will be supported through the project is the activation of a voluntary system of early warning of whitening in the coral reefs of Cuba, under the methodological design proposed by Alcolado in 2004[125].

124 McField, M. And Kramer O. (2007) Arrecifes Saludables ara gente Saludable ; Guía de indicadores de salud del arrecife mesoamericano. Smithsonian Institution. Belize City Belize.

125 Alcolado, P.M. (2004) Manual de Capacitacion para el Monitoreo voluntario de alerta temprana en los arrecifes coralinos. Instituto Oceanologia, La Habana, Cuba pp 42-46

Table 23 Detailed Stakeholder Table for Implementation Activity 1.3

Stakeholders with Active Participation in Implementing the Activity	Actions for Development of the Activity	Deliverables to be Provided	Existing Capacities (Co financing)	GCF inputs that will be provided to comply with the deliverable
ICIMAR	• Define the technical specifications of the equipment to be procured. • Installation of equipment procured at the national reference laboratory. • Training provincial labs on the technology procured. • Training provincial institutions involved in the monitoring process on the technologies procured. • Monitoring physical and chemical parameters to evaluate sea water quality. • Monitoring physical parameters to improve local weather forecasts, as well as the impact of extreme meteorological events. • Field trips to evaluate the health status of ecosystems.	• Equipment procured and delivered to beneficiaries. • Equipment installed. • Personnel operating the equipment have been trained. • Ecosystem health maps. • Database with field trip and monitoring findings. • Local weather reports. • Annual reports on the evaluation of coastal marine ecosystems.	• Trained scientific and technical personnel in each province and at national level. • Salary for all the personnel involved.	• IT and office equipment. • Laboratory equipment • Laboratory inputs • Equipment for marine stations (16 permanent stations, 4 surf stations, equipment for oceanographic sampling.) • Inputs and tools for the installation and/or maintenance of marine stations • 1 4x4 vehicles. • Office furniture. • Vessel for marine expeditions. • Diving equipment • Drones for aerial photography (drones from 1.1 will be used)
Environmental studies centers (ECOVIDA, CIEC, CIMAC, Universidad de Granma)	• Define the technical specifications of the equipment to be procured.	• Equipment procured and delivered to beneficiaries. • Equipment installed.	• Trained scientific and technical personnel in each province	• Laboratory equipment • Laboratory inputs • 1 vehicle • IT equipment • Office furniture.

	• Installation of procured equipment at the 4 provincial labs. • Monitoring physical and chemical parameters to evaluate sea water quality. • Monitoring physical parameters to improve local weather forecasts, as well as the impact of extreme meteorological events. • Field trips to evaluate the health status of ecosystems. •	• Personnel operating the equipment have been trained. • Ecosystem health maps. • Database with field trip and monitoring findings. • Annual reports on the evaluation of coastal marine ecosystems.	and at national level. • Salary for all the personnel involved.	• Diving equipment
GeoCuba	• Monitoring of sea level and ground motion.	• Surge tables. • Sea level behavior reports.	• Trained scientific and technical personnel. • Salary for all the personnel involved.	• 6 sea level stations • 6 ground motion stations. • Access to vehicles • IT equipment
ANC, Flora and Fauna, CNAP	• Field trips to evaluate the health status of ecosystems.	• Ecosystem health maps. • Database with field trip and monitoring findings. • Annual reports on the resilience of coastal marine ecosystems.	• Trained scientific and technical personnel. • Salary for all the personnel involved	• IT equipment • Office furniture • Access to 4x4 vehicles.
INSMET, provincial meteorological centers. (10 persons at the national level and 3 persons in each province.)	• Monitoring of atmospheric parameters.	• Local weather reports. • Climate information products for locations.	• Trained scientific and technical personnel. • Salary for all the personnel involved.	• Automated meteorological stations. • IT equipment • Office furniture • Access to vehicles.

6.3.1.4 Activity 1.4 Enhance water conduction systems along targeted watersheds to restore freshwater drainage in coastal ecosystems and aquifers to reduce and monitor saline intrusion in target sites

682. This activity aims to restore the natural hydrological process along the watersheds and aquifers in the area of influence. The 30 years intervention will improve freshwater availability in 544,300ha ha by reducing saline intrusion and improving freshwater recharge.

683. The monitoring program will contribute to the identification of catchment areas, rainwater catchment and salt-wedge advancement/receding. This project will also strengthen the present hydro-meteorological network and stations in order to holistically manage fresh-water resources

684. The equipment, capacity and monitory system proposed with GCF funds will ensure that the required quantity and quality of water drains into coastal ecosystems, particularly to swamp forest, during long drought periods, which are key instruments for aquifer recharge. Ensuring enough freshwater drainage into these ecosystems will reduce saline intrusion by enhancing filtration to soils and aquifers. Currently, there is not a possibility to assess an ecological flow due to the lack of measuring stations to manage upstream water distribution towards coastal ecosystems.

685. Required equipment includes: bathometers; radar automatic water level recorders; conventional gauges with semiautomatic transmission via mobile phone; automatic hydro-meteorological stations with rain gauges, for measuring flow rates in surface currents and levels in reservoirs and wells; conventional evaporimeters to balance water reservoirs; water quality probes amongst other. Given the current economic blockage to Cuba, accessing instruments is an immense challenge. Co-financing of GoC includes technical assistance and specialist input (staff hired specially for this project), labor, maintenance and basic services (such as water and energy).

Sub-activity 1.4.1 Clear rainwater channels and enable water conductions systems in target sites to increase water flow into coastal wetlands and aquifer recharge in drought affected aquifers

686. Rehabilitation actions in coastal wetlands (Activity 1.1 and 1.2) are considered to be an effective measure to counteract the effects of long-term saline intrusion, since by storing water for long periods of time, these ecosystems promote natural infiltration into underground aquifers, as well as contributing to filtering contaminants. This action will be paired with government actions for targetted aquifer recharge, through GoC resources. Both actions will allow the countering of the effect saline intrusion in the short and medium term.

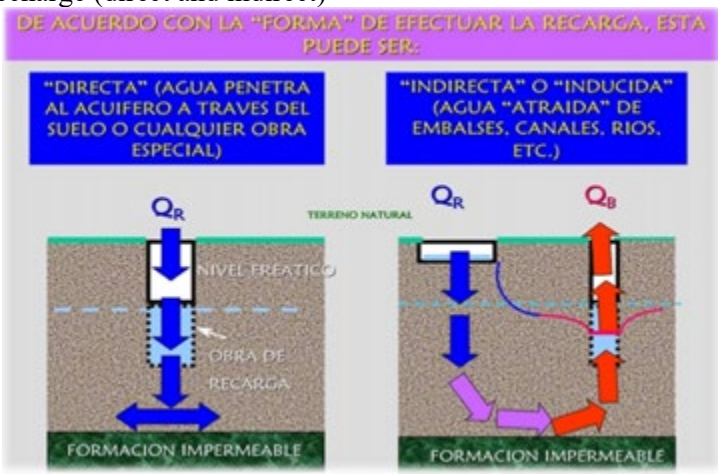
687. GoC will invest in building wells and hydraulic restoration actions for recharging selected aquifers affected by long periods of drought including 19 wells established in Jucaro and another 38 that will be built in Camagüey (Annex 1 in the Feasibility Study). The infiltration of fresh water through these wells will use the following measures to be led by the INRH:

- Channels that collect rainwater locally and transport water by gravity through the existing natural topography towards the infiltration wells (direct recharge). The geological and hydrogeological conditions of the region allow this type of recharge, since it comprises a variety of karstic formations, such as sinkholes, deep cavities and karstic wells, with which natural water infiltration can be performed, especially if they are characterized by having a high vertical permeability that allows direct connection with the aquifer.

- Water conduction systems from reservoirs/dams built for other purposes which transfer surplus water and infiltrate them directly into the wells. Indirect recharge will transfer water from Zaza dam to Ciego de Avila. Using secondary canals provided for irrigation of agricultural areas, water will be deviated from this master canal to previously constructed recharge wells.

688. Aquifer recharge through GoC funds will result not only in salt wedge retreat, but also in wetland improvement.

Figure 73- Aquifer recharge (direct and indirect)



Sub-activity 1.4. 2 Invest in monitoring equipment to develop a real time water flow control system in target areas for the monitoring of groundwater with a basin management approach to assess the evolution of saline intrusion in target areas and response capacity to climate impacts and EBA interventions

689. The restoration of coastal wetlands including the rehabilitation of freshwater hydraulic flow (sub-activity 1.1.2), will allow a water surplus increasing the natural floodplain, which will also reduce the risk of flooding in settlements downstream. The infiltration processes in these areas will contribute to reduce saline intrusion through increasing the water table. To evaluate the effect of the project interventions and monitor saline intrusion as a result of aquifer recharge actions, GCF funds will be used for the monitoring of ground water with a basin management approach. Through the monitoring of salt wedge advance or retreat- essential to determine recharge effectiveness- national and local authorities will be able to perform a more efficient resource management.

690. Measuring stations (will be located along the basin, close to the boundaries of the basins and along coastal zones, upstream and downstream of the reservoirs. This will allow an accurate estimate of the water balance (including the salt wedge) and provide relevant data on the quantity and quality of water reaching the coastal area.

- 40 Monitoring stations will be placed in the most important subterranean basins in the intervention areas (30) in the following distribution: 27 basins with one station 2 basins with 4 stations and 1 with 3 stations.

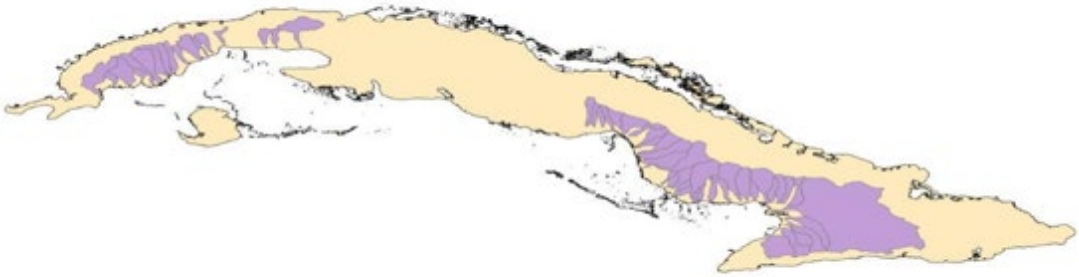
Figure 74- Location of hydrogeological sensors (blue areas are main aquifers)

- Evaporomiters and water level monitors will be placed in all 71 reservoirs included in the hydrographic basins within the intervention areas.

Figure 75- Reservoirs in target areas

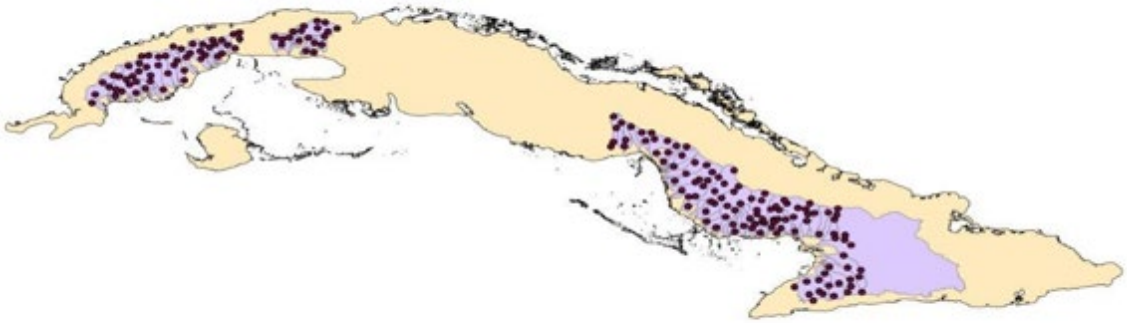
- Hydrometric points: Stations to measure water flow speed and levels will be installed in hydrometric points included in 53 superficial basins in areas over 100km^2. This will be in addition to the 5 hydrometric points that will be installed in the Cauto basin.

Figure 76- Superficial basins



- Pluviometers will be located in all 71 reservoirs in the intervention areas and in all 58 hydrometric points as well as in all stations installed to measure subterranean water levels.

Figure 77- Location of conventional pluviometers



691. Hydrological variables´ cycle will be measured based on the World Meteorological Organization and quality standards, including: fresh water quality, water quantity and temporal and spatial distribution within basins, ability to meet current and future demand.

692. Monitoring will include the following basic elements: i) wells measurements, water levels and quality (salinity, dissolved oxygen, hardness, heavy metals); ii) water discharged from the reservoirs to the rivers to ensure the ecological flow; iii) analysis and evaluation of the impact of the interventions.

693. The monitoring will be done on a monthly basis and reported to the environmental information system through municipal information modules, but then centralized by INRH at a Provincial level. Water monitoring will include: measurement of the wells and measurements in rivers when dams release water to deliver ecological flow discharge to verify the corresponding environmental flow release. This monitoring is done before and after the time of release of water. Data will be taken and analyzed monthly with a review of semiannual and annual changes to establish quality indicators that provide information to the information systems proposed by the project at the local, municipal and national level in the Output 2.

694. **Required equipment includes**: bathometers; radar automatic water level recorders; conventional gauges with semiautomatic transmission via mobile phone; automatic hydro-meteorological stations with rain gauges, for measuring flow rates in surface currents and levels in reservoirs and wells; conventional evaporimeters to balance water reservoirs; water quality probes amongst other (For full detail see Table 24). Given the current economic blockage to Cuba, accessing instruments is an immense challenge.

695. This activity will be led by INRH that will act as a service provider for this activity. Co-financing of GoC includes technical assistance, labor and specialist input (such as hydrologist, modelers, GIS, etc) of staff hired specifically for this project.

Maintenance of Monitoring Measures

696. Maintenance of project outputs include two main aspects, (1) the continuity of water monitoring wells during the project's lifespan (30 years) and (2) the maintenance of wells and water transfer from reservoirs. Maintenance of these will be performed once a year and will be maintained by INRH during the project's lifetime with GoC funds (30 total).

697. In terms of the acquired equipment with GCF funds, equipment is foreseen to require maintenance periodically every 5 years; therefore, maintenance will be carried out during the implementation of the project and 5 regular maintenances the following 22 years. This will be done by specialized experts in

the INRH. Costs for these have been included within the project's Operation and Maintenance Plan with commitmments from the INRH to maintain these for project specific purposes.

698. In addition, the project will procure monitoring equipment under a service contract that will allow not only for the purchase of the equipment but also in support in general system maintenance and training on how to deliver the required actions. It should be noted that the INRH has the capacities (through its various specialized offices) including construction equipment and specialized staff to perform system maintenance. Sufficient spare parts will be procured with the equipment itself.

Sub-activity 1.4.3 Develop hydrological models to support hydrological processes and water management (identification of catchment areas, salt-wedge advancement/receding and saline intrusion) to better assess the impacts of SLR and change on precipitation patterns on coastal conditions.

699. This sub-activity will result in the production of hydrological models (real time and prognoses) to support water management and monitor saline intrusion, both during climate extremes (drought, floods) as well as in normal conditions to assess the impacts of SLR and change on precipitation patterns. Models will be developed by the INRH that will hire national experts to provide technical support in producing these models.

700. The monitoring data will be used in hydrological models (real time and prognoses) to support water management and monitor saline intrusion, both during climate extremes (drought, floods) as well as in normal conditions to assess the impacts of SLR and change on precipitation patterns. Hydrologic and hydraulic flood simulations will also be nable in real time allowing for flood and drought forecasting through automated real time hydrologic and hydraulic simulation.

701. Superficial and underwater runoff will be modelled to predict the evolution of saline intrusion through time and identify flood risk areas. This information will provided locally for enhanced planning and decision making (Activities 2.2 and 2.3).

702. Investments provided through GoC co-financing provided by the INRH includes the processing of the data provided real time water flow control system (Sub activity 1.4.2) and that will result in the hydrological models.

703. GCF funds will be directed in the training of INRH hydrological specialists in data management and in the enhanced ICT capacity that has proven a barrier for real time monitoring and climate modelling due to current limited information processing capacity for these actions.

Table 24 Detailed Stakeholder Table for Implementation Activity 1.4

Stakeholders with Active Participation in Implementing the Activity	Actions for Development of the Activity	Deliverables to be Provided	Existing Capacities (Co financing)	GCF inputs that will be provided to comply with the deliverable
Water Resources National Institute (INRH), 7 provincial INRH delegations	• Cleaning of natural streams to conduct rainfall water to recharge wells. • Cleaning of ditches and Canals built to conduct rainfall water and/or	• Number of canal kilometers fit for recharging aquifers. • Number of wells fit for recharging aquifers.	Waterworks maintenance brigades. Trained technical personnel. Salary for all the personnel involved.	• Field trips inputs and tools. • Vehicles. • Hydrological monitoring equipment. • IT and office equipment

	surface water reserves to the recharge wells. • Maintenance of recharge wells. • Equipment installation and commissioning. • Monitoring of water availability and quality of inland waters. • Monitoring of aquifer recharge. • Use of hydrological models to evaluate climate change impact on saline intrusion and water availability. • Implementation of water management models. • Evaluate and use ecological flow to provide coastal ecosystems with the required fresh water.	• Hydrological stations established. • Availability and quality of inland water maps. • Salt-wedge variation maps. • Reports on the quantity of water artificially introduced in underground aquifers. • Reports on quantity of water from high basins to the coast. • Cubic meters of water delivered as ecological flow. • Hydrological scenarios with the impact of climate change on saline intrusion and water availability.		• Consultancy and/or training in the use of hydrological models.

6.3.2 Output 2. Increased technical and institutional capacity to climate change adaptation in Coastal Communities, Governments and Economic Sectors

704. Output 2 is focused on working with coastal communities located along climate vulnerable coastlines, local governments and economic sectors to mainstream EBA actions and information into community-based adaptation measures while working to enhance local and national governance mechanisms within the framework of Tarea Videa and the 2019 Constitution. Through this output the project will address key barriers related to information access and lack of capacity for adaptation and will create opportunities for inter sector coordination to ensure that EBA investments are appropriated by communities and become institutionalized through a legal framework and mechanisms to allow for their long term sustainability. This will bring about the paradigm shift, required by the project beyond the EBA investments themselves.

705. A key outcome of this output will be sectoral and municipal regulatory frameworks strengthening specifically on EBA mainstreaming and approaches based on results derived (such as ecological flow calculation) from Output 1 and their inclusion into local development, land use planning, disasters risks reduction and CZM plans. Output 2 will allow for the contextualization and the correct packaging of information derived from Output 1 to foster the appropriation of EBAs at the local level, promoting a "bottom up approach" for EBA initiatives and mainstream it into national planning processes and

information systems for on the ground decision making. This novel approach to national planning and adaptation is in tune with the current constitutional reform process undergoing in Cuba.

706. Through enhanced understanding, awareness and capacity to identify and monitor coastal vulnerabilities to climate change, coastal communities and local governments in targeted areas will become active agents for adaptation favoring solutions that take advantage of national best practices, ecosystems (as demonstrated in Output 1), and consolidated information systems.

707. Implementation of this output will be coordinated by CITMA/AMA. Implementation will rely on the active involvement and support of municipal government and structures leveraging on existing networks while incorporating in them the capacity to coordinate and manage adaptation actions.

6.3.2.1 Activity 2.1 Develop a climate adaptation technical capacity building program for coastal communities and local stakeholders (government & economic sectors) to enable adaptation actions and capacities

708. This activity will develop and implement a capacity building program to be delivered to targeted coastal communities (24 municipalities) to build understanding of CC impacts and vulnerabilities such as coastal flooding (from extreme weather and SLR) and saline intrusion (from droughts and SLR). The program will increase awareness and knowledge for adaptation actions and skills to strengthen the resilience of key stakeholders in these communities, prioritizing EBA over other management strategies. This will include providing results and techniques derived from the project as seen in Output 1 to ensure their maintenance and replication. It will also allow information from the Knowledge Management Platform (Activity 2.2) to be included and contextualized through a locally relevant learning program.

709. Design of the training content will allow for the coordination of key actors in municipalities (economic, learning and government sectors) thus integrating key technical information (derived through project monitoring and other information systems) from each sector/institution and allowing for active coordination of local priorities for adaptation (water management, physical planning, adapted livelihoods). This will allow the curricula to be relevant to key sectors within each area and to focus on a multidisciplinary and local approach for adaptation.

710. Training under this activity will be targeted to 24 municipalities located within 7 provinces in the project's targeted coastlines, these have been selected based on vulnerability assessments to coastal threats from CC and directly in areas where rehabilitation interventions (Output 1) are taking place.

711. Training will be delivered through Capacity Builiding Centres (CBCs) (Feasibility Study Section 4.2.3.1) located in each municipality that will be enhanced as well as through 7 classrooms that will be created in each of the restoration intervention areas (Output 1). This will allow training programs to be included within existing learning and coordination structures that have proven to be a local expression of coordination on issues such as disaster risk planning, and integrated coastal management training thus allowing these issues to be integrated within an adaptation framework (considering they will be informed by local climate information products (Activity 2.2)). The training program will be sustained by existing local structures (provinces and municipalities) as they will be integrated them into municipal and provincial daily life.

Sub-activity 2.1.1 Identification, design and packaging of the training content to be provided to coastal communities and stakeholders to increase coastal adaptation capacity for local adaptation actions including EBA

712. The Project will carry out institutional agreements to create alliances for the development of training programs, according to the topics to be addressed, and design the training programs, according to the vulnerabilities related to CC and ecosystem adaptation approach identified in the intervention communities and the information and communication needs.

713. GCF funds will be used to design the training programs. This includes the establishment institutional agreements to create alliances or procurement processes (in the case of research centers) among key institutions such as INRH, MINAG, MINAL, productive centers, and national and international learning centers for the development of specific training content, according to the topics to be imparted.

714. These will be then transformed and packaged into a training curriculum designed to address key local concerns. Experts from the Municipal University Centers (CUM) and universities will be convened for this process. Entities that are expected to be participating in capacity building, are listed below by sectors, but are not limited to the following;

- ✓ **Central governments** including at least AMA-CITMA, ANPP, CAP, CAM, CP, DC.
- ✓ **Economic sector** INRH, MINAG, MINAL, MICONS, associations of Communal producers
- ✓ On knowledge management in formal education (MINED, MES) in non-formal education CITMA (AMA, CES, CBCs, Annexed Classrooms, CNAP, CEDEL), and in scientific and technical associations (ACTAF, UNAIC, others),
- ✓ On control and enforcement: CITMA (DMA, Territorial Delegation), IPF (Municipal, Provincial and National), ONEI (Municipal, provincial and national) MEP (Municipal, provincial and national) MINCEX (provincial and national), MININT (rangers and border guards), MINSAP (provincial and municipal offices, one clinic center and doctor's office and Nurse)
- ✓ Socio-cultural: Civil society organizations (FMC, ANAP and others), Culture (House of culture, projects, art instructors, social workers).

715. Experts from the Municipal University Centers (CUM) and universities will be convened to develop the training programs.

716. . Training workshops and training will be designed according to the user trainees (governments, sector or community) and particularities and interests of the territories, which will determine the topics to be addressed.

717. A curriculum will be developed during the first year of the project once the existing information opportunities and CC and EBA demands have been established. However, a preliminary list of the proposed ABE training topics includes:

- Climate Change in Cuba (causes and impacts)
- Adaptation and mitigation to CC
- Ecosystem services of mangroves, coastal swamps, seagrasses, coral reefs
- Ecosystem Based Adaptation for coastal resilience
- Environmental sustainability in local productive manament and EBA benefits.
- Ecological sustainability and benefits of the EBA (sustainable livelihoods).
- Design and development of low risk infrastructure under EBA
- Pollution and water management under EBA
- Reduction of disaster risks through the EBA
- Efficient management of water resources

- Effects of human impacts on ecosystems (such as pollution, mangrove logging)
- Rehabilitation and integral ecological restoration
- Rehabilitation and ecological restoration, with emphasis on coastal ecosystems.
- Location of infrastructure with reduced vulnerability.
- Knowledge Management and its application at the community level.
- Territorial planning of the community and municipalities considering the EBA and the impacts of CC.

718. During project implementation it is expected that other training topics and interest in coastal communities will arise, and that they would be accommodated in the curricula.

Sub-activity 2.1.2 Enhance physical and operational capacity in 24 Capacity Building Centers in targeted coastal municipalities, and establish 7 Annexed classrooms in the intervention areas to provide an adequate space for community and stakeholder capacity building, community monitoring and for the coordination of local adaptation activities

719. This activity will leverage existing infrastructure at the Capacity Building Centres, which already serve an important role as local brokers for environmental knowledge, enhancing their capacity to train on coastal zones adaptation in the 24 targeted municipalities. Enhanced CBCs and annexed classrooms that will be placed directly in the EBA intervention areas (Annex 1 of the FS) and will also serve as spaces for environmental monitoring and training . This will allow, at the very local levelto have a space to directly disseminate the work related to the EBA measures and become a workspace that will reach the most vulnerable coastal populations.

720. The CBCs in Cuba are the most local expression of inter-agency mechanisms by the CITMA capacity for coordination, hence this model will leveraged, enhanced and upscaled to integreate an adapatation framework that integrates natural resource management, disaster risk planning, integrated coastal management and adapatation to climate change through EBA. The enhanced CBCs will serve as key figures in providing EBA training to communities, and information relevant to support inter-sector adaptation towards climate impacts to coastal activities.

721. Investments will be focused on enabling the existing premises of CBC's and annexed classrooms that will be built through GoC co-financing in the seven ecosystem intervention sites identified in Output 1. Centres will be renamed as Capacity Building Centres for Adaptation Knowledge Management (CBCS) and will be key for providing EBA awareness and training to communities; these Centers will also be key in the provision of relevant information to support inter-sector climate change adaptation in coastal activities. They will also become crucial in implementing and coordinating Tarea Vida at a municipal scale as training spaces in the 7 settlements where ecosystem intervention will occur (Output 1), ensuring that targeted communities appropriate and learn to maintain the EBA investments.

722. GCF funds will be used to enhance physical/infrastructure capacity within these Centres and to guarantee their adequate operation (See Table 16 for existing/identified infrastructure). The project aims to create an extra classroom fitted with the required training equipment and media tools required to train local stakeholders. Premises will be designed to meet the following requirements: Accessibility of different users, connectivity (audio, data, video, internet) and physical security as well as capacity to train 25 people (15 in case of annexed classrooms).

723. Municipal governments will provide the premises (physical infrastructure) for the CBCS and for the annexed classrooms. Co-financing for these activities is planned and is included in the project co-financing budget. Staff from local governments, through the Council of Municipal Administration, will be responsible for the administration, payment of current accounts, energy plans, availability of communications, security, access, maintenance and repair of the CBCS and the annexed classrooms, to guarantee its operation and sustainability. CBCSs will be operated by two specialists (environmental and information technology specialist) to be selected by the provincial delegations of the CITMA (one in the

case of annexed classrooms) and will be responsible for their salaries throughout the project and after its conclusion. CITMA in coordination with municipal governments will be responsible for coordinating this activity.

724. The CBCS and the annexed classrooms, will have the following functions:

- Train local actors on the effects and impacts of CC in Cuba and on adaptation alternatives (both green and gray) in vulnerable coastal areas.
- Manage information, knowledge and information products to support adaptation to CC.
- Create opportunities for exchange, consultation, popular education and learning for adaptation for local, provincial and national actors.
- Promote the process so that ABE actions are included in the territorial and sectoral development plans.
- Evaluate the impacts of training.

725. As shown in Table 21 the targetted project area has 24 CBCs (or possible spaces) identified in municipalities of the two stretches chosen for the project implementation. It currently has 7 Annexed Classrooms. These will be enhanced in capacities and training. This will include the following immediate actions under this subactivity; (1) Awareness-raising Governments and other workshops with key stakeholders, (2) Enable the premises for the CBCS (repair and equipment) and Annexed classrooms.

Table 25 - CBCs and annexed classrooms in municipalities and settlements.

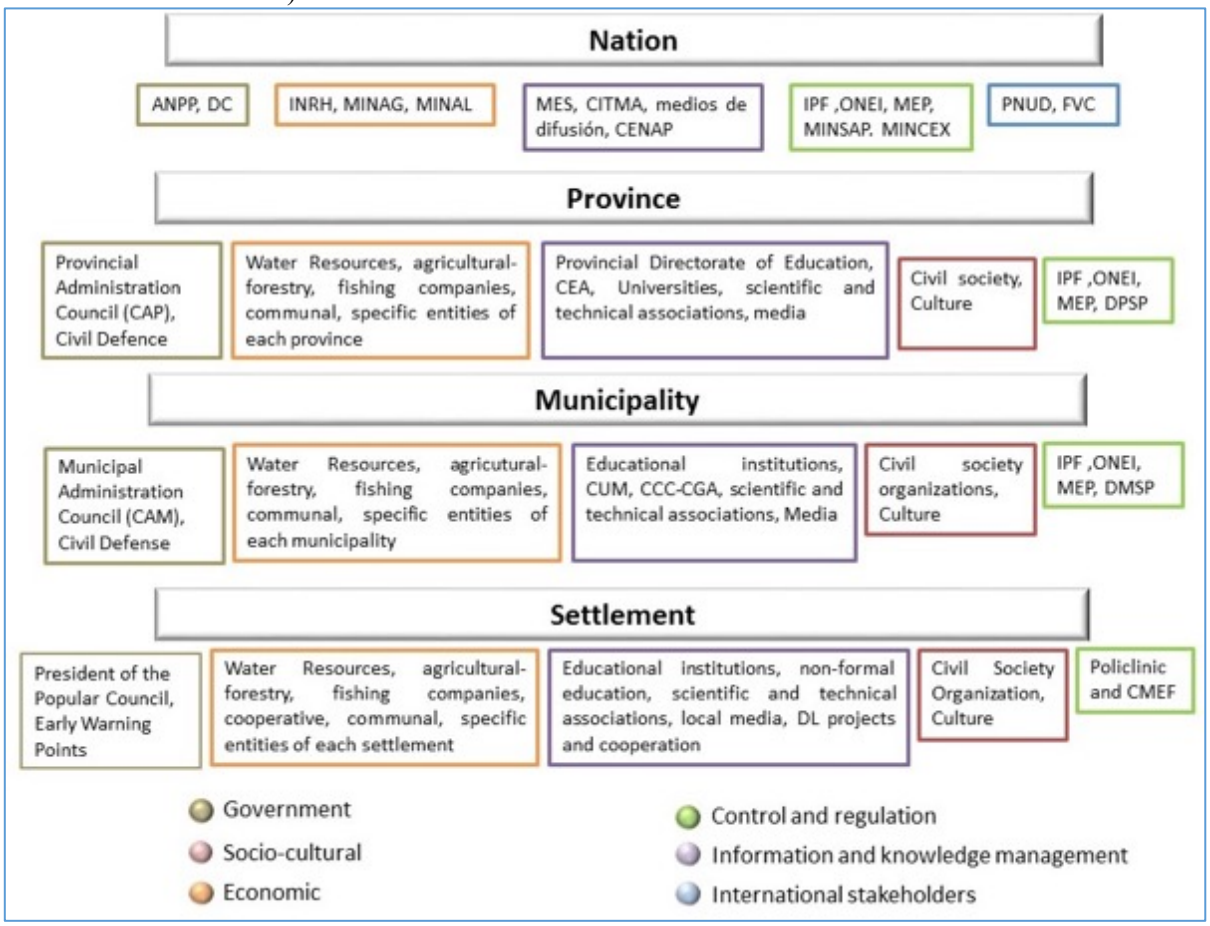
Stretch 1 (San Juan y Martínez-Güines)				
PROVINCES	**MUNICIPALITIES**	**CBCS**	**LOCATIONS**	**ANNEXED CLASSROOMS**
PINAR DEL RIO	San Juan y Martínez	1		
	San Luis	1		
	Pinar del Rio	1	La Coloma	1
	Consolación del Sur	1		
	Los Palacios	1		
ARTEMISA	San Cristóbal	1		
	Candelaria	1		
	Artemisa	1		
	Alquízar	1		
	Güira de Melena	1	El Cajío	1
MAYABEQUE	Batabanó	1	Surgidero de Batabanó	1
	Melena del Sur	1		
	Güines	1		
Stretch 2 (Júcaro-Manzanillo)				
CIEGO DE AVILA	Venezuela	1	Júcaro	1
	Baraguá	1		
CAMAGUEY	Florida	1	Playa Florida	1
	Vertientes	1		
	Santa Cruz del Sur	1	Santa Cruz del Sur	1
LAS TUNAS	Amancio Rodríguez	1		
	Colombia	1		
	Jobabo	1		
GRANMA	Rio Cauto	1		
	Yara	1		
	Manzanillo	1	Manzanillo	1
TOTAL	24	**24**		**7**

Sub-activity 2.1.3 Implement in 24 targeted municipalities and 7 intervention sites a capacity building program through local structures (CBCs and annexed classed rooms)

726. Implementation of the capacity building program in the 24 municipalities and 7 intervention sites will take a two pronged approach: 1) implement a "trainer of trainer" methodology to allow training curriculum to flow into communities and 2) using the CBCs and annexed class rooms to provide adaptation training with a strong EBA focus to key community stakeholders leveraging their role as knowledge brokers on natural resources and integrated coastal planning at a local level. It should be noted that prior to this activity adaptation and EBA training had been absent within these structures.

727. Local and national government representatives, communal producers, civil society organizations, and key community members will be trained as identified during the project's consultation process through the stakeholder mapping process (See Figure 61). The focus of the training will be training the trainers so that a higher level of multiplication and replication of the project can be achieved.

Figure 78- General scheme of the structure of key stakeholders according to territorial levels (PNUD is UNDP and FVC is GCF).



728. Twenty-four (24) municipalities along the coastal stretch will be targeted or active capacity building. GoC co-financing will be used to hire a specialized team in each community that will lead the training program. The team will be comprised of project representatives at the national and territorial levels hired for this project.

729. During the formulation of the project, visits were made to the intervention sites and the FLACSO team made a Public Consultation, in two settlements (La Coloma, Santa Cruz del Sur.) The results confirmed the need to incorporate ABE focused on their lifestyles, cultural practices and active labor. All the invited local stakeholders (40 people) participated in the planned activities, demonstrating a high level of participation, involvement and interest in the project. Almost all (98%) reported knowing what CC is and its consequences for Cuba, however, their perception and understanding of the benefits of ABE are limited.

730. The CUM and FLACSO will play an important role as facilitators or teachers at the community level, in collaboration with specialists from the Management Center Risk Reduction disasters of Civil Defense, the Centers for Environmental Studies of CITMA and sectors of water resources, physical planning, fishing, agriculture and forestry. The training will take place from Year 2 of the project on a quarterly basisThe

731. Awareness-raising meetings however will be held in year 1 to allow the presentation of the project at its inception and raise awareness among local stakeholders and governments in understanding the relevance of the enhanced CBCs and the annexed classrooms, as well as establishing commitments for site selection, security and functioning of the centers and annexed classrooms. Awareness meetings will be conducted in the 24 project target municipalities and will result in commitments aimed at:

- Guaranteeing an adequate location for the operation of the center and the Annexed Classroom and the maintenance of the service by the local government once the project is completed.
- Raise awareness about the relevance of the participation of local experts in the design and delivery of courses and in the use of products based on climate information, for adaptation based on EBA.

732. In the case of enhanced CBCs (Sub activity 2.1.2), these will be operated by two specialists (environmental and information technology specialist) to be selected by the provincial delegations of the CITMA. In the case of the newly created classrooms these will be operated by one specialist. The provincial delegations of the CITMA will guarantee their salaries as part o the commited co financing for this project.

733. The specialists hired in operating CBCs and classrooms will program community training and awareness (based on identified local needs) by enlisting community trainers on set topics to provide capacity building locally under the designed curricula (Sub activity 2.1.1).

734. The professional team that will work in the enhanced CBCs (Activity 2.1.2) will have the support of CITMAS´s Environmental Studies Centers (CEA for its acronym in Spanish) within the CITMA and its provincial specialist, the project staff and other invited professionals. They will promote coordination and common understanding among key project stakeholders in communities, governments and sectors, to manage strategies and actions to increase their adaptive capacity

735. The responsibilities of the environmental specialist are:

- Guarantee the functioning of the CBCS and the Annexed Classrooms
- Manage information, knowledge and products to support the reduction of disaster risks and adaptation to CC.
- To manage information on the design and selection of adaptation alternatives in vulnerable coastal areas.
- Promote spaces for exchange, coordination and learning for adaptation between local, provincial and national actors. Promote networking.
- Coordinate training and evaluation of their results.
- The responsibilities of the computer specialist are:

- Guarantee the operation and maintenance of the technological systems of the CBCS and the annexed classrooms
- Compile, organize and socialize the information contained in the Knowledge Management Platform for Coastal Adaptation.

736. The functions of the person in charge of the annexed classroom will be:

- Guarantee the functioning of the annexed classroom
- Manage information, knowledge and products to support the disaster risk reduction and adaptation to CC.
- Manage information on the design and selection of adaptation alternatives in vulnerable coastal areas.
- Promote networking and space for exchange, coordination and learning on EBA to CC between local, provincial and national actors.
- Coordinate training and evaluation of their results.

Table 26 Detailed Stakeholder Table for Implementation Activity 2.1

Stakeholders with Active Participation in Implementation	Actions for Development of the Activity	Deliverables to be Provided	Existing Capacities (Co financing)	GCF inputs that will be provided to comply with the deliverable
ICIMAR	Application of tools (surveys, questionnaires) at the community level to update the local environmental situation and have it included in training topics. Identification and selection of contents in selected topics for the training of decision-makers, planners and communities on issues related to marine water quality, EBA, CC-sensitive oceanographic variables, causes for the deterioration of ecosystems, and mitigation actions. Identification and selection of tools for effective training of key stakeholders and communities. Design and packaging of programmes for the 24 CBCs and 7 annexed classrooms. Design and logistical organization of workshops, consultant services, etc.	Performance report on the tools applied. The content of training topics designed. The tools appropriate for the training selected. The training programmes for the 24 CBCs and 7 annexed classrooms developed.	The qualified technical personnel for these actions is supplied, and the personnel wage cost is covered through CITMA.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, accommodation, food, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (42 in 24 municipalities), international consultant services (2).
National Aquarium (ANC)	Identification and selection of contents in selected topics for the training of decision-makers, planners and communities on topics related to sea grass conservation and management and coral reefs.	The content of training topics designed. The tools appropriate for the training selected.	The qualified technical personnel for these actions is supplied, and the personnel wage cost is covered	

	Identification and selection of tools for effective training of key stakeholders and communities.		through CITMA.	
INSMET	Identification and selection of contents in selected topics for the training of decision-makers, planners and communities on topics related to climate change, causes, threats and adaptation actions. Design and packaging of programmes for the 24 CBCs and 7 annexed classrooms.	The content of training topics designed. The tools appropriate for the training selected. The training programmes for the 24 CBCs and 7 annexed classrooms developed.	The qualified technical personnel for these actions is supplied, and the personnel wage cost is covered through CITMA.	
IES	Identification and selection of contents in selected topics for the training of decision-makers, planners and communities on topics related to coastal wetlands, function and services, mangroves and their benefits.	The content of training topics designed.	The qualified technical personnel for these actions is supplied, and the personnel wage cost is covered through CITMA.	
INRH	Identification and selection of contents in selected topics for the training of decision-makers, planners and communities on topics related to management of water resources and quality of drinking water. Design and packaging of programmes for the 24 CBCs and 7 annexed classrooms.	The content of training topics designed. The training programmes for the 24 CBCs and 7 annexed classrooms developed.	The qualified technical personnel for these actions is supplied, and the personnel wage cost is covered.	
FLACSO	Application of tools (surveys, questionnaires) at the community level to update the local environmental situation and have it included in training topics. Identification and selection of contents in selected topics for the training of decision-makers, planners and communities on topics related to social and environmental safeguards, social equity and gender approach. Identification and selection of tools for effective training of key stakeholders and communities.	Performance report on the tools applied. The content of training topics designed. The tools appropriate for the training selected. The training programmes for the 24 CBCs and 7 annexed classrooms developed.	The qualified technical personnel for these actions is supplied, and the personnel wage cost is covered through GoC co finance.	

	Design and packaging of programmes for the 24 CBCs and 7 annexed classrooms.			
Provincial, municipal and territorial governments (CAP and CAM)	Refurbishment and provision of premises (CBCs and annexed classrooms) made available to the project	Premises refurbished and strengthened, including the conditions required for training: communication services and Internet access	Premises where CITMA CBCs are located at the provincial level and where the 7 intervention sites are located. Construction maintenance and repair cost for the premises (24 CBCs and 7 annexed classrooms) Fixed costs related to the implementation of CBCs and annexed classrooms (energy, water, cleaning)	Cost of module for the enhancement of CBCs and annexed class rooms per facility (31= 24+7) includes chairs, projection screens, stationary and office equipment, tables, lecterns, desks, office equipment, TV set 172 PCs to support training activities at the 24 Capacity Building Centres and 7 annexed classrooms (6 per each of the 24 CBCs + 4 per each of the 7 annexed classrooms) Office supplies (printing paper, binders, etc.) to support the information capacities, as well as, training capacities of 24 Capacity Building Centres and 7 Community Level Classrooms.
(24) Provincial and (7) Municipal CITMA specialists	Responsible for activities to be developed at CBCs and classrooms	Personnel with livelihoods that ensure the implementation of project activities at CBCs (24 provincial CITMA specialists) and annexed classrooms (7 municipal CITMA specialists)	Trained personnel (specialists and technicians) for the operation of CBCs and annexed classrooms	bicycles to support the mobility of the people who are in charge of the 24 capacity building centres and 7 community

			Wages for all personnel involved	level classrooms (31 total, of which 50% will be women) to provide coordination support and capacity building along various sectors. Equipment in support of the training processes and knowledge management for trainers including acrylic boards, lecterns for holding flip charts, office equipment, etc.

6.3.2.2 Activity 2.2 Integrate project (technical and community based) derived information, information from early warning systems and national datasets into a Knowledge Management Platform, to provide climate information products to monitor, evaluate and inform coastal communities on local (community and ecosystem) capacity to manage climate change impacts.

737. This activity will collect information derived from the local ecosystems rehabilitation actions and hydrological dynamics restauration (Output 1) to integrate it into national databases through a Knowledge Management Platform, which in turn will feed the development of national and local climate information products, including: i) A Protocol for Coastal Resilience Assessment (PERC) ii) enhancing successful existing early warning systems (disasters and emergency attention, EWS for drought in agriculture, forest fires, health, etc.); and, iii) coastal vulnerability and resilience assessments for coastal adaptation that will integrate information on ecosystem monitoring (Output 1) with indicators derived from community monitoring of local conditions.

738. Community derived information will result in an important paradigm shift in the way that information is managed in Cuba by enabling a two-way information flow, flowing not only down from national governments to settlements but also up from settlements to national government. This will allow for the development of useful climate information products that are built upon transparent and clearly identified data that will serve as important instruments to measure community capacity for resilience. It will also allow information to adapt to local conditions and serve as an early warning for coastal capacity to adaptation responding to the various hazards particular to coastal communities (coastal flooding, saline intrusion, extreme weather).

739. Capacities developed through Activity 2.1 and the interrelation with scientific data will result in communities becoming active and informed drivers of adaptation and local agents for climate adaptation action.

Sub-activity 2.2.1 Integrate project and national databases and monitoring systems into a Knowledge Management Platform for Coastal Adaptation (KMPCA)

740. This activity will create a Knowledge Management Platform for Coastal Adaptation to integrate and manage national and local information to contribute to the National Environmental Information System currently being developed by the GoC.

741. The KMPCA will integrate information derived from community monitoring with environmental conditions monitored via Meteorological Stations, Environmental Health Units, Hydraulic Resources, Forestry Companies, Protected Areas and Volunteer Groups. In other words, it will consolidate new and existing data from: i) current monitoring systems that are placed in the area of interest; ii) data bases from various sectors and institutions and iii) information being collected through community monitoring.

742. Integration of all datasets will allow a clearer and more complete picture (rather than a partial sector linked idea) of the impact of CC and through community monitoring, will assess the improvement due to project's interventions in addressing i) ecosystem´s rehabilitation, ii) water availability, iii) coastal erosion, iv) environmental degradation, etc.

743. It will result in an almost real time monitoring system for coastal resilience that also involves local communities in informing a centralized information node (centralized database managed though AMA's ICIMAR). Thus, helping provide an integrated and more complete view of the impacts of CC in the project's target sites as well as the capacity of its ecosystems to manage these.

744. The information (input data) will be collected in the KMPCA that will in turn integrate it to information outputs. The results and information generated by the KMPCA will allow governments, sectors and society to monitor the project's objectives and progress over time; as well as to identify priorities and weaknesses that may arise during implementation (full 30 years) it will also allow to better assess the resiliency conditions of these coastal stretches.

745. The KMPCA will be coordinated by CITMA through an operative node within ICIMAR that will house and integrate all investigation and projects on coastal adaptation. The node will receive and integrate: i) Indicators of climate change (including the PERC) and ii) Project information (such as interventions evolution & monitoring). Additionally, the KMPCA will support the incorporation of EBA indicators into the National Statistical System (SEN) , to be used by the Government and to facilitate its use within all sectors, which in turn, will promote inter-sectoral coordination and the incorporation of EBA measures in sectoral planning instruments at both a national and subnational level.

746. Information from Existing Monitoring Networks that will be integrated into the KPMCA

- Meteorological Observation System
  - Climate Observation Bulletin
  - Drought Supplement (Information collected on drought with specific indices and indicator at various spatial and temporal scale)
  - Forecast conditions of ENSO (up to 6 months)
  - Deterministic and probabilistic localized forecasts of ranifall and extreme monthly, quarter and seasonal temperatures
  - Information and models of extreme climate hazards currently used for risk reduction
- Hydrological Observation System
  - Precipitation models
  - Water quality montiroing of superficial and underground wáter sources
- National Mareographic Network
  - Tide tables and information including models
- Early Warning Alert Systems
  - Drought alerts
  - Agricultural drought alert

- Hydrological Surveillance
- Severe storm alert.

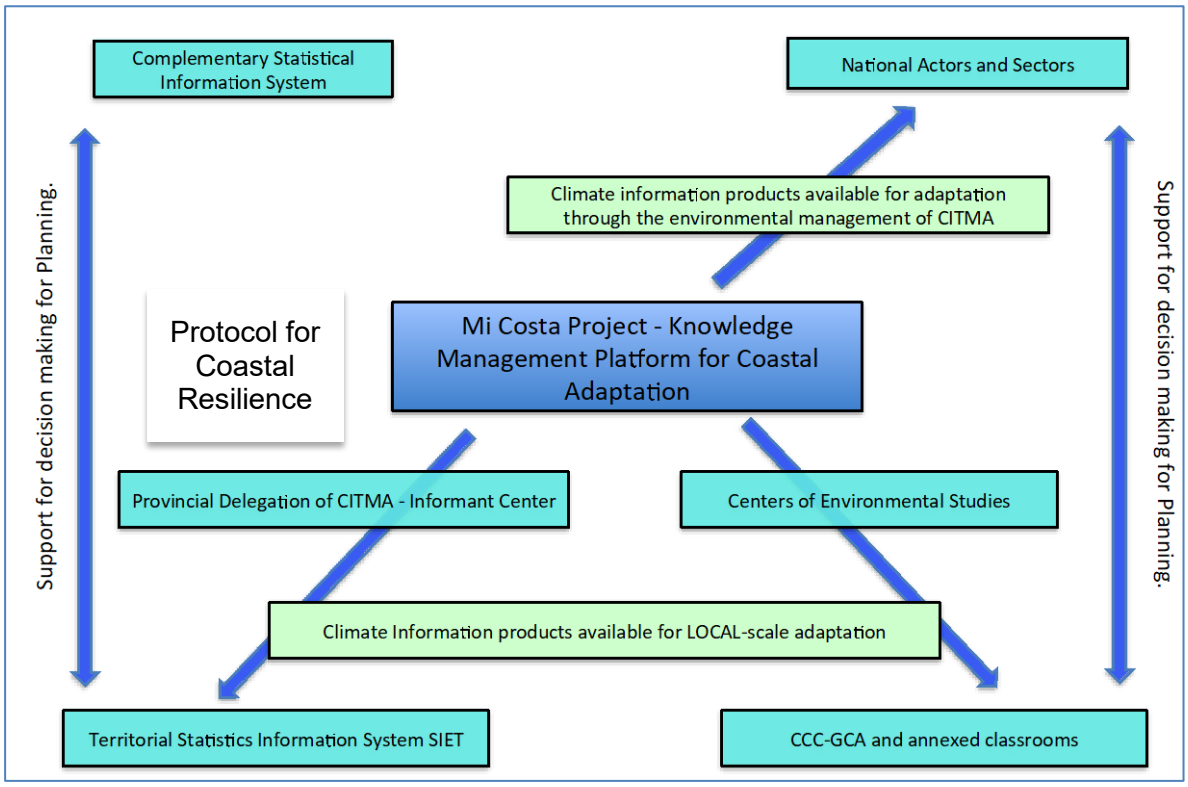
747. The National Office of Statistics and Information (ONEI) manages the National Statistical System (SEN), it is the methodological framework of the official statistical information that supports the analysis and valuations in the different levels of the country's management, as well as other informative requirements. The SEN coherently integrates the statistical information systems of the country, which interact to meet the information needs of the State, the Government and society, in order to know the behaviour of geographic, economic, demographic, social and environmental processes for the monitoring of economic and social development, as well as responding to international statistical commitments (Resolution70 / GOC-2016-473-EX26). Hence information included within the SEN becomes an established baseline for development targets at a territorial and sector levels.

748. The inter-territorial networks will ensure that the information flows back to the territories through monitoring reports (output data) and recommendations developed in close cooperation with the territories (popular councils and municipal councils) so that the monitoring results can be integrated into the local planning mechanisms(See Figure 62) that will be further supported by this project through by legal advisors. The project will also work with exising communication and coordination channels used for succesful early warning systems and alerts to better inform existing vulnerability assessments and indicators and alerts. This way the project will be able to integrate itself within existing mechanisms allowing for an improved opportunity for mainstreaming the derived environmental information

749. In this way the information will not only flow from the territories (to gauge impact of interventions and EBA as a general strategy through community monitoring) but back to them and between them to gauge coastline resilience thus creating a clear connection between environmental indicators and resiliencey.

750. The exchange of information from the local to the national will favor the continuous flow of information and knowledge generated by the Project leveraging national and locally relevant knowledge management tools and databases to ensure communication and facilitate upscale. to

Figure 79- Diagram of information flow into sectors and communities



751. GCF funds will be used for the purchase of information technology equipment required to facilitate communications between institutions, sectoral databases, national information systems, national/international expertise and technical support services (to integrate diverse databases, design appropriate communication solutions to leverage existing capacity per locality for communication to the KMPCA as well as support in the technical design and development of the information node) as detailed in the project's log frame. Currently information flows within the country are hindered not only as a result of a silo mentality but also due to a capacity gap for effective communication between terrotoritories and national systems. This wil be corrected by the project by facilitating access to these (including IT equipment such as servers and routers and linking these to the KMPCA through various softwares) to enable the communication flow amongst institutions at all levels.

Sub-activity 2.2.2 Train communities to provide community monitoring of coastal ecosystems and local conditions (indicators for socio economic, environmental, climate health, and drinking water quality) as part of a community monitoring system to complement information derived from EBA monitoring systems and better assess coastal vulnerability and resilience.

752. Actions will result in the training of communities in community monitoring (on EBA indicators, community vulnerability assessments) building on CITMA's experience in the creation of multidisciplinary groups to produce hazards, vulnerability and disaster risk studies and strategies. These systems have become an important baseline for disaster risk reduction in the face of immediate hazards. These include the following:

- Meteorological Surveillance System.
- Hydrological Surveillance System.
- Meteorological and Agricultural Drought Surveillance System.
- Seismological Surveillance System.

- Rural Fire Surveillance System.
- Comprehensive Health Surveillance System.
- Comprehensive Animal Health Surveillance System.
- Plant Health Surveillance System.
- Radiological Surveillance System.
- Hydrocarbon Spill Surveillance System.
- Surveillance System for Accidents and other Technological Disasters.

753. GCF Funds will be used for community monitoring workshops and for the procurement of basic equipment (cameras, recording equipment, etc.) which will remain within the communities for such monitoring activities. mmunity monitoring will complement the technical monitoring system of the coastal zone (Output 1) with the involvement of the community in the generation of information and knowledge of local interest for adaptation to climate change while also ensuring cost efficiency and system sustainability. Information from the communities´ monitoring system will partly feed the KMPCA. This will in turn be shared with, the enhanced CBCs that will consolidate this information with community concerns and will advise on the user based information products to be developed locally.

754. CITMA/ICIMAR will coordinate this activity and ensure its integration with site specific EBA monitoring. Data from the monitoring will be transformed into locally information products (Activity 2.2.1).

755. Some of the main activities that will be carried out in relation to the development of the community monitoring system, include but are not limited to the following;

1. Characterize the community from the socioeconomic and environmental point of view, evaluating its evolution over time.
2. Support in identifying the training needs of local actors.
3. Obtain local, accurate information about the coastal dynamics in the intervention sites.
4. Identify and timely report events that affect the functioning of coastal wetlands and marine ecosystems.
5. Evaluate drinking water quality during extreme events (floods and droughts)
6. Evaluate the behavior of health indicators of interest for human health, related to CC.
7. Assess the local scaling of actions that increase the resilience of the community.

756. Community monitoring training and actions will be based on the following stages:

757. **Preparatory phase: Year 1**

- Preparation of a manual with the methodological guidelines for the implementation of the Coastal Community Monitoring System.
- Purchase of the necessary equipment for the execution of the monitoring.
- Preparation of work maps for each locality.
- Design of the database for the registration of information.
- Preparation of the training course for the specialists who will manage the Annexed Classrooms (activity 2.1.2).
- Selection, preparation and certification of the community that will execute the monitoring.

758. **Execution phase: Years 2-8**

- Execution of the monitoring according to the program.
- Generation of participatory maps.
- Systematization of lessons learned (Annual).
- National community monitoring workshop (Years 2, 4, 6 and 8).
- Update of the monitoring manual based on the accumulated experience (Year 4).

- The community monitoring workshops must provide inputs to continue this system once the project is completed

Sub-activity 2.2.3 Create user driven climate and environmental information products as tools for EBA implementation, appropriation and maintenance

759. Through this activity the project will use GCF funds to generate climate and environmental information products as tools for EBA implementation and maintenance. Information will be packaged within existing information products and new locally relevant climate information products. These include: A Protocol for Coastal Resilience Assessment (PERC), environmental information for coastal adaptation (environmental modules on EBA) and community-based early warning systems. See Feasibility Study Table 19 for a developed list of possible information products.

760. Information products will be based on local climate and oceanographic data and will be prepared locally, supported by national entities, with the aim of improving disaster risk reduction, natural resources management, EWS and thus enhancing adaptation to CC. CITMA's Centres for Environmental Studies will be responsible for improving existing local-scale early warning information products through the inclusion of relevant local information, such as the coastal erosion index, the saline intrusion line, coastal flooding characteristics, the state of the ecosystems, and others. Climate products (bulletins, weather reports, meteorological networks, etc.) will be updated annually based on the results of the monitoring and complemented with the existing monitoring networks, with particular focus on the integration of ecosystems related information and their functionality. This will be done in line with relevant institutions such as INSMET and Disaster Risk Mangement groups locally.

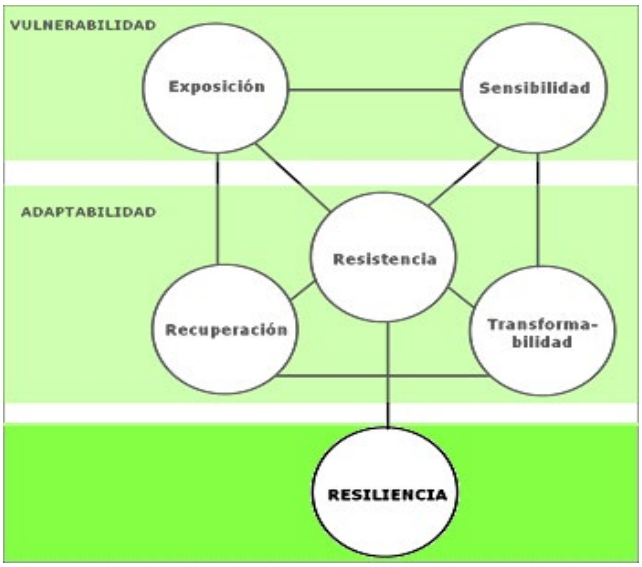
Protocol for Coastal Resilience Assessment (PERC)

761. A Protocol for Coastal Resilience Assessment (PERC), following the conceptualization of the recently developed Drought Index, will result from this activity. This protocol will be designed with local stakeholders and will be integrated into the Territorial Statistical Information System (SIET), which in turn will ensure the inclusion of the main vulnerabilities to CC in municipal and national development plans. The PERC will take into account 5 outputs: vulnerability, sensitivity, adaptability, resistance and transformability. The PERC will be monitored and updated through the Knowledge Management Platform (Activity 2.2.2) and made available at a territorial level through CITMA provincial delegation. This will allow coastal communities to better identify and assess their resilience to incoming climate impacts.

762. The PERC will be based on the methodological proposal for the establishment of a drought resilience index on farms in the province of Guantánamo (Vazquez Moreno L. 2016)[126] that was built around agricultural and climatic information and applied in the Guantanamo province to assess drought vulnerability and local capacity to adapt.

Figure 80- Resilience Index components.

126*http://www.agroecologynetwork.org/uploads/4/9/2/9/49299363/resil_sequia_luis_vazquez.pdf*



Source: Vázquez Moreno. 2016. Resilience to drought on agroecological bases. Belgian Cooperation / OXFAM.

763. The elements proposed for the PERC will include; (1) vulnerability, (2) sensitivity, (3) adaptability, (4) resistance and (5) transformability, transforming these indicators to coastal vulnerability to CC (Table 19 below establishes the criteria for each of these CRI components).

Table 27 - Main elements of the PERC indicators.

Vulnerability	Sensitivity	Adaptability	Resistance	Transformability
Houses between the coastline and the isoline of 1m above sea level	Impacts to human health due to water quality	Availability by families of means of work (tractors, boats, vehicles)	Diversity of livelihoods	Added Value to production levels.
Existing infrastructure within the area between the coastline and the isoline of 1m above sea level	Impacts to agriculture due to water quality	Means of organization of the members of the family (independent worker, member of a cooperative)	Tipe of hauses	Sources of energy used at the home and productive activities
Land use within the area between the coastline and the isoline of 1m above sea level	Impacts on livestock due to water quality	School level of family members	Freshwater sources	Gender equity
	Impacts to agriculture due to the quality of the soil	livelihoods and means of production covered by insurance.	Percent of the area between the coastline and the isoline of 1m above sea level covered by coastal vegetation	Existence in the municipality of aCBCS
				Incorporation in the Network of municipalities for climate change

764. A preliminary proposal of indicators to be integrated in the PERC, is presented below:

765. **Vulnerability:**

- Exposure: Level at which a system is exposed to important climatic variations and is a function of geographical location.
- Existing dwellings within the area between the coastline and the iso-line of 1m above sea level
- Existing infrastructure within the area between the coastline and the isoaline 1m above sea level
- Land use within the area between the coastline and the isoaline 1m above sea level

766. **Sensitivity:** The degree to which a particular natural or human system is affected. The sensitivity is expressed in productive species, whether animal or plant, as well as in soil, and livestock farming systems, irrigation systems, among other agricultural components. The sensitivity of the productive species is expressed in the injuries or direct damage to their tissues or organs, the alterations of their physiology, the reduction of the growth, the decrease of the productive performances or their quality for the market, among other criteria

- Impacts to human health due to water quality
- Impacts to agriculture due to water quality
- Effects on livestock due to water quality
- Impacts to agriculture due to the quality of the soil

767. **Adaptability:** Ability of an organism to alter itself or its responses to the changed environment

768. **Recovery:** Existing capacities to recover after the event, related to the capital endowment of the production system (natural, physical, human, social and financial)

a) Availability by families of means of work (tractors, boats, vehicles)
b) Forms of property of family members (independent worker, member of a cooperative)
c) Education level of family members
d) Productive activities and means of production covered by insurance.

769. **Resistance:** Ability to resist or tolerate the exposed components (species and productive practices, soil, water), dependent on the design and management of production systems

- Diversity of livelihoods
- Type of housing
- Freshwater sources
- Percent of the area between the coastline and the isoline of 1m above sea level covered by coastal vegetation

770. **Transformability:** Capacity for innovation, determined by human, social and financial capital.

- Adding value to production
- Sources of energy used in the home and in productive activities
- Gender equality
- Existence in the municipality of aCBCS
- Incorporation to the Network of municipalities due to CC

771. The indicators to be included in the PERC will be socialized and selected in a participatory manner, with local actors to be refined based local vulnerabilities and needs, seeking their relevance and their contribution to the incorporation of adaptation and in particular EBA to planning.

Ecosystems Based Adaptation Information Modules.

772. To support adaptation actions, the project will identify the need for products based on climate information already available in the localities, as well as other information that could be developed in different territories or by national institutions, focused on EBA measures with emphasis on addressing multiple sectors. This will allow the development of a set of tools to ensure improved adaptation to CC

and improved management of natural resources (with an emphasis on water resources) and facilitate the conservation of the marine-coastal environment.

773. The Information Modules for Adaptation are information products, which are based on the data and information collected and processed. Used for various purposes such as decision making and land management as well as for training, provide references on climate change at the local level and action proposals for the reduction of risk factors in communities and settlements.

774. The Centers for Environmental Studies (CEA), the Capacity Development Centers and Knowledge Management for Adaptation (CBCS) will design and prepare the ABE module content in digital form, based on relevant products related to ecosystem-based adaptation. These organizations will work together with other local actors, such as universities, production centers, Disaster Prevention Centers (PVRs) and municipal authorities to ensure dissemination of these products, use them in the development of capacities in activity 2.1 of Output 2 and in the integration of these tools in the Municipal Development Plans.

775. Some examples of products have already been identified through the Meteorological and Environmental Observation System are listed below:

- ✓ Climate Watch Bulletin
- ✓ Drought supplement.
- ✓ Forecast conditions of the El Niño - Southern Oscillation Event (ENSO), up to 6 months.
- ✓ Studies of extreme climatic hazards aimed at reducing risks.
- ✓ Products obtained through the Hydrological Observation System:
- ✓ Reports on rainfall behavior
- ✓ Reports on the quality of surface and groundwater.
- ✓ Tide Tables

776. Other content to be included in the ABE module could include:

- ✓ Good practice guides for the main activities of infrastructure development in the coastal zone based on EBA.
- ✓ Manuals for the implementation of EBA measurements, in the most frequent coastal ecosystems.

777. All products will be used in the training process proposed in Output 2, activity 2.1 through training activities, bulletins, audiovisual materials and publications needed to disseminate in the communities. For the purpose of training at the local level, an annexed clasroom it will be located in the CBCS, to support the adaptation actions of technicians and members of the community

778. Whenever possible and when the scientific basis is available, the project will use the available experience of CITMA to stimulate the application and dissemination through other organizations of different sectors of the government or even to influence or develop in the elaboration of national policies for the adaptation to the CC and its impacts. Table 23 below presents the main products produced by the project based on CC information.

779. The information of output 2 that will be contained in the ABE module will be updated by the CES and made available to the CBCS, will allow the flow to and from the territories to be maintained.

Table 28 - Products (goods and services) based on project climate information

Output	Level	Proposed Actions	Coordinator	Participants	Products	Frequency
1	**Community - municipal - provincial - national**	Strengthening of coastal environmental monitoring systems in intervention stretches	ICIMAR	Centers of Environmental Studies, Multidisciplinary Groups	Indicators on the status and trends of coastal ecosystems in the intervention tranches	Annual
2	**Community**	Identification and update of the main locally available products of early warning systems and monitoring systems Implementing a community monitoring system for adaptation to climate change	Centers of Environmental Studies (CEA) Annexed Classrooms and CBCs	Center for Capacity Building and Knowledge Management for Adaptation (CBCS), Aulas and Anexas Community activists Center for Capacity Building and Knowledge Management for Adaptation (CBCS), Centers for Environmental Studies (CEA), ICIMAR	Print and audiovisual information materials. Good practice guides, bulletins, dissemination of results and publications required by the communities (local level). Guiding documents updated and others that are indicated by the CITMA (national level) Community newsletters that will be registered in the database. Alert to extreme weather events and local vulnerabilities	Annual By quarter According to the occurrence of events
	Municipal	Implementation and updating municipal climate information from the knowledge management platform for Coastal Adaptation	CITMA´s Provincial Delegations	Centers for Environmental Studies and Center for Capacity Building and Knowledge Management for Adaptation (CBCS)	Reports on local coastal adaptation for communities, government and sectors	Annual

Output	Level	Proposed Actions	Coordinator	Participants	Products	Frequency
	Provincial	Update indicators on the status and trends of marine and coastal ecosystems and other groups of indicators.	ICIMAR Centers of Environmental Studies (CEA)	Multidisciplinary groups, Local governments	Updated provincial nodes of knowledge management platform for Coastal Adaptation indicators municipal nodes	Six months
		Update of the Territorial Statistical Information System (SIET)	CITMA´s Provincial Delegations	Center for Environmental Studies	CRI municipal incorporated into SIET	Annual
	Nacional	Implementation and updating of Node Development (national) and other nodes (AMA, DMA, CEAs, provincial delegations) knowledge management platform for Coastal Adaptation	ICIMAR	AMA Centers for Environmental Studies, CITMA in provinces and municipalities and settlements project	Annual reports with information on project results, interventions and behavior indicators and IRC	Annual
		Coordination and training for coastal adaptation of municipal governments	ICIMAR	Municipal Governments	Creating a network of Cuban coastal municipalities to Climate Change	Annual
		Coordination and training of sectorial legal advisors for coastal adaptation	ICIMAR	Sectors	Creating a Network inter-sectorial legal advisors	Annual
		Coordination and training of community monitoring networks for coastal adaptation	ICIMAR	Activists from intervention communities	Building national community monitoring network for coastal adaptation Strengthening of National Early Warning Systems	Annual
		Compilation and dissemination of CRIs of municipalities where there is intervention	Complementary Statistical Information System (SIEC) of CITMA, Directorate of Environment CITMA	CITMA´s Provincial Delegations	Incorporation of climate change indicators in SIEC and SIEN	Annual

Community based Early Warnings

780. The Project aims to generate climate and environmental information tools for ecosystem-based adaptation, which in turn facilitates decision-making and sectoral and territorial planning. This includes working with communities to understand vulnerability assessments within a wider context for adaptation to slow onset events.

781. The CITMA's Centres for Environmental Studies, will be responsible for this activity looking to enhance existing local-scale information products derived throught the early warning and monitoring systems. New early warning information products for EBA will be developed during project implementation to monitor saline intrusion line, coastal flooding characteristics, the state of the ecosystems, and others. The climate products for EBA will be updated annually based on the results of the community monitoring and complemented with the other existing monitoring networks

782. Information products will be based on local climate information and will be prepared in the territory or by national entities, with the aim of achieving a better adaptation to CC, disaster risk reduction, and an improved management of natural resources (with emphasis on the water resources) as well as for the preservation of the marine-coastal environment. These will be produced with support from INSMET and will take into advantage existing EW information flows and alerts that have proven to be succesul at a national and local level and will be enhanced by environmental monitoring observations of coastal ecosystems and areas. Products to be enhanced include (not limited to): i) Products obtained through the Meteorological and Hydrological Observation System and the National Tidal Network; and ii) Print and audio-visual information materials.

783. By incorporating into existing EWS, information to monitor local vulnerability to CC these will become tools for preventive planning to not only immediate threats but also from slow onset pressures to CC, thus generating a system that allows communities to take these threats into account in timely manner in decision making. It also allows the project to leverage existing EW models and capacities that have proven to be successful in managing immediated threat by mobilizing communities and local government sectors.

784. Information derived from the community based EWS will leverage existing communication channels that exist for the delivery of early warning systems in Cuba that have proven to be succesful at providing information to communities. These products will also be evaluated through surveys prepared by FLACSO to ensure that they are relevant and provide the information that is required for adapation action particularly as how populations relate to their coastal ecosystems in the case of water, access to natural resources and livelihood management.

Table 29 Detailed Stakeholder Table for Implementation Activity 2.2

Stakeholders with Active Participation in Implementation	Actions for Development of the Activity	Deliverables to be Provided	Existing Capacities (Co financing)	GCF inputs that will be provided to comply with the deliverable
CITMA (DMA)	Select and compile information on climate change indicators to be delivered to the National Environmental Information System. Select EBA indicators for the National	Integrated studies, including national and local information, to contribute to the National Environmental Information System that is currently being developed. Selected EBA indicators in the	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training

	Statistical System (SEN).	National Statistical System (SEN) to be used by the Government and facilitate use by all sectors.		actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.
ONEI	Identify selection criteria for the information to be delivered to the National Environmental Information System from the provincial and municipal levels (indicators).	Identified criteria for climate and environmental information (indicators at the local level) for the National Environmental Information System (indicators).	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.
AMA	Formulate climate change indicators proposals for CITMA system.	Formulated climate change indicators proposals for CITMA system. Personnel trained on data collection standards and protocols. Protocol adopted to select, package and	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training

		distribute climate and environmental information generated by the project.		actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.
ICIMAR	Process and integrate results from monitoring systems in the 7 intervention areas (marine and terrestrial biodiversity, atmospheric variables, quality and availability of ground and marine water, and community health). Formulate a proposal to integrate monitoring results into local planning mechanisms to contribute toward the flow of information from territories. Select indicators over marine and coastal ecosystem situation and trend in intervention areas. Prepare annual reports including information on project results, interventions and behaviour of indicators. Formulate a proposed Protocol for assessing	Monitoring results integrated into the platform. Monitoring reports and recommendations formulated in close cooperation with territories (people's and municipal councils), so that monitoring results can be incorporated into local planning mechanisms to contribute toward the flow of information from territories.	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.

	coastal resilience (PERC).			
Centre for Environmental Studies (CEAs)	Process and integrate monitoring and early warning system results at the provincial level (marine and terrestrial biodiversity, atmospheric variables, quality and availability of ground and marine water, and community health). Select indicators over marine and coastal ecosystem situation and trend in intervention areas. Practical training actions, basic equipment (cameras, recording equipment, etc.) management, use and conservation for community monitoring. Develop a procedure to measure coast line retreat rates, maximum flood reference points, mangrove survival rates, etc. Prepare annual reports including information on project results, interventions and behaviour of indicators. Prepare Protocol for assessing coastal resilience (PERC).	Primary information from each province is incorporated into the platform. Indicator studies and reports over marine and coastal ecosystem situation and trend in intervention areas. Environmental information studies for coastal adaptation from communities. Environmental modules on EBA and community-based early warning systems. The 7 community monitoring system brigades are trained. Procedures developed to measure coast line retreat rates, maximum flood reference points, mangrove survival rates, etc. Prepared Protocol for assessing coastal resilience (PERC).	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.
CITMA provincial representation offices	Formulate a proposal to integrate monitoring results into local planning mechanisms to	Proposals are formulated to update planning tools at the territorial and local levels.	The qualified technical personnel for the implementation of these actions are	Cost of workshops, technical meetings, training actions, consultant services (premise rental,

	contribute toward the flow of information from territories. Ensure the incorporation of climate change indicators into SIEC and SIEN. Practical training actions, basic equipment (cameras, recording equipment, etc.) management, use and conservation for community monitoring. Develop a procedure to measure coast line retreat rates, maximum flood reference points, mangrove survival rates, etc.	Incorporation of climate change indicators into SIEC and SIEN. The 7 community monitoring system brigades are trained. Compilation and dissemination of results from the implementation of the Protocols for assessing coastal resilience (PERC) at the territorial level.	supplied, and the personnel wage cost is covered.	printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.
CBCs and annexed classrooms and community activists (50% women)	Identify, select and compile information on the knowledge received by communities in connection with the implementation of activities that inform community system objectives and support activities under Component 1. Collect and update community-based environmental information for integration into the knowledge management platform. Provide information to early warning systems.	Information reports on the knowledge received by communities in connection with the implementation of activities that inform community system objectives and support activities under Component 1. Updated platform, including information generated in the 7 communities during project life. Local information provided to warning systems.	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.

INRH	Systematically update monitoring results over the quality and availability of ground waters in intervention areas during project life, which inform the knowledge management platform.	Report on the results of activities for their integration into the knowledge platform	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.
MINAG	Systematically update results over the rehabilitation of coastal wetlands in intervention areas during project life, which inform the knowledge management platform.	Report on the results of activities for their integration into the knowledge platform	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.

IPF	Systematically update the information on territorial planning during project life, which informs the knowledge management platform. Formulate a proposal to integrate monitoring results into local planning mechanisms to contribute toward the flow of information from territories.	Report on the results of activities for their integration into the knowledge platform	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.
INSMET, IES, National Aquarium CNAP	Systematically update the results of environmental monitoring in intervention areas during project life, which inform the knowledge management platform.	Report on the results of activities for their integration into the knowledge platform	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premise rental, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (70 at the national level, 7 at the provincial level and 24 at the municipal level), international consultant service (1). Connectivity services, ICT equipment, management software, and office furniture for the implementation of the Knowledge Management Platform.

INSMET, IGT, IES	Select indicators over marine and coastal ecosystem situation and trend in intervention areas. Prepare annual reports including information on project results, interventions and behaviour of indicators. Formulate a proposed Protocol for assessing coastal resilience (PERC).	Proposed indicators over marine and coastal ecosystem situation and trend in intervention areas. Prepared methodologies, manuals and guides on good practices (brochures) in connection with CC community adaptation. Prepared Protocol for assessing coastal resilience (PERC),	The qualified technical personnel for the implementation of these actions are supplied, and the personnel wage cost is covered.	Cost of workshops, technical meetings, training actions, consultant services (premises rental, accommodation, food, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (10 at the national level, 7 at the provincial level and 24 at the municipal level). International consultant service (1)
Community monitoring brigades	Implement community monitoring.	Data (coast line retreat rates, maximum flood reference points, mangrove survival rates, etc.)	Voluntary personnel are supplied.	Cost of workshops, technical meetings, training actions, consultant services (premises rental, accommodation, food, printed and digital information, etc.) for the preparation of the training plans. Workshops, technical meetings and training actions (10 at the national level, 7 at the provincial level and 24 at the municipal level). Equipment for community monitoring

6.3.2.3 Activity 2.3 Mainstream EBA approaches into regulatory and planning frameworks at the territorial and national levels for long term sustainability of EBA conditions and investments for coastal protection

785. Activity 2.3 will specifically address gaps in the legal and regulatory frameworks, identified as barriers for EBA approaches, and look for inter-sector coordination at all levels to ensure that ecosystem-based integrated coastal management is embedded within planning frameworks as a to strengthen resilience to climate change. The project will strengthen the legal national framework by:

- Leveraging on "Tarea de Vida", its existing framework and its prioritization of climate adaptation.
- Compiling and systematization of field experiences and good practices under existing frameworks, regulations and institutions (Technical Norms and Legal Guidelines).
- Building up, through enhanced capacity and tools (Activity 2.1), current political
- Updating local ordinances and development plans to mainstream EBA and ensure initiatives sustainability through updated provincial and municipal management plans. This will be

based on scientific information derived from monitoring of Component 1 and its intregration into the KMPCA (Activity 2.2.)

786. These actions will contribute more broadly to the strengthening of public policies and regulations at a national local level through a bottom up approach that will be fully supported by national guidelines and norms that are regulatory in nature. During the period of development and implementation of the project, changes will be occurring in the strategies and policies of various activities (forestry, agriculture, water resources, land use, among others as a result of the implementation of Tarea Vida), in addition to the consolidation of the development of a new local management model much more decentralized than the current one (results of the 2019 Constitution). This project will provide the EBA methodological and normative framework for all these developments in sectorial and local policies and regulation to address the specific opportunities and capacity gaps identified through the project for an enhanced EBA approach to CCA.

787. Results from this activity will include the development of Cuban Technical Standard (Norm) of "Terms and Definitions for the EBA in Cuba" and “Technical Guidelines for the Establishment of the Ecological Flow” that will act as regulatory norms for environmental management. It will also result in the integration of EBA into Municipal Environmental Management Territorial Models, Muncipal Land Use Plans and Municipal Development Strategies.

788. At the end of the project Cuba will have a strengthened regulatory framework, conducive to sectoral and governmental planning, with new legal instruments developed, approved and implemented, in addition to 2 networks (1 at sector level and 1 at municipal level) as follows:

- Cuban Technical Standard Norm on “Terms and Definitions for EBA in Cuba”.
- Compendium of methodologies to determine the calculation of the ecological flow in any area of the country.
- First 7 technical standard norms that will establish the specific method to determine the ecological flow in each river basin represented within the intervention areas.
- Twenty-four management plans with a regulatory character to eradicate anthropogenic barriers for each direct intervention sites.
- Twenty-four integral development plans including EBA measures at the municipal level.
- Twenty-four land and urban plans including EBA measures at the municipal level.
- First network of legal advisors facing climate change.

789. The resources provided by the project will be used for conducting technical workshops, training, production and dissemination of content on ABE in various media and provide information technology for linking network members. Funds will also be used in enhancing capacities in topics for municipalities such as developing cost benefit analysis on adaptation measures, on coastal marine planning through an ABE lens. GCF funds will also provide support in promoting exchanges at a national and international level with countries in the region and Europe, with practical experiences in coastal adaptation based on natural solutions and measures of community resilience, to present results obtained by the project's working group and networks created within its framework. This will be key in identifying best practices and exchanging information on the incorporation of EBA into national and community governance frameworks.

Sub-activity 2.3.1 Create a network of legal advisor to develop a detailed analysis of the regulatory, legal and institutional framework and solutions (costing tools, legislation, regulations) to integrate EBA investments and management in 24 municipal and 7 provincial economic plans through concrete actions and investments.

790. Actions include creating and funding the support that will be provided under a network of legal advisors (3 per province) representing economic and planning sectors relevant to coastal management and government levels to provide support at municipal, national and provincial government authorities to integrate EBA approaches into development plans and budget allocation mechanisms for coastal areas.

791. Specific investments include include financing directed at the hiring of legal experts that will provide support and developing a legal capacity gap assessment (GoC co-financing), providing them the space (GoC fund) and the equipment required to operate (GCF funds), as well as covering the logistic costs of providing support and training to municipalities and provinces (GCF funds). Through the network of advisers, the project will directly address existing capacity gaps identified during the project's barriers.

792. The network of advisors will produce a detailed analysis of the regulatory, legal and institutional framework for integrating EBA as an adaptation and sustainable development strategy, identifying implementation gaps and possible solutions to address these by introducing regulations, legal recommendations, costing tools. These tools and recommendations will be provided as direct support of the legal network to the 24 municipalities involved in the project to contribute in the preparation of regulatory documents (as identified in the analysis).

793. This coordination mechanism will work at municipal, national and provincial levels to integrate EBA approaches, as defined by the newly created Technical Standards (Sub activity 2.3.2), into development plans and budget allocation mechanisms through mechanisms available to municipalities as a result of the 2019 Constitution.

794. A key result will be the development of environmental management plans in to include the sustainability of EBA in the 7 project districts and 24 municipalities.

795. A network of exchange of climate vulnerable coastal municipalities targeting all 24 municipalities involved in the project will be creatated to exchange best practices and to contribute in the preparation of regulatory documents for municipalities. The network of legal advisors will work closely with these municipal governments to frame these for their discussion in popular councils and legislation bodies.

Sub-activity 2.3.2 Produce technical standards for the inclusion of EBA in national and sectoral regulations

796. Through this activity, the project will develop a Cuban Technical Standard (Norm) of "Terms and Definitions for the EBA in Cuba" and "Technical Guidelines for the Establishment of the Ecological Flow." This will be achieved during the first half of the project based on early project information (Output 1) resulting in the following targets:

- The project will prepare the first Cuban Technical Standard Norm on "Terms and Definitions for EBA implementation in Cuba". This new norm will have a legal character and, through its approval, it will constitute evidence of the implementation of a new legal instrument (CITMA) within Cuban regulatory framework. These will be prepared and approved within the first 4 years of the project.
- The project will prepare the first compendium of methodologies to determine the ecological calculation. These will be prepared in the first year of implementation and approved in the 2nd.
- The project will prepare the first 7 Technical Standard Norms to determine the ecological flow, according to the characteristics of each river basin represented in the direct intervention

areas. These standard norms will have a legal character and demonstrate the implementation of a new legal instrument (CITMA) within Cuban regulatory framework, for annual, medium and long-term planning of terrestrial waters and their control at provincial and national levels. These will be prepared and approved within the first 3 years of the project

797. The technical standards and guidelines will constitute a base for EBA approaches integration into municipal and national actions and budgets and will also be key instruments for governments in water management planning. Standards, which are regulatory in nature, will provide the criteria for restoring coastal ecosystem´s functionality for coastal protection and instructions on how to maintain such functionalities and nexus within ecosystems.

798. Information to integrate these standards will be derived from Output 1 activities which will feed the KMPCA and the inputs it provides to national databases. These will provide criteria for restoring ecosystem´s functionality and resilience and also instructions on how to maintain such nexus and functionalities including ensuring proper water allocation for ecosystems in water management instruments.

799. GCF funds, for this sub-activity, will be used for technical workshops organization and material (i.e. leaflets), training tools, the development of an EBA communications strategy, information technology and communication equipment (to promote communication amongst actors in the network of municipalities).

Sub-activity 2.3.3 Integrate EBA into Environmental Management Territorial Models, Land Use Plans and Municipal Development Strategies

800. This activity will look to incorporate EBA into municipal territorial and natural resource planning instruments, , including in local plans for "Tarea Vida", Risk Reduction Management Strategies territorial land use plans (Planes de Ordenamiento Territorial- POT) and local environmental ordinances on resource management (Modelos de Ordenamiento Ambiental- MOA). Through this activity, actions for coastal resilience will be included in land use ordinances to reduce climate vulnerability and look to reduce pressure on ecosystems services of coastal landscapes.

801. Technical support and advice will be provided to key sectors (water, agriculture, fisheries and environmental) and key stakeholders (local governments, productive organizations, local scientific / technical research centers, community leaders, representatives of civil society), to achieve successful inter-sectoral coordination of EBA in their sectoral planning instruments. Information products derived from Activity 2.2. will be key instruments for this work as will the statistical data provided through the KMPCA, that will serve to ensure that all sectors understand the impact of their actions in enhancing coastal resilience.

802. Information exchanges include both at a national level to share project results to other coastal communities for a national upscale and to better integrate the project with the objectives of Tarea Vida. It will also include courses and trainings from research centres and institutions including the University of Cantabria to socialize the model and trouble shoot around key issues related to integrate EBA system into community governance systems.

803. GCF funds will also be used to foster knowledge exchange among municipalities, hiring of national and international experts for capacity building on streamlining of EBA and adaptation measures and integrating them into territorial planning and disasters risk reduction instruments.

804. Through this sub activity the project will result in the following:

- The project will develop 24 management plans with a regulatory character to remove anthropogenic barriers for each direct intervention site. These management plans will be approved by the provincial governments by legal instrument; they will have a scientific and

legal basis, and will include a cost-benefit analysis that demonstrates the feasibility of EBA measures.

- Twenty-four integral development plans will be developed at the municipal level including EBA measures.
- Twenty-four land and urban plans including EBA measures will be developed.

Table 30 Detailed Stakeholder Table for Implementation Activity 2.3

Stakeholders Implementing the Activity	Actions for Development of the Activity	Deliverables to be Provided	Existing Capacities (Co financing)	GCF support
Legal advisers from CITMA, INRH, MINAG, ONEI, IPF at the national level:	Identify and select the contents to be developed in the network of legal advisors' work program. Identify the legal regulations related to the project activities. Design proposals for EBA inclusion in sector planning.	Prepared work program for the network of advisers, for coastal planning and management. Detailed study of the regulatory, legal and institutional framework to integrate EBA as an adaptation and sustainable development strategy. Prepared studies and reports to integrate EBA into development plans for coastal areas	Qualified technical personnel are provided to carry out these actions and the personnel's salary costs are covered.	Cost of workshops, technical meetings, trainings, consultancies (rental of premises, accommodation, food, printed and digital information, etc.) depending on the preparation of training plans. Workshops, technical meetings and trainings (28, distributed nationwide, 7 provinces and 24 municipalities). ICT equipment and office furniture
Legal advisers of provincial and municipal delegations of CITMA, INRH, MINAG, ONEI, IPF	Identify the legal gaps in the regulatory framework. Review development plans at the territorial level. Identify the budget allocation structures for coastal areas, at the sectoral level Prepare proposals for legal strategies to include EBA in sectoral financial planning. Advise government structures on financial planning. Develop regulatory management plans to eradicate anthropogenic barriers at intervention sites.	Elaborated criteria for environmental management plans that include the EBA's sustainability in the 7 project districts and 24 municipalities. Elaborated regulatory management plans in order to eradicate anthropogenic barriers in intervention sites. Elaborated legal strategies to include EBA in the sectoral financial planning. Prepared proposals for urban regulations of coastal areas to include in the legal framework for land-use planning.	Qualified technical personnel are provided to carry out these actions and the personnel's salary costs are covered.	

	Prepare proposals for environmental management plans to include the EBA's sustainability in the 7 project districts and 24 municipalities. Prepare a proposal to modify urban regulations for updating physical planning rules in coastal areas.			
Specialists from DMA*	Identify requirements established by the National Standardization Office (ONN) for the elaboration of technical standards. Review international methodologies for the elaboration of technical standards. Develop EBA term and definition criteria. Develop proposal for a Cuban Technical Standard (Norm) of "Terms and definitions for EBA in Cuba" Submit to the ONN the proposal of the Cuban Technical Standard (Standard) of "Terms and definitions for EBA in Cuba", for approval.	Report about established requirements for the elaboration of technical standards, by the National Standardization Office Reports of methodologies studied for the elaboration of technical standards. Develop EBA term and definition criteria. Elaborated Cuban Technical Standard (Standard) of "Terms and definitions for EBA in Cuba.		Workshops, technical meetings, trainings, consultancies (rental of premises, accommodation, food, printed and digital information, etc.) depending on the preparation of training plans. Workshops, technical meetings and trainings (10, distributed nationally, 7 provinces and 24 municipalities)
INRH:	Collect information about the hydrographic basins' status, located in provinces where the project will take place.	Prepared reports about the hydrographic basins' status, located in provinces where the project will take place.	Qualified technical personnel are provided to carry out these actions and the cost of the salary of these personnel is covered.	
Specialists from CITMA, INRH, MINAG MES	Identify methodologies to determine the ecological flow, according to the characteristics of the basins located on project intervention sites.	Elaborate methodologies for determining the ecological flow, according to the characteristics of the basins located in project intervention sites.	Qualified technical personnel are provided to carry out these actions and the personnel's	

	Validate information and select methodologies to consider in the study as well as selection of techniques for establishing the ecological flow, with the participation of university professors and universities. Make a proposal for "Technical guidelines for establishing the ecological flow".	Reports of methodologies to consider in the study and selection of techniques for establishing the ecological flow, Elaborated proven to Technical "Guidelines for the establishment of ecological flow "	salary costs are covered.	
MINAG, IPF	Identify, select and develop criteria proposals for the inclusion of coastal resilience in land-use planning.	Coastal resilience included in sector planning instruments	Qualified technical personnel are provided to carry out these actions and the personnel's salary costs are covered.	Cost of workshops, technical meetings, trainings, consultancies (rental of premises, accommodation, food, printed and digital information, etc.) depending on the preparation of training plans. Workshops, technical meetings and trainings (23, distributed nationwide, 7 provinces and 24 municipalities), International Consulting)
Local governments (government representatives from the 7 provinces and 24 municipalities)	Validate the possibility of including EBA in municipal instruments for territorial planning and natural resources, including local plans for "Tarea Vida", Risk reduction management strategies (forecast based financing) and territorial plans for land-use planning (Territorial Planning Plans - POT) and Environmental Management Models-MOA.	Introduced proposals for EBA's insertion in planning at the territorial level (Territorial Planning Plans-POT) and Environmental Planning Models-MOA.	Qualified technical personnel are provided to carry out these actions and the personnel's salary costs are covered.	

VII. Project Impact

7.1 GCF Project investments and proposed activities

805. The project will provide support in transitioning from a reactive disaster and emergency management approach to a preventive and holistic approach, considering adaptation as a continuous process, which in this case builds on maximizing natural infrastructure functionalities along coastal zones and is grounded on, and sustained through coastal communities and informed planning mechanisms.

806. Through the complementarity and synergies of its interrelated outputs, the project will ensure that the necessary conditions are created for nationwide application by addressing the baseline actions required for effective EBA (fully functional ecosystems, communities as active agents of adaptation and planning frameworks).

807. Project outputs have been designed to directly contribute in reducing climate risks along highly vulnerable coastal areas, by rehabilitating and enhancing the ecosystem services of coastal wetlands to better manage coastal flooding saline intrusion, reduce coastal erosion and provide a buffer to increased storm intensity. Together with strengthening community, government and sector adaptive capacity through capacity building, access to tailored climate information for enhanced decision making at municipal scale, and mainstreaming evidence-based ecosystem planning approaches to address climate change impacts. These outputs will generate a true shift, by the GoC, on climate risk management, from a reactive approach to a preventive.

808. In short, while Output 1 will enhance natural infrastructure as defense systems to mitigate climate impacts to coastal zones, Output 2 will promote a shift from a traditional reactive approach that considers communities as passive stakeholders into a preventive/proactive approach where they are informed active agents in natural resources and risk management. Thus, including within the project logic an important opportunity in the country to enable information flow back to communities so that it can be integrated into local coastal planning mechanisms, moving beyond the implementation of top down directives. The transformation of current EWS that will be enhanced by information derived from the project will also allow for this shift in mentality from an immediate hazard approach to one of adaptive long-term planning.

809. The project has been designed to address key barriers in the development of a new approach to address climate impacts mainly the lack of awareness, at a local and inter sectoral levels, of climate change impacts and potential adaptation solutions. These will be addressing these barriers by strengthening capacities, communication and awareness in key stakeholders and sectors in a manner that is locally relevant and innovative for Cuba in its top down and bottom up approach. Furthermore, via capacity building of local governments the project will directly influence on local planning instruments. Mainstreaming EBA on local planning instruments has been selected as key indicator of the project implementation. The monitoring systems established in Output 1 and Output 2 will be essential instruments to enable inter-sectoral coordination- another important barrier- while providing consistent information on the effectiveness of investments on coastal natural infrastructure, which will be valuable not only for national upscale but to other tropical countries in their efforts to implement EBA initiatives in coastal zones. Community capacity building will be enhanced by the CBCSs and the provision of relevant information on climate risks and natural resources management that will serve as local adaptation strategies.

7.2 Project Beneficiaries

810. 1,324,114 inhabitants (over 11% of the national population) located along 24 coastal municipalities along a 1,300km coastline are the direct and indirect beneficiaries of this intervention. The economic importance and size of human settlements in these stretches is also significant with

four national main fishing and agricultural zones. Furthermore, the current constitutional reforms provide an important opportunity to engage local communities and develop capacities at a local level to promote integrated coastal management in planning and governance frameworks and ensure climate change risks are considered and addressed.

811. There project will directly benefit 444,793 inhabitants and indirectly 879,321 inhabitants. The latter also affected by CC-related impacts (coastal erosion, flooding and salt intrusion) and that will benefit through the project's actions along the target coastline

812. A climate change mitigation co-benefit is emissions reduction and blue carbon sequestration. The project will rely on a combination of natural regeneration and artificial regeneration (planting) of mangroves to achieve the rehabilitation of the desired structure (output 1) to restore systems functionalities and adaptation-related services in mangroves and other associated coastal ecosystems. Improved management of forest will contribute to emission reduction and blue carbon sequestration (far more carbon per hectare than tropical rainforests or marshes). Mangroves are unique carbon storehouse in their ability to lock carbon up in anaerobic soils. Globally, blue carbon ecosystems are known to be significant CO2 sinks with average carbon sequestration rates of 8.3 t CO2 per hectare, per year for Mangroves[127]. For a total extent of 11,427 ha, the total annual sequestration is 94,844 t CO2/year, thus the expected lifetime (22 years) emission reductions is 2,086,568 tCO2. Rehabilitation of swamp forest and swamp grasslands will also have an important sequestration effect, however as national formulas are still being developed, a numeric estimate cannot yet be calculated. However, it should be noted that while the project will have cross cutting results, it is classified as a purely adaptation project in accordance to the GoC's preference.

Table 31 - Scope of Project Interventions (Ecosystems and Beneficiaries)

Geografic Areas	Coastal Line (Km)	Area Km2	Land Area Km2	Marine Area Km2	Direct Beneficiaries	In-Direct Beneficiaries	Total Beneficiaries
Stretch 1	271.00	12,660	6,500.00	6,682.00	222,737.00	527,285.00	750,021.00
Stretch 2	1,029.00	14,660	11,007.00	3,623.00	222,056.00	352,036.00	574,092.00
Total	1,300.00	27 320.00	17,507.00	10,305.00	444,793.00	879,321.00	1,324,114.00

7.2.1 Calculating Project Beneficiaries

813. improved quality of life that is attributable to project actions to improve the resilience of coastal areas in Cuba against the impacts of climate change. It is very clear and important to recognize that the project can not eliminate the impacts of climate change, what it does is improve the conditions that give resilience to coastal ecosystems and these conditions allow local people to have a better quality of life and greater adaptability.

814. Direct and indirect beneficiaries were established by outputs, taking into account the expected benefits for each output, to achieve the planned activities and the product of each.

815. Since the activities of output 1 are more specifically aimed at the rehabilitation of ecosystems, in 7 of the 24 coastal municipalities, this rehabilitation improves the capture of the benefits derived and ecosystem services, therefore it is expected that the direct beneficiaries are somewhat lower more related to specific sites of intervention. Moreover, indirect beneficiaries are elderly people as many

127 This value was calculated using biomass losses and gains methodology as stated in Section 2.3.1, Chapter 4, Vol 4, IPCC Guidelines for National Greenhouse Gas Inventories, 2006.

as indirectly benefit in more extensive in the 24 coastal municipalities included in the two Stretches areas.

816. On the other hand, if the output 2 is more focused on developing enabling capabilities for the development of Output 1 and capacity building in a way allowed in all 24 municipalities in the two stretches, so their number direct beneficiaries is higher, although the nature of their actions indirect actors are slightly lower.

817. Given its scope, the benefits will be felt beyond the inhabitants in settlements to intervene. By using Geographic Information Systems the project identified potential affected settlements by saltwater intrusion; flooding from category 5 hurricanes; located in areas of mangrove forests, tropical swamp forests or below the line forecast rise of sea level to 85 cm (AISN), of each of the municipalities that make up the stages of intervention (24 municipalities)- Figures 38 and 40 Section 3.

818. Other criteria considered to identify beneficiaries of the project were the opinion of key actors in the territories. During visits to communities, interest groups identified the settlements project they considered that would benefit. To do so, they used printed images of the satellite with landmarks identified by the communities.

819. For calculations of the total population of each settlement, data from Census of Population and Housing 2012 National Office of Statistics and Information (ONEI) of Cuba was used as a source. Data from the total population of municipalities and provinces were taken from the same source.

820. Below are the criteria and definitions with which the number of beneficiaries was established by Output and Stretch;

Output 1

In this output, only Direct Beneficiaries (BD) were established in the 7 settlements where direct interventions will be made in the ecosystems (AI) and in the settlements close to these that meet the AISN conditions.

(BD1) = Population of AI + Population of AISN)

The Indirect Beneficiaries (BI) of Output 1 refer to the people of the municipalities where interventions are to be carried out; As it established as indirect beneficiaries persons residing in these municipalities that do not derive direct benefits from the project (do not reside in the target sites).

(BI1 = Town population - BD1)

The direct and indirect beneficiaries of Output 1 were calculated by intervention stretches and in a general manner.

Output 2

In this Output, Direct Beneficiaries (BD) are expected in the 24 municipalities covered by the project, since the Capacity Building Centers for Knowledge Management for Adaptation (CBCs) will be strengthened in these and complemented with 7 annexed Classrooms that will be created in the settlements where they are to make direct interventions.

Direct Beneficiaries (BD) of output 2 are established in the settlements where the CBCs are located, which will be in the 24 municipal capitals (AC) (60% of the settlement's population were identified as direct beneficiaries in these urban settlements), the population of the AISN settlements and the key

actors with capacity to replicate the process of training and education in the rest of the settlements of the municipality (ARM).

(BD2 = 60% Population of AC + Population of AISN + Population of ARM)

The main criteria for establishing a ratio of 60% from the total population in 24 municipalities are as follows:

- The project with established skills and time available not considered feasible serve the entire population.
- Considering the issues and types of training proposed by the project it is estimated that 40% of the population will not have the interest to get involved.
- The baseline established during the interview process in formulating the project show that the baseline is very small and, in some cases, nonexistent.
- The experience of FLACSO-Cuba has demonstrated in previous projects that 60% of the target population is actively involved.

Indirect Beneficiaries (BI) of output 2 refer to people from the 24 municipalities that will benefit from the enhanced capacity in their communities but are not considered direct beneficiaries of the component (receiving taining or providing training).

(BI2 = Population of the municipality - BD2)

7.3 Sustainability of the project "Adaptation to climate change in the coastal zone of Cuba with an ecosystem-based approach" ("Mi Costa")

821. The sustainability of the project outcumes and objectives have been assured through its intregation of activities into existing institutions, policy frameworks and leveraging the GoC's high capacity for scientific development.

822. Furthermore, all areas involved in the project implementation have signed agreements to co-finance the project over the 8 year and to plan funding for maintenance interventions and related to the restoration of coastal ecosystems infrastructure, equipment and facilities associated with resilience communities, for the subsequent 22 years. For the GoC this is a 30 year project with funding considered beyond the scope of the GCF funding (8 years).

823. An O&M Plan gas developed fro this project. All project investments included a careful analysis of institutional capacities to maintain project investments.

824. The project being integrated as part of the State Plan for facing Climate Change, known as "Tarea Vida" is considered a key measure to ensure the project's sustainability as well as ensuring the mobilization of co financing. As a State Plan, "Tarea Vida" legal hierarchy is hierarchy superior to previous documents related to climate change. Furthermore, its approval was foreseen as a progressive program with short (2020), medium (2030), long (2050) and very long term (2100) investments in prioritized areas and places. This in tun assures through government directives, required funding as needed in support of its implementation as a priority in the Economic Plan at all levels.

825. Thus, ministries, provincial and municipal governments and other entities shall include in their plans required investments as needed including the identification and targeting of sources, pathways and mechanisms of funding.

826. CITMA under “Tarea Vida” has the function of supervising the planning entities and all investments for “Tarea Vida” including prioritizing investments, calculating its cycles for its inclusion in the Economic Plan and in reviewing and adjusting the methodological aspects and annual figures required with the Ministries of Economy and Planning (MEP) and Finance and Prices (MFP).

827. At the provincial level, a group has also been assigned for the implementation of the "Tarea Vida", chaired by a Provincial Vice President. The provincial CITMA Delegation acts as the secretariat of said group. This mechanism promotes and enhances joint actions of integration between sectors, stakeholders and communities for decision-making at regional level, aimed at integrated and sustainable management of coastal ecosystems and confrontation of climate change. The government of the nation systematically controls the implementation of the “Tarea Vida” at the provincial level.

828. One of the major contributions of the project is to strengthen the understanding and participation of local stakeholders (communities, government and sectors) in the design, implementation and monitoring of adaptation actions and governance, so they can improve their adaptive capacity to in the face of emergency situations, reduce vulnerabilities and reduce levels of social, economic and environmental impact.

829. Therefore, the project ensures that investments are integrated into government structures, increased participation of local stakeholders in the planning and implementation of project activities to ensure their long-term sustainability and recognizing that Local Organs of People's Power (OLPP) are key for project implementation at the local actors and their involvement contributes to the ownership of interventions.

830. Through the implementation of the Knowledge Management Platform for Coastal Adaptation by the project, the intersectorial and interactorial relationship is guaranteed, to integrate the planning mechanisms that are being developed and updated within the framework of "Tarea Vida", the implementation, maintenance, control and sustainability of project interventions.

831. The project has planned the realization of specific actions included in the "Tarea Vida", among which are the following:

- Identify and undertake actions and projects to adapt to climate change, integral and progressive, necessary to reduce the existing vulnerability in areas identified as prioritized.
- Implement the legal norms necessary to support the execution of the State Plan; and ensure strict compliance, with particular emphasis on measures to reduce the vulnerability of the built heritage, giving priority to coastal settlements threatened.
- Direct reforestation towards maximum protection of soil and water quality and quantity; as well as the recovery of mangroves most affected.
- Implement and control adaptation and mitigation measures to climate change derived from sectorial policies in programs, plans and projects.
- Strengthen monitoring systems, monitoring and early warning, to systematically evaluate the status and quality of the coastal zone, water, drought, forest, human health, animal and plant.
- Prioritizing the measures and actions to raise risk awareness and increase the level of knowledge and degree of participation of the entire population in addressing climate change and a culture that encourages water conservation. Manage and coordinate to use the financial resources available to implement investment projects and actions arising from each of the tasks of this State Plan.

832. The tax modality known as Territorial Contribution, Local Development Initiative Projects, Integral Development Plans (PDI), foreign collaboration and other ways that complement the

Economy and State Budget Plan, are also seen further tools directed to ensure the scaling of the project at a local level. Below are the most relevant elements of these mechanism;

- Law 113 of the Tax System provides a contribution to sustainable development of municipalities, which taxes income from the sale of goods or services, obtain businesses, corporations and cooperatives themselves and their establishments each territory. The income collected from this concept is used to finance activities aimed at guaranteeing sustainable territorial development, through the management of the Municipal Administration Councils.
- The Municipal Initiative for Local Development (IMDL). The Ministry of Economy and Planning, promote a fund to finance Municipal Initiatives for Local Development (IMDL) as part of a process of decentralization of funding for the territories. Currently it implemented in all municipalities, with the aim of supporting the development and implementation of their own development strategy, by managing economic projects based on the exploitation of local resources, able to finance it and generate profits in order to benefit the territory.
- The PADIT project (Platform Articulated Integral Development of Territories) that supports the decentralization process through the creation of tools and spaces that gives channel initiatives and multi-level consultation and multi-stakeholder management.

833. In addition, the project has created internal mechanisms to ensure operational and institutional sustainability of interventions by including local mechanisms of th interventions available to local actors, such as:

- Inclusion of key actors (government, communities and sectors) in the design, implementation and monitoring of interventions, to ensure their appropriation.
- Public consultations, to ensure that interventions are responsive to the priorities and requirements of local actors.
- Design the monitoring of interventions, so as to allow adaptive management, to ensure timely corrective action and maximize the expected impact.
- Coordination of environmental funds available locally (FONADEF, Conservation Program and soil management), to support overall environmental priorities identified in the sections intervention.
- Promotion from local structures, diversification of livelihoods (beekeeping, ecotourism, crafts, nurseries), which use the goods and services of ecosystems rehabilitated and promote conservation.
- Systematize and disseminate in sectors and decision-makers, the results of the cost-benefit studies and the costs avoided by the interventions.

VIII. Project Implementation Arrangements

8.1 Project Governance Arrangements

834. This project will be executed in the Republic of Cuba under Article 1 of the Standard Basic Assistance Agreement (SBAA) between the Government of Cuba and the United Nations Development Programme, signed by the parties on May 17, 1975. The objectives and expected results of the project correspond to the priorities defined in the Country Program Document (CPD) 2020-2024 agreed between the GoC and the UNDP.

835. The project implementation will be regulated by the provisions of Resolution 15/2006 of the former Ministry of Foreign Investment and Economic Cooperation (MINVEC), currently the Ministry of Foreign Trade and Foreign Investment (MINCEX), dated May 26, 2006, which states that the Rules for Economic Cooperation that Cuba receives are mandatory for all stakeholders and will be applicable in the project implementation.

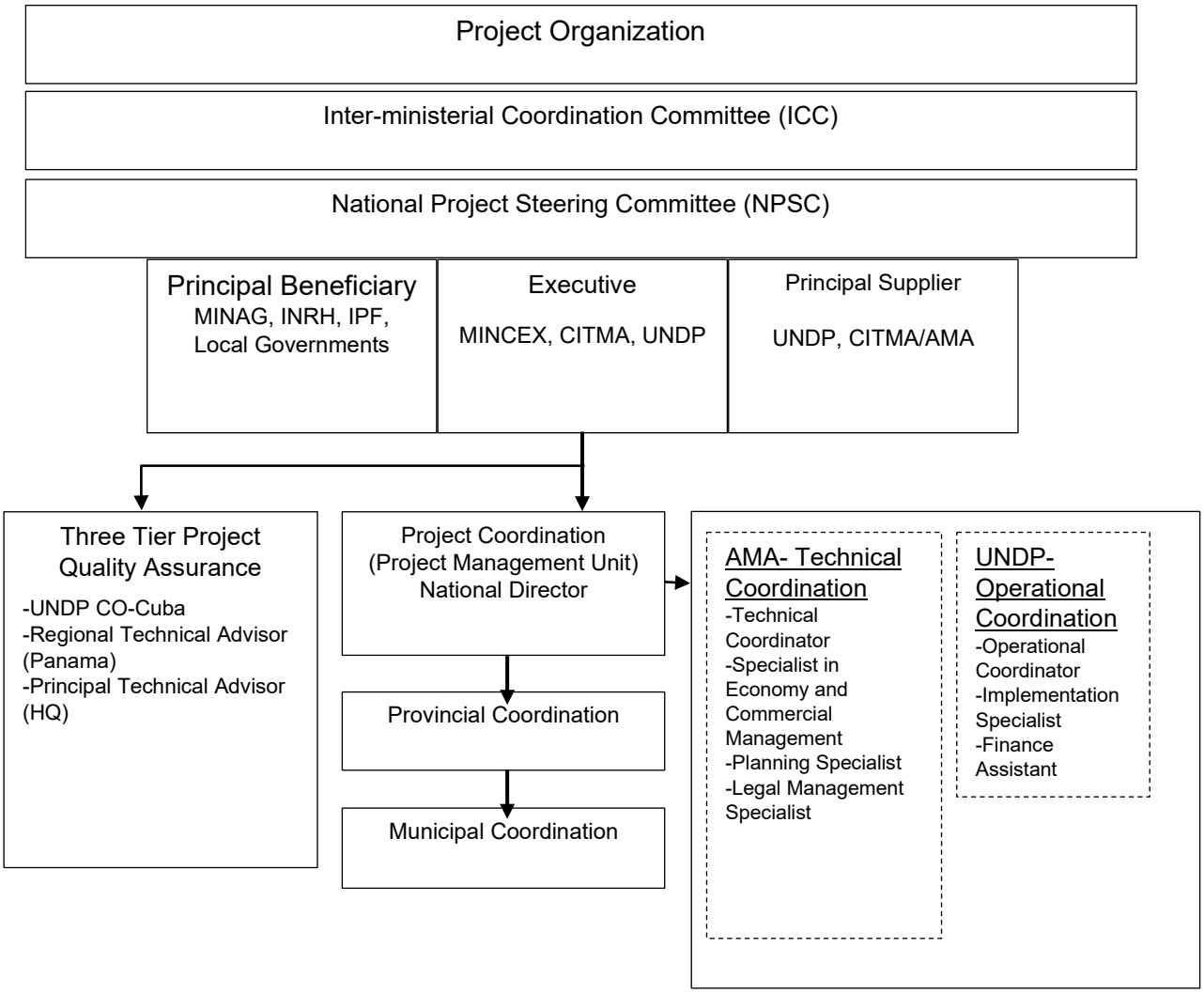
836. The project will be implemented following UNDP's national implementation modality (NIM) - according to the Standard Basic Assistance Agreement signed between the GoC and UNDP, on 17 May 1975, the Country Program Document (CPD) 2020-2024 and as per policies and procedures outlined in the UNDP (POPP) (see: https://popp.undp.org/SitePages/POPPSubject.aspx?SBJID=245&Menu=BusinessUnit). All references in the SBAA to "Executing Agency" shall be deemed to refer to "Implementing Partner".

837. The national executing entity - also referred to as the national 'Implementing Partner' in UNDP terminology - is required to implement the project in compliance with UNDP rules and regulations, policies and procedures (POPP), including the NIM Guidelines. These include relevant requirements on fiduciary, procurement, environmental and social safeguards, and other performance standards. The (national) Implementing Partner for this project is the Environmental Agency (AMA) of the Ministry of Science, Technology and Environment (CITMA) of Cuba. AMA will act with the support of its ascribed research centres, amongst these ICIMAR and CITMA's specialists based in the project involved provinces and municipalities. AMA will be accountable to UNDP for managing the project, including monitoring and evaluation of project interventions, achieving project outcomes, and for the effective use of UNDP resources. AMA/CITMA will designate a National Project Director to carry out the strategic direction of the project and oversee its operational and technical execution.

838. As requested by the GoC to UNDP for this project and in accordance with the agreement between CITMA and UNDP through a Letter of Agreement (LOA) referred to above, UNDP will provide services in support of the procurement of goods and services necessary to achieve the expected results. Cuba must import almost all the resources and equipment that this project requires. Considering the restrictions of the blockade that limit the capacity of Cuba's importing institutions, the GoC has requested UNDP to be responsible for all procurement that requires importing goods . In addition, the GoC may request UNDP to provide direct project services for this project related to administrative and financial management support including the processing of payments, fund management services, etc. The UNDP and GoC acknowledge and agree that those services are not mandatory and will be provided only upon Government request and specified in the Letter of Agreement. If requested, the direct project services would follow UNDP policies on the recovery of direct project costs (DPC) relating to GCF funded projects.

839. The management arrangement for this project is summarized in the Figure 64 below.

Figure 81- Organization Structure



840. The Inter-Ministerial Coordination Committee (ICC) of the GCF: The First Deputy Minister of CITMA was appointed as the National Designated Authority (NDA) of Cuba to the GCF. He is also responsible for all scientific, technological and environmental activities, among others, in specialized management offices of the ministry. Given the importance of the GCF, the ICC was established by the National Government in 2018, to promote, approve, and oversee GCF projects at national level. This Committee is formed by the Central Bank of Cuba (BCC), which presides it; the Ministry of Science, Technology and Environment (CITMA), which acts as its Secretariat; the Ministry of Foreign Trade and - Investment (MINCEX); the Ministry of Economy and Planning (MEP); the Ministry of Finance and Prices (MFP); the Ministry of Energy and Mines (MINEM); the Ministry of Agriculture (MINAG) and the National Institute of Hydraulic Resources (INRH). The ICC will provide oversight to the National Project Steering Committee (NPSC) and will require periodic reporting from the NPSC, for this project.

841. The NPSC is responsible for making management decisions by consensus when guidance is required by the National Project Director, including recommendations for UNDP/Implementing Partner approval of project plans and revisions, and to address any complain at the project level. To ensure UNDP's ultimately accountability, the decisions of the National Project Steering Committee

should be taken in accordance with standards that ensure management for development results, best value money, fairness, integrity, transparency and effective international competition. In case of not being able to reach a consensus within the National Project Steering Committee, the final decision will rest with the UNDP Resident Representative in Cuba.

842. The NPSC will be chaired jointly by the Ministry of Foreign Trade and - Investment (MINCEX), CITMA and UNDP. The NPSC will meet at least once a year or more as necessary.

843. The NPSC has the following roles.

- An Executive that holds the project ownership and chairs the NPSC. This role will be exercised jointly by MINCEX, as rector of international cooperation in Cuba, CITMA and UNDP.
- A Senior Supplier representative providing guidance regarding the technical feasibility of the project, compliance with donor requirements, and rules pertaining to use of project resources. This role will be fulfilled by CITMA and UNDP;
- Senior Beneficiary representatives who ensures the realisation of project benefits from the perspective of project beneficiaries. The Main Beneficiary is comprised of: Ministry of Agriculture (MINAG), National Institute of Hydraulic Resources (INRH), Institute of Physical Planning (IPF), and local governments at the provincial level of Pinar del Río, Artemisa, Mayabeque, Ciego de Ávila, Camagüey, Las Tunas and Granma.

844. Project Quality Assurance: UNDP provides a three-tier oversight and quality assurance role involving UNDP staff in Country Offices and at regional and headquarters levels. The quality assurance role supports the NPSC by carrying out objective and independent project oversight and monitoring functions. This role ensures appropriate project management milestones are managed and completed. Project Assurance must be independent of the Project Management function; the NPSC cannot delegate any of its quality assurance responsibilities to the National Project Director. The project assurance role is covered by the accredited entity fee provided by the GCF. As an Accredited Entity to the GCF, UNDP is required to deliver GCF-specific oversight and quality assurance services including:.(i) day to day project oversight supervision covering the start-up and implementation; (ii) oversight of project completion; and (iii) oversight of project reporting.

845. The Project Management Unit (see Figure 64) will be headed by the National Project Director that will be designated and ascribed to AMA/CITMA. The PMU will have two divisions that will support the National Project Director: i) a technical division and ii) an operation division, each led by its own coordinator.

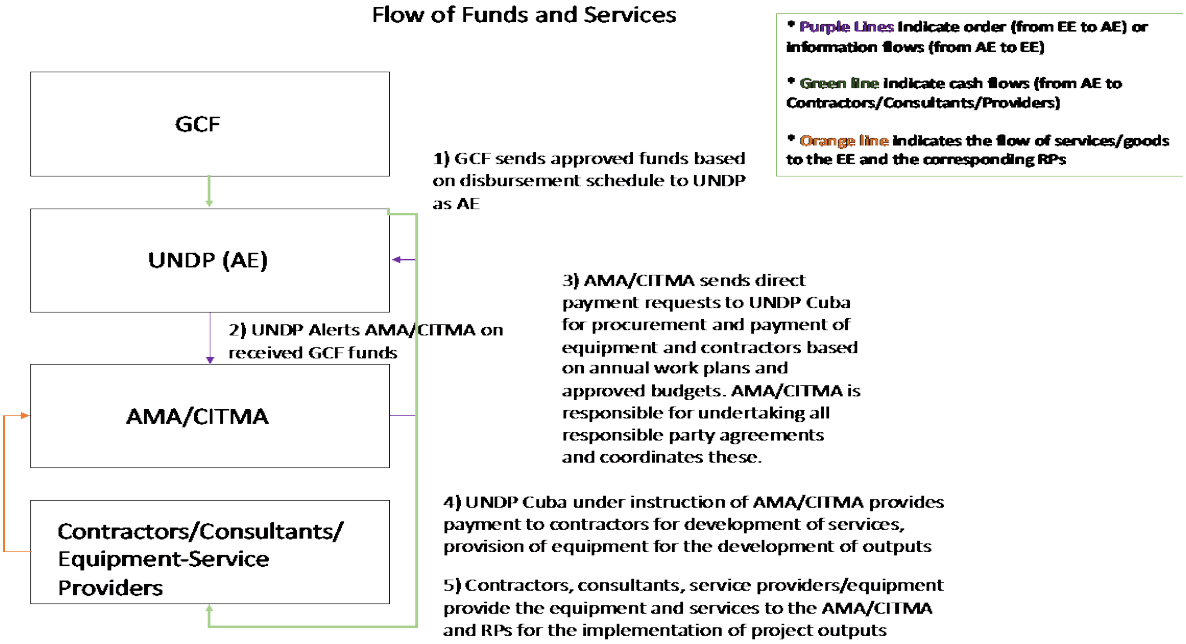
846. National Project Director: The National Project Director has the authority to execute the project daily activities on behalf of the NPSC within the constraints laid down by the NPSC. The National Project Director oversees managing and making project decisions daily. His/Her main responsibility is to ensure that the project generates the results specified in the project document, with the required level of quality and within the specified time and cost limitations. The Implementing Partner (AMA) appoints the National Project Director, who must be a different person from the Implementing Partner representative in the NPSC.

8.1.1 Flow of GCF Funds

847. As the AE, UNDP Cuba will disburse funding (received from the GCF according to the FAA disbursement schedule), through direct payments as per the requests received from AMA as the EE according to the project workplan. Also, AMA will conclude agreements with the CITMA, MINAG, and INRH (co-financing) and these Letters of Agreement (LOAs) will be attached to the Project Document. A Letter of Agreement (LOA) shall be signed between UNDP Cuba and AMA/CITMA

since UNDP will provide direct support to implementation to develop the process of procurement of goods and services necessary to achieve the expected results. Considering the restrictions of the blockade that limit the capacity of Cuba's importing institutions, the GoC has requested UNDP to be responsible for all procurement that requires importing goods. In this project the implementing partner coincides with the responsible party since AMA through its National Project Director, carries out the strategic direction of the project and oversees its operational and technical executionThe following diagram outlines the flow of funds and services to the project.

Figure 82- Flow of Funds and Services



ANNEXES

Annex I Specific Project Intervention Actions Output 1

848. While Output 1 actions where detailed in Section 6, this section presents specific interventions within the project target areas including an initial assessment of scope and impact.

849. As stated above the geomorphology of the coast of Cuba constitutes a solid basis for arguing the need to focus the project on rehabilitation of coastal wetlands on the southern coast of Cuba. The zones prioritized by the project are in fact some of the most sensitive and vulnerable areas to the effect of CC in the country, including the most threatened and degraded mangroves in the country, as well as some of the areas with reef crest and or greater frequency of deterioration or extreme deterioration (Iturralde and Serrano, 2015).

850. In these areas, low, swampy and mangrove-lined shores are surrounded by an extensive, shallow submarine platform, bordered by numerous cays and coral reefs, which provide effective protection against the waves generated in deeper waters. In fact, grey measures are considered unsuitable in these areas due to the high risk of sinking and potential for increased erosion.

851. The coastal stretches selected for implementation include coastal ecosystems such as mangroves, together with their associations with swamp forests and swamp grasslands, as well as marine ecosystems such as coral reefs and seagrass. The boundaries of the sites on the mainland were defined by the limit of the wetland ecosystem and the boundaries of the projected flood area from a category five hurricane. The use of an ecosystem-based approach and joint work with local and national stakeholders allowed for a better definition of the direct intervention areas in each of the two selected stretches.

852. On the basis of a prioritization, the project will focus specifically on two coastal areas (see Figure 66):

- La Coloma to Surgidero de Batabanó (Southwest coast)
- Júcaro to Manzanillo (Southeast coast)

Figure 83- Project intervention Stretches.

853. The proposals for intervention at the ecosystem level in this region are aimed at restoring resilience conditions that will increase the benefits of ecosystem services and reduce the impacts of sea level raise, decreasing or avoiding saline intrusion and improving adaptation to the effect of

catastrophic events and floods due to hurricanes and storms. The interventions focus on the integrated rehabilitation of coastal ecosystems and their positive impacts on marine ecosystems, which will require the reforestation of water catchment areas and the rehabilitation of mangroves, coastal lagoons, as well as the monitoring of aquifers.

854. To date, responses by the Government and local actors in Cuba to the current and potential implications of CC in coastal areas have focused primarily on structural and behavioral measures. Foremost among the structural investments has been the construction of the 50km long Southern Dike retention wall, which has been counterproductive in the long term, as it has interrupted natural hydrological processes and thereby led to the mortality of mangroves, undermining the potential for EBA. Behavioral measures have largely focused on short-term emergency responses and on relocating people, which have suffered productive and infrastructural damage from CC-related flooding and storms, further inland.

855. This activity will use GCF funds to rehabilitate degraded coastal wetlands along 1,337 km of Southern Coastline, with specific interventions being made in 7 key sites in the areas of La Coloma (stretch I); El Cajío (stretch I); Surgidero de Batabanó (stretch I) Júcaro (stretch II); Santa Cruz del Sur (stretch II); Manzanillo (stretch II) and Playa Florida (stretch II). Investments will be made in the rehabilitation of mangroves, swamp forests and swamp grasslands.

Stretch I: From the Coloma to Surgidero de Batabanó, on the Southwest coast

856. As part of the project design process presented to GCF, three investment sites (subzones) were identified in stretch I for direct intervention, these include: (1) La Coloma, (2) El Cajio, (3) Surgidero de Batabanó.

Interventions in the La Coloma Subzone

857. La Coloma (Pinar del Río municipality, Pinar del Río province): It is a settlement qualified as urban settlement (5000 to 9999 inhabitants) by ONEI[128.] It has 1,929 houses and a total population of 5,433 inhabitants. 99.6% of the population has electrical services, 98% of water supply and 49.9% of sewerage services.

858. The fundamental economic activity is fishing. The La Coloma Industrial Fishing Industry is dedicated to the export of different species that are captured and processed in that center. The catch comes from waters of the western coast of Cuba; the main products are finfish, lobster and shrimp which are processed in this industrial fishing center. The community has medical services with six medical offices and a pharmacy. On education there is a preschool, a primary school, a middle school, as well as a special education center. The community has a cemetery, a post office, 24 public radio stations, 252 residential telephone lines. In addition, 40% of streets are paved, 30% with gravel and the remaining 30% being rustic.

859. The interventions site of La Coloma is located on the coast south of Pinar del Rio in an area of approximately 500 hectares, strongly developed for the establishment of agriculture (Figure 67).

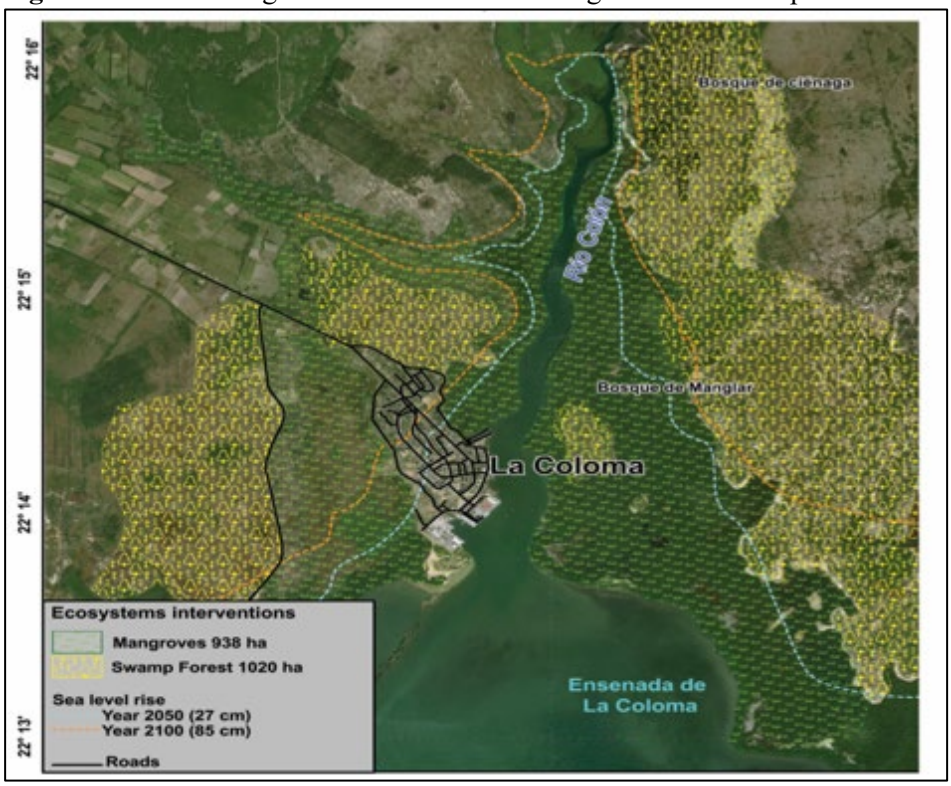
860. The land area that surrounds the communities includes 938 hectares of Mangroves and 1,020 hectares of swamp forests (see Figure 67 below). The marine zone is dominated by a system of keys that includes islands and islets that protect the interior coasts at least to the east of the area.

861. The rehabilitation proposal presented below includes a group of baseline actions being undertaken by the government in nearby areas, aimed at improving protection services of ecosystems

128 National Nomenclature of Human Settlements, Population and Housing Census, 2012. National Office of Statistics and Information of the Republic of Cuba, ONEI, 2017

in La Coloma. GCF resources will be invested in mangrove and swamp forest rehabilitation focusing entirely on the additionality of generating the conditions for coastal resilience.

Figure 84- Detail image with intervention in mangroves and swamp forest around La Coloma area.



862. The project will be focus on the following activities:

- Restore water flows to the coastal zone (drainage ditches, channeling, cleaning and maintenance of channels)
- Eliminate pressures on the coastal zone (landfill disposal, invasive alien species, pollution)
- Rehabilitate strips of red mangrove and other key dominant species of the forest, mostly red mangrove.
- Eradication of Invasive Alien Species (IAS).
- Monitor the impacts of interventions on water quality, the health of coastal wetlands, seagrasses and coral reefs.

863. The co-finance by the GoC will contribute to the effectiveness of the EBA investments implemented with the GCF resources will be implemented by INRH, CITMA and MINAG and will include the following complementary activities:

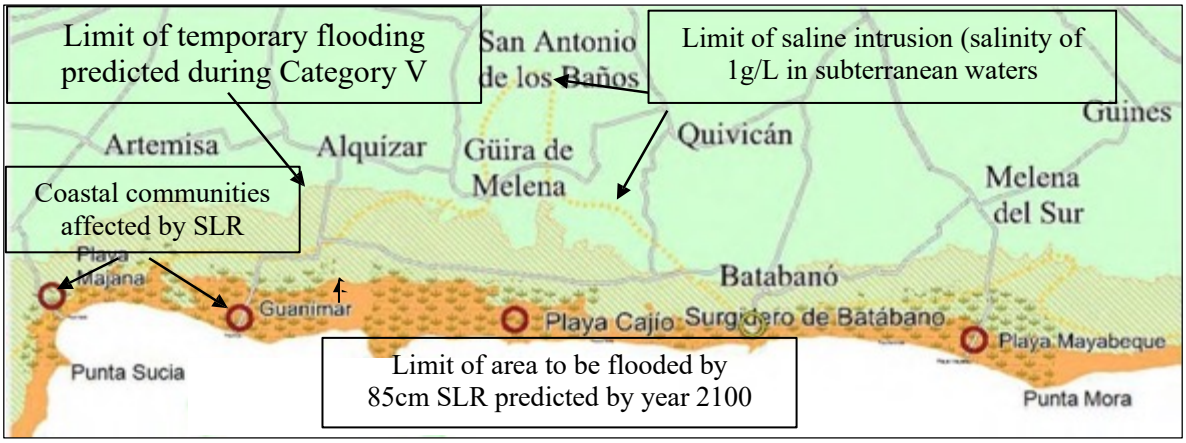
- Prevent overexploitation of aquifers and ensure the ecological flow of dams located north of the site
- Restore water flows upstream to the coastal zone (drainage ditches, channeling, cleaning and maintenance of canals, build speed bumps on roads and access roads)
- Eliminate and reduce pressures on the coastal zone (clean sewer ditches and solid waste, eliminate landfills, clean and maintain channels and drainage ditches).

Interventions in the El Cajio Subzone

864. Cajío area is located in the eastern region of the southern coast of Cuba, it is a particularly important area for the national economy because it represents the most important agricultural region. This area has very flat topography and is dominated by soils that combine alluvial and karstic soils with variable dominance by region, with limited surface water availability. This area is particularly subject to the problem of saline intrusion into its subterranean aquifers, which are typically located between 20 and 30m below sea level.

865. The area is also one of the main sources of drinking water for the city of Havana. The narrowness of the island in this area (which in places is little more than 30km wide) means that it is susceptible in almost it's entirely to water extraction issues (see Figure 68).

Figure 85- Areas to be affected by CC-related saline intrusion, temporary flooding during hurricanes and SLR.



Source: "Manglar Vivo" Prodoc Document

866. Playa del Cajío (Güira de Melena municipality, Artemisa province): This is an urban settlement with 196 households and a total population of 524 inhabitants. The full population has electric service (100%) and 62% have water systems. The community medical services include five medical offices and a pharmacy. It also has a school.

867. Its main economic activity is forestry for wood and charcoal production, with the municipality of Guira de Melena being the most important for the industry. Another source of revenue is the marketing and use of water and sludge with high sulfur and iodine which are sold for pharmaceutical purposes and for tourism and cosmetic treatments.

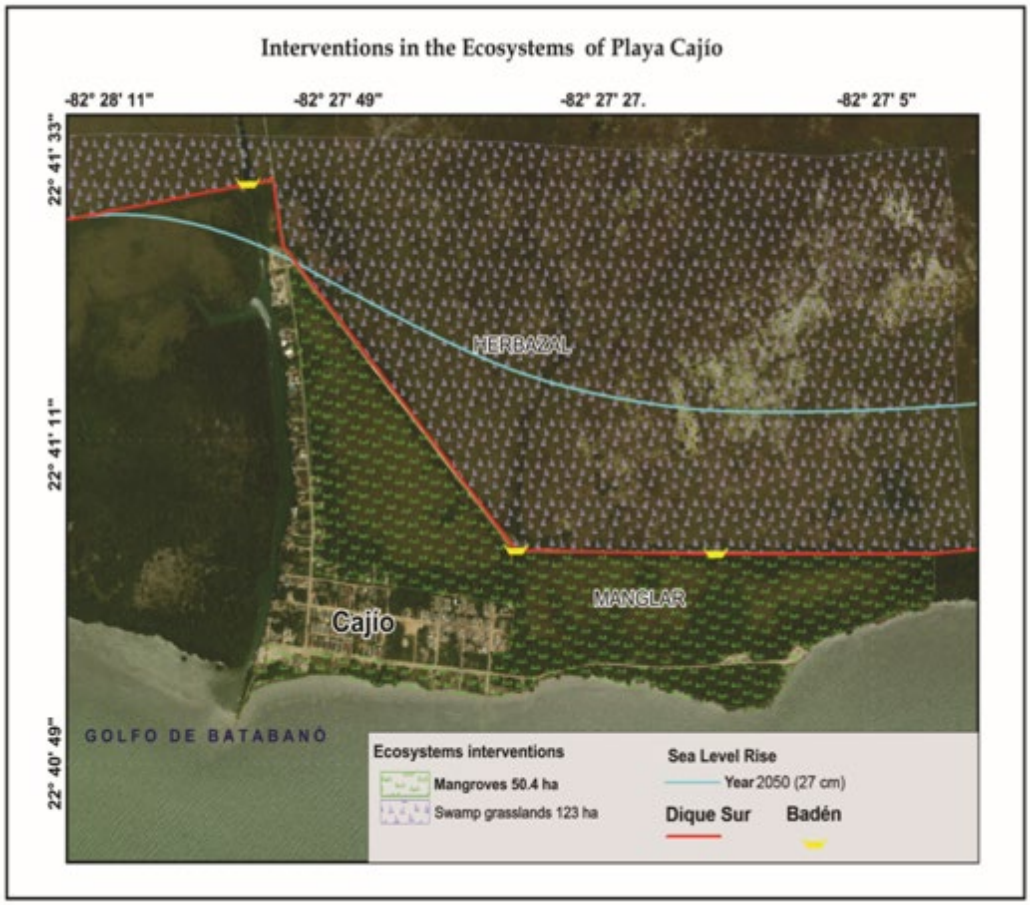
868. This area is also an important area for the finfish and lobster fisheries, as well as an important region for the production of charcoal through local forestry companies based on the extraction of exotic species such as almond *(Terminalia catappa)* and Australian pine *(Casuarina sp)*.

869. El Cajio is an excellent example of the negative impacts on the system of marine and coastal ecosystems due to the use of gray methods for containment of environmental threats. The presence of a coastal contention wall, as well as a gabion, at the mouth of the el Cajio Chanel in the community have brought erosion to the west. This has added to the existing problems for the mangroves causing rapid deterioration and a silty-sandy deposit to the north.

870. Other example is the presence of the South Dike, which resulted in dramatic changes in local hydrology, resulting in a considerable increase in salinity downstream, reduced freshwater flow into the mangroves and thus the loss of dominance red mangroves in the coastal strip. These changes resulted in the loss of the most effective species to prevent physical impacts of storms, hurricanes, "sures" winds and oceans or waves on the coast.

871. Because the Cajío is a flat lowland area with plains dominated by mangroves (50.4 hectares) and swamp grasslands (123 hectares) figure 60 below, it is quite sensitive to changes in hydrology. The region has the tendency to divert surface water that now does not drain to the wetlands and has reduced its structure and composition size, making it more sensitive to the effects of CC.

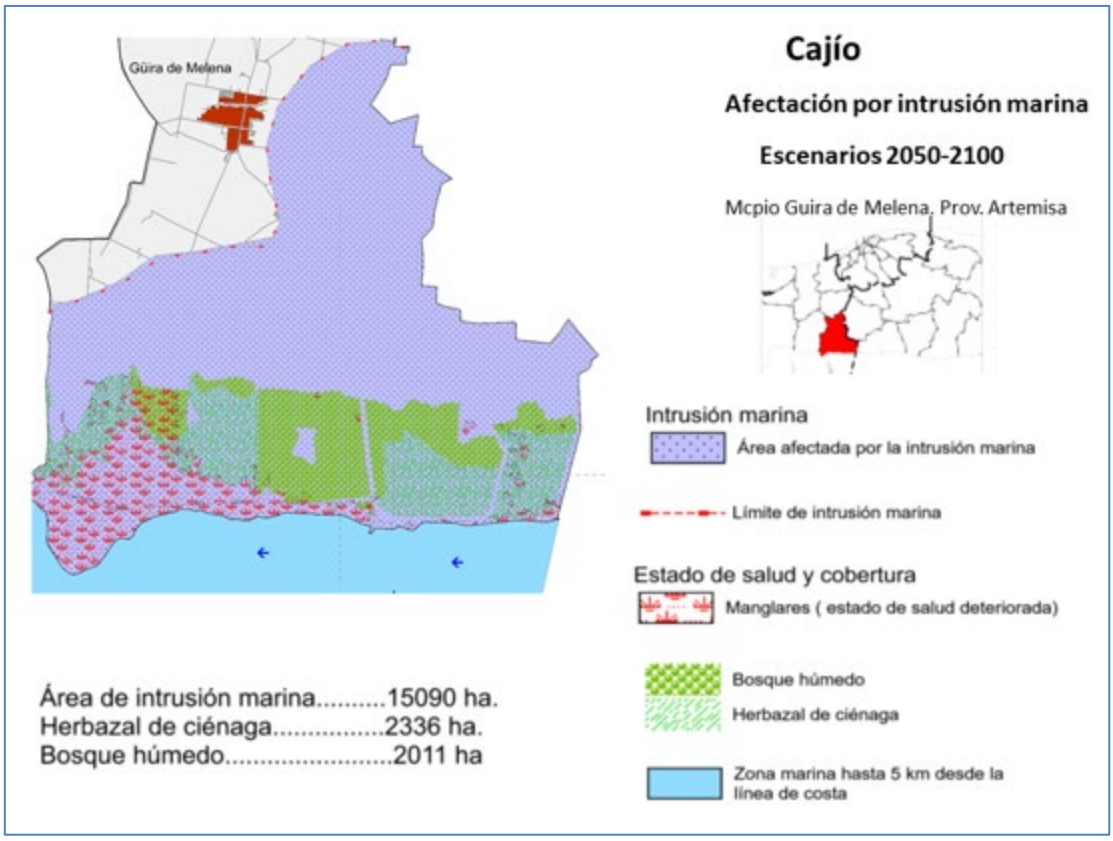
Figure 86- Expected impacts for the communities of the Cajio coast due to the sea level rise for the years 2050 and 2100.



872. The inherent vulnerability of the target areas to climate-related effects is reflected in, and exacerbated by, the high levels of degradation that have been suffered by their coastal ecosystems. Some of the highest levels of beach erosion in the country have occurred in this area: the beaches of Majana, Guanimar, Cajio, Mayabeque, Caimito, La Pepilla, Tasajera and Rosario were left completely without sand as a result of the erosive waves generated by Hurricanes Ike and Gustav in 2008. At La Pepilla beach, the coast is receding at a rate of up to 2m/year (Guerra et al. 2000). The mangroves of the area also have some of the lowest health index in the western region of the country (Iturralde y Serrano, 2015).

873. Figure 89 shows schematically how the communities of Cajio would be vulnerable to the levels of saline intrusion on the coasts, as well as the levels of flood by marine penetration in the 2050 and 2100 scenarios on the impacts of CC reported by Iturralde and Serrano (2015).

Figure 87- Wetland ecosystems on the Cajío coast and expected impact of saline intrusion for scenarios 2050 and 2100.



874. The issues described above makes this section an area highly sensitive and vulnerable to CC. The GEF project "Manglar Vivo" has worked on the rehabilitation of mangroves and mangrove swamps in the western part of this area. It is proposed that the GCF project invest in the rehabilitation of the eastern zone by applying EBA measures in the mangroves and in the swamps and swamp grasslands. The GCF project will collect data and monitor the entire area to verify the progress of rehabilitation and its effects, taking advantage of the initiatives of the "Manglar Vivo" Project and combining them with its own experiences.

875. The proposed interventions in this sub-zone of El Cajio include a series of measures to be implemented by the government of Cuba, as co-finance in support and strengthening to the EBA measures and the use of its climate and planning tools to improve the resilience of the on-site costs financed with GCF project resources.

876. The activities proposed in the GCF project include the rehabilitation of freshwater flow in coastal ecosystems with seasonal oscillations, facilitating the restoration of the laminar flow of water in ecosystems. Once the hydrology has been restored, actions will be required to rehabilitate the structure of the ecosystems, support the natural zoning of the mangrove on the coasts with clearings of black and white mangrove zones and favoring the establishment of red mangroves, mainly in areas with direct access to the waves. The elimination of exotic species both in the swamp grasslands and in the swamp forests will be some of the actions required for these sites. Below is a brief description of the proposed activities:

- Restore water flows to the coastal zone by means of drainage ditches, cleaning and maintenance of channels

- Rehabilitate and build speed bumps or steps through the South Dock in order to improve water flows to the coastal wetland
- Eliminate invasive alien species such as *casuarina*, almond, *leucaena* and marabou
- Rehabilitate strip of red mangrove and other species of the bog forest

877. Actions of various government sectors (National Institute of Hydraulic Resources, Ministry of Agriculture and Ministry of Science, Technology and Environment) will focus on the rehabilitation of coastal hydrology, through the reordering and maintenance of existing ditches and canals, eliminating micro-dumps in the coastal zone (Government of the municipality, Aqueduct and Sewerage Base Business Unit and Municipal Administration Council).

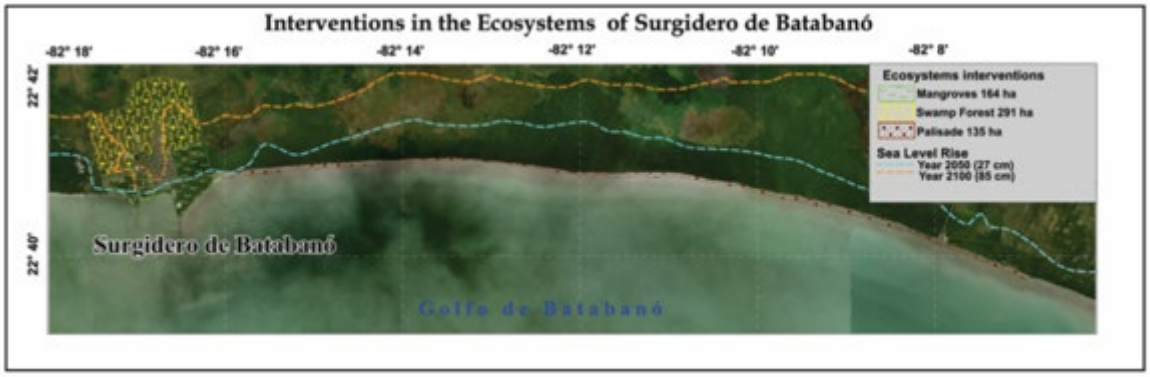
Interventions in the "Surgidero de Batabanó" Subzone

878. Surgidero de Batabanó (Batabanó municipality, Mayabeque province): It is a settlement qualified by ONEI as an urban area of third order (2000 to 4999 inhabitants). With 1,614 homes, a total population of 4,697 inhabitants. 99.7% have electric service, up to 98.8% have water management system and 50.4% have the sewerage system. They have five medical offices, a center for children, a pharmacy, 18 public telephone stations, 272 fixed residential lines. In addition, 27% of the streets are paved, 9% with gravel and the remaining 64% rustic.

879. The community has a fishing port with maritime links to Isla de la Juventud, one of the largest islands of the Cuban archipelago with great tourist attractions. Among the main fishery products are lobster and shrimp. It is a very important habitat for sea turtles and has a great diversity of sponges. It is the main port and fishing industry in the province of Mayabeque. Its economy is based on industry, with the fishing industry and the seafood processor that supplies the national market and also exports. There is also a Shipping company, a travel agency and a shipyard.

880. Surgidero of Batabanó is a very flat area, subject to heavy flooding and is mainly dominated by agricultural landscapes and livestock, as well as coastal wetlands. The remaining natural ecosystems located around the town and adjacent to the coast are mainly 164 hectares of mangroves and 291 hectares of swamp forest in very deteriorated condition **(**see Figure 71 below**).**

Figure 88- Batabanó intervention areas.



881. In Figure 71 in green is the area of mangrove rehabilitation and in yellows the swamp forest rehabilitation area. Note in this section of the coast there is no swamp grassland. In the right side of the image is the construction of a palisade to promote the development of the red mangrove rehabilitation.

882. The project will focus the EBA activities in the following actions:

- ✓ Restore water flows to the coastal zone (drainage ditches, channeling, cleaning and maintenance of channels)
- ✓ Eliminate pressures on the coastal zone (landfill disposal, invasive alien species, pollution)
- ✓ Rehabilitate strip of red mangrove and other species of the swamp forest.
- ✓ Construction of a fence "estaquillado" near the coast that contains the sediments and minimize their transfer due to the effect of waves and wind. This will facilitate the development and recovery of the red mangrove strip

883. The GoC (INRH, CITMA, MINAG) will focus on complementary activities as part of the co-finance like rehabilitation of water flows to the coastal area (drainage ditches, channeling, cleaning and maintenance of channels, build speed bumps on roads and access roads, ensuring the ecological flow of the dams located north of the site. As well as, eliminate and/or reduce pressures on the coastal zone (clean 14 km of sewer ditches and solid waste eliminate landfills, clean and maintain channels and drainage ditches.

Stretch II: From Júcaro to Manzanillo, on the southeastern coast

884. As Stretch I, this area consists of a wide shelf fringed by a string of cays and coral reefs which separate it from the open ocean; its coastline is dominated by low-lying and swampy coastal areas, with many mangroves, and coastal wetlands associated with coastal lagoons, numerous sandy beaches, seagrass beds and coral reefs, together with many human settlements. Its cays contain many species of importance for the fisheries sector.

885. As part of the project design process, three investment sites (subzones) were identified in stretch II, these were as follows; (1) Júcaro, (2) Playa Florida, (3) Santa Cruz del Sur and (4) Manzanillo. These will be described in more detail in the section entitled Project Intervention Areas.

Interventions in Jucaro

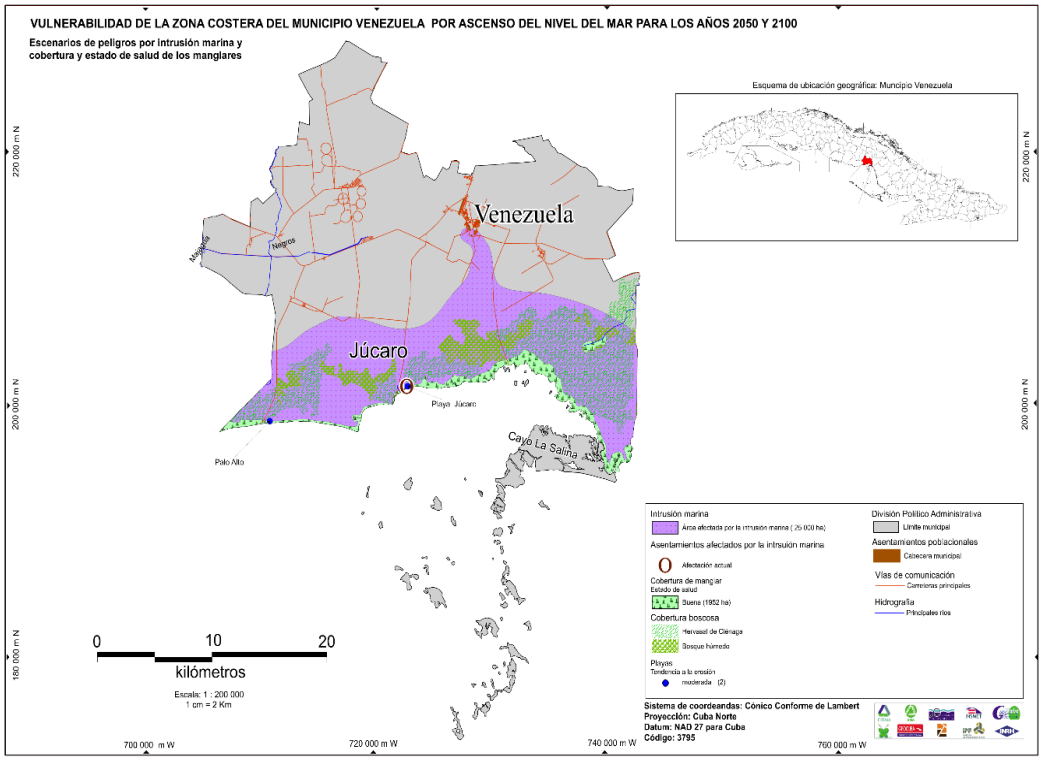
886. **Júcaro (municipality Venezuela, Ciego de Ávila province):** it is a human settlement that corresponds to the category of first order town (1,000 to 1,999 inhabitants), urban, which has 566 houses, a total population of 1,581 inhabitants. It is estimated that the available services for the population of this stretch include electrification services for approximately 98.9% and systems for water supply approximately for 95.4% health services include 3 offices for medical services, 1 pharmacy, they also have 1 primary school, and 1 post office.

887. El Jucaro, is part of "La Trocha" and it is constituted by a geological mount formed by limestone rocks of the Miocene. The limestone rocks that form the subsoil are very similar to those of the Havana-Matanzas Plain and form large, very cracked and fractured banks. Despite the rapid absorption of water by the cracks of limestone rocks, which produces a very active underground drainage, in this area there are many more rivers than in the Havana-Matanzas karst plain.

888. The main port of this area is Júcaro, through which a large amount of sugar was exported. Due to the shallowness of the place the sugar was extracted in barges and then transported to cargo ships anchored offshore. At the beginning of the century, the area was almost uninhabited until the clearing of large areas of forest for the cultivation of sugarcane began, mainly during 1906 until 1919. At present, the area no longer relies on sugar exports (none are present) and the population of Júcaro, of about 3000 inhabitants, depends mainly on fishing and on ecological tourism that takes place in the waters of Los Jardines de la Reina (Figure 72, below).

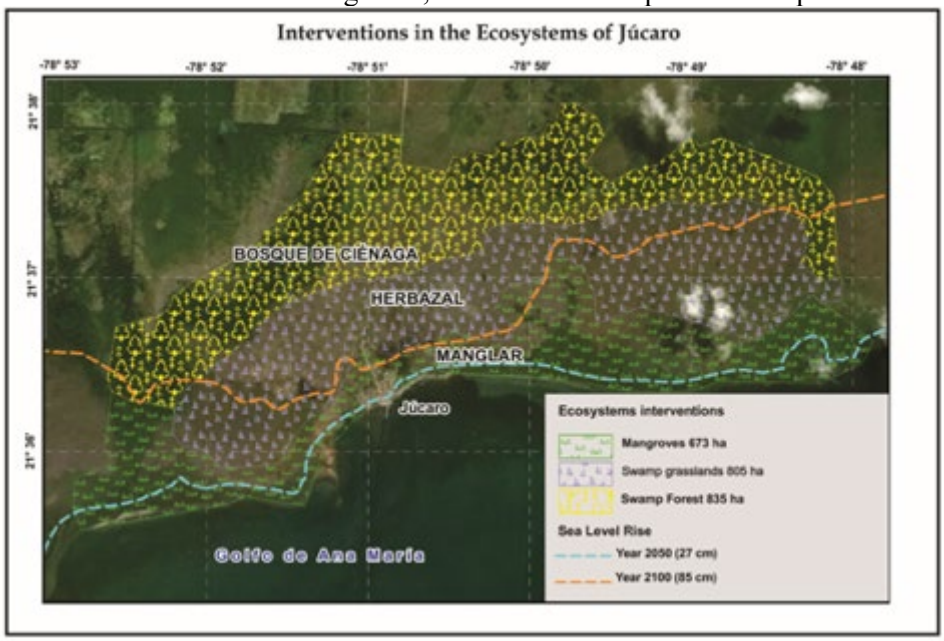
889. This section is located in the buffer zone of the Cayo de Ana María Wildlife Refuge and the Jardines de la Reina National Park area, and as such has a high ecological value. It is the closest human settlement to these protected natural areas.

Figure 89- Vulnerability and general characteristics of the sub-sector Stretch II.



890. The intervention area in which Jucaro is located is an ecosystem dominated on the coastal edge by Mangroves with 673 hectares, followed by an 805 hectare herbaceous swamp, which is bordered by 835 hectares of swamp forests forming a functional ecosystem, the Jucaro perched between the coast and these wetlands is highly sensitive to the direct and indirect impacts of CC (see figures 91 and 92).

Figure 90- Rehabilitation areas of mangroves, herbaceous swamps and swamps forest in Júcaro



891. The settlement of Júcaro is located within the South Ciego de Ávila geological basin, which has a direct relationship with the sea, so the freshwater-salt interface line moves in correspondence with the behavior of several factors among which are:

- High exploitation of wells along the areas near the coast that causes significant decreases in the levels of the aquifer and favors soil salinization.
- Clearing of a high percent of the mangrove that make up the wetlands in the coast lines, which causes the aquifers linked to them to be more vulnerable to the processes of saline intrusion.
- The coastal zone of Júcaro has been widely altered by different human interventions. The following images show how a road parallel to the coast has acted as a dam that impedes the natural flow of the waters (Figure 92 above) and how the shoreline has receded leaving only some isolated mangrove trees.
- Penetration of saline wedge flows inland, putting the health of the population at risk and the possibilities for agribusiness and aquaculture activities in the area.
- The community was built in what was once a mangrove area, without any protection from the sea, producing a high risk of surges, hurricanes and storms, as well as the impact of marine invasion, saline intrusion and flooding.

892. The land area has characteristic ecosystems that surround the communities that include 673 hectares of Mangroves, 805 hectares of swamp grasslands and 835 hectares of swamp forests.

Figure 91- Road and infrastructure in front to the sea, built on areas of mangrove with serious danger

Figure 92- Loss of mangroves in Júcaro coast and isolated samples of black mangrove *Avicennia sp*.

893. The rehabilitation proposal presented below includes a group of actions, which will be undertaken by the government, aimed at improving the supply of water to the coastal zone and recharging the aquifers to prevent saline intrusion. The Hydraulic Utilization Company of Ciego de Ávila, for example, manages a total of 90 systematic observation wells, of which 15 are measured monthly and constitute the information network that is used for the hydrological bulletin of the province. All this information that will be used as a baseline to evaluate the impacts of the actions of rehabilitation and planting of mangroves.

894. In the area of Susana-Júcaro-Venezuela there are a total of 26 wells, which recharge part of the surface runoff that is caused in the area during the wet periods and a volume that will be allocated annually for the balance of the Zaza-Ciego canal, all this will contribute to elevate the loads of fresh water to the groundwater level in the territory and therefore avoid the phenomenon of saline intrusion.

895. The main interventions in the area of the Júcaro Village are based on the rehabilitation of the wetlands; recovery of mangroves profiles in the coast, rehabilitation of grassland swamps and rehabilitation of swamp forest, around the main population and the monitoring of the salt intrusion.

- Main area of the intervention: 673 Ha of mangrove (Figure 92 above).
- 805 hectares of Swamp grasslands rehabilitated.
- 835 hectares of swamp Forests rehabilitated
- Monitoring of saline intrusion and testing of wells established by the government.

896. Project interventions will focus on the following activities;

- Restore water flows to the coastal area by eliminating the section of road that runs parallel to the coast
- Rehabilitate 673 Ha of mangrove forests
- Monitor water quality in 29 bathometric wells
- Evaluate the effectiveness of aquifer recharge using 4 limnigraphs

- Monitor the impacts of interventions on water quality, the health of coastal wetlands, seagrasses and coral reefs. The Monitoring Program is attached
- Eliminate pressures on the coastal zone (elimination of landfills, invasive alien species, pollution)

897. Complementary actions to be financed by the government of Cuba will contribute to the effectiveness of the EBA investments implemented with the GCF resources. These include the following actions:

- Reactivation of the system of natural drainages, for its sanitation, with actions of structural and functional maintenance such as cleaning of sediments and other obstructive materials, with the participation of community actors, the Júcaro Popular Council, the Agroforestry Unit of Venezuela and Unit del National Institute of Hydraulic Resources.
- Eliminate pressures on the coastal zone (elimination of landfills, invasive alien species, and pollution.

Interventions in Playa Florida

898. **Playa Florida (Florida municipality, Camagüey province):** is a human settlement that is typically urban which has 329 homes and a total population of 467 inhabitants. It has electric services for approximately 100% of the population and the water supply system reaches approximately 94.4% of its population. Health and educational services include 1 medical office, 1 pharmacy, 1 primary school. Community counts with 1 post office, 3 public telephone stations, in addition, it owned 100% of the paved streets.

899. The main interventions in the area of the Playa Florida village are based on the rehabilitation of the wetlands; recovery of mangroves profiles in the coast, rehabilitation of grassland swamps and rehabilitation of swamp forest, around the main population and the monitoring of the salt intrusion.

- Main area of the intervention: 1760 Ha of mangrove (Figure 95 below).
- 316 Ha of swamp Forests.

Figure 93- Rehabilitation areas of mangroves, herbaceous swamps and swamps forest in Playa Florida

Interventions in Santa Cruz del Sur

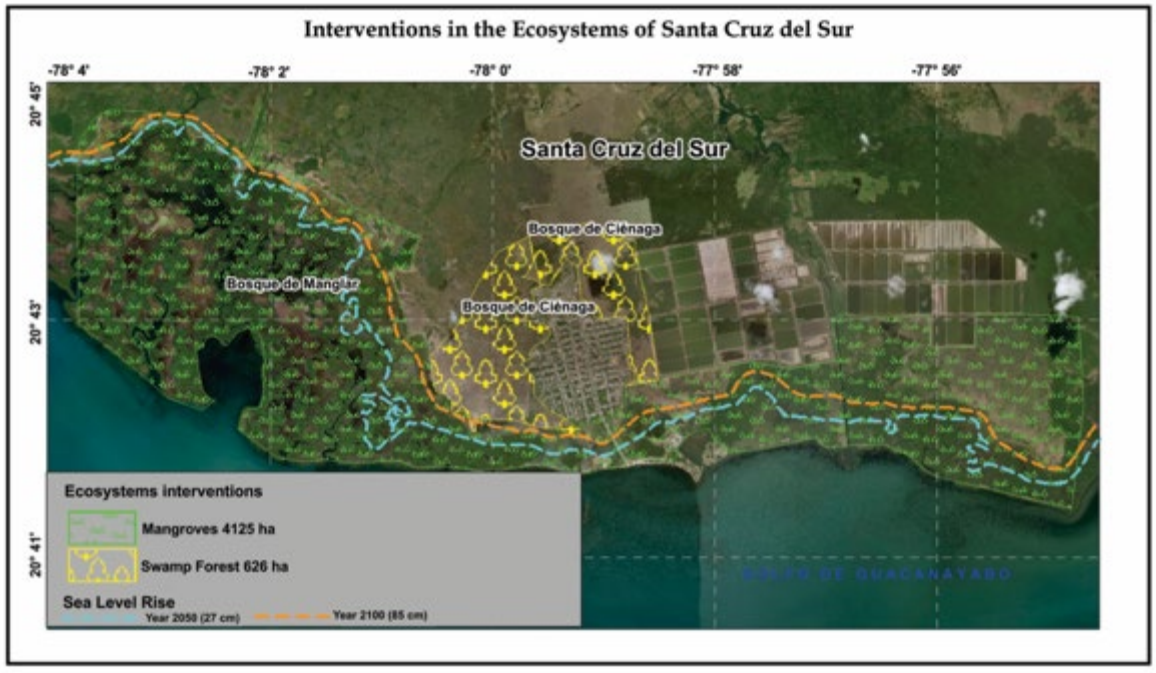
900. **Santa Cruz del Sur (Santa Cruz municipality, Camagüey province):** is a human settlement that corresponds to the category of town of first order (10,000 to 19,999 inhabitants), typically urban, which has 5,731 homes, a total population of 16 569 inhabitants. It has electric services for approximately 99.5% of the population and the water supply system reaches approximately 98.5% of its population. In health and education, they have 1 hospital, 1 polyclinic, 12 medical offices, 3 pharmacies, 1 maternal home, 1 grandparent house, 1 children's preschooler school, 5 primary schools, 1 secondary school, 1 technical and vocational school, 1 pre-university, 1 special education center, 1 university headquarters (belonging to the University of Camagüey). Community counts with 1 cemetery, 1 post office, 108 public telephone stations, 2685 residential landlines, 2 Internet browsing rooms. In addition, it owned 95% of the paved streets and 5% with gravel.

901. In the local economy, the agro-industrial sector is based on three economic activities: the sugar cane industry, fisheries and agriculture.

902. The main interventions in the area of Santa Cruz Village (Figure 96) are based on the rehabilitation of the wetlands; recovery of mangroves profiles in the coast and rehabilitation of swamp forest, around the main population and the monitoring of the salt intrusion.

903. Main areas of the intervention include 4,125 Ha of mangrove and 626 Ha of swamp Forests (Figure 96 below).

Figure 94- Rehabilitation of mangroves and swamps forest in Santa Cruz del Sur.



Interventions in Manzanillo

904. **Manzanillo (Manzanillo municipality, Granma province):** is a human settlement categorized as a second-order city (50,000 to 99,999 inhabitants), which has 32,618 homes, a total population of 98,904 inhabitants. In terms of services, 97.1% have access to electrification and approximately 95.7% to aqueduct systems. It also has 4 hospitals, 4 polyclinics, 87 medical offices, 1 maternity home, 1 nursing home, 2 grandparents' homes, 9 nurseries, 24 primary schools, 9 secondary schools, 4 technical and vocational schools, 4 pre-university centers, 6 centers of special education, 1

cemetery, 17 pharmacies, 3 post offices, 1 public telephone station, 7306 residential landlines. In addition, it owned 75% of the streets paved and 15% with layout and 10% rustic.

905. It bases its economy on small industries, textile confection workshops and a shipyard. Among the main physical productions are: shrimp, fish, preserves, accumulators, footwear, clothing and sugar.

906. The main interventions in the area of Manzanillo Village are based on the rehabilitation of mangroves profiles in the coast, around the main population and the monitoring of the salt intrusion. The main area of intervention has mangrove 3, 582 shown in Figure 97 below.

Figure 95- Rehabilitation areas of mangroves in Manzanillo area.

Annex II: Map of Project Intervention Areas