Sustainable livelihoods in Cuba's coastal zones: The challenge of achieving climate resilience in tourism, energy, fisheries, agriculture, and communities

Technical Report

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Finding the ways that work

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ABOUT RISDOC

Formed in 2016, the **Research Initiative for the Sustainable Development of *Cuba*** (RISDoC) is a coalition of academics, Cuban and international civil society associations, and representatives of international agencies interested in exchanging experiences on sustainability and climate resilience in Cuba. The core coordinators of this process, i.e., Caribbean Studies Program [Cátedra del Caribe] of the University of Havana, the Antonio Núñez Jiménez Foundation of Nature and Mankind [Fundación Antonio Núñez Jiménez de la Naturaleza y el Hombre-FANJNH], the United Nations Development Program, the Cuban Economy Studies Center [Centro de Estudios de la Economía Cubana], Environmental Defense Fund, and Caribbean Agroecology Institute, hope that this initiative encourages exchanges among specialists of diverse Cuban sectors interested in developing sustainable practices within a global low-carbon economy and in accordance with the national guidelines of sustainable development and climate resilience. The three main objectives of RISDoC are:

1. Create learning opportunities for the academic community, representatives of ministerial agencies, local governments, companies, associations, and the self-employed in Cuba on issues related to the development of sustainable models.
2. Promote opportunities for learning and discussion on sustainable development in Cuba with international actors.
3. Exchange, document, and disseminate knowledge on sustainability issues in Cuba.

Cover photo: Playa Florida, by *Noel López Fernández*

Editorial Committee:

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FOREWORD

SUSTAINABLE LIVELIHOODS IN CUBAN COASTAL AREAS:

THE CHALLENGE OF ACHIEVING CLIMATE RESILIENCE IN TOURISM, ENERGY, FISHERIES, AGRICULTURE, AND COMMUNITIES

Sustainability in Cuba is one of the Cuban government's greatest challenges. In a scenario of global climate change and environmental degradation, daily practices continue to deepen problems such as water scarcity and quality, loss of land and sea biodiversity, pollution and urban growth, food security, among many others, which means we need to ensure that our population is prepared with the knowledge and tools necessary to find viable solutions in the short and medium term. Although advances in science and information and communication technologies mean that we can almost instantaneously obtain up-to-date information about our planet, these breakthroughs have not been used sufficiently to promote environmental awareness or to solve the problems that threaten our survival as human beings. Thus, we need to reflect on the way we live, design, and distribute the spaces we inhabit. We should understand that environmental unsustainability generally begins in our own homes, appearing in our daily habits without our realizing the environmental damage we cause. Therefore, we need to fundamentally change our own consciences, based on a conceptual reevaluation of our habitats, in order to design them in a way conducive to promoting sustainable livelihoods.

We should acknowledge that comprehensive analyses are available regarding the environmental problems that affect us today and the measures that should be adopted for their mitigation or solution. Environmental protection is a citizen's duty. Therefore, guaranteeing access to knowledge and information is an important objective established by Cuba's Environmental Law 81.

This document contains a large amount of useful information, the relevance of which stems from the cooperation of a large group of scientists from different Cuban organizations and institutions who worked together to prepare it, coordinated by the Antonio Núñez Jiménez Foundation of Nature and Mankind.

We are pleased to make available to decision makers, professionals, teachers, communicators, students, and the general population greater information about how our country works to move forward, to increase protection and care for the environment, while achieving sustainable socioeconomic development.

This is the spirit of the articles and topics that are grouped thematically in this technical report.

The authors herein discuss recently observed climate changes, specifically the increase in annual average temperature, affected by an increase in minimum temperature, a decrease in cloud cover, more intense and prolonged droughts, increased precipitation, and a greater anticyclonic influence. These climatic changes will have a clear impact on Cuba's ecosystems, productive sectors, and coastal communities.

The authors have different perspectives on environmental concerns derived from health problems in ecological connectivity processes, which are essential to ensure healthy and productive ecosystems. Their concerns are a clarion call for building resilience in coastal

communities and developing a new vision in the management and conservation of biodiversity resources on which the livelihood of coastal populations depends.

One of the analyses here warns us of the harmful impacts on ecosystems caused by anthropogenic factors such as overfishing, inadequate waste disposal, mechanical damage, and rising sea temperatures. In addition, there are impacts caused by extreme and increasing hydrometeorological events.

Issues such as tourism, energy, sustainable agriculture and fisheries are current opportunities and challenges for resilience and sustainability in Cuba's coastal communities and are clearly revealed and discussed by their authors.

Also worth recognizing is the work done by the Institute of Meteorology, one of our distinguished institutions, which has worked for more than 30 years with the Pedro Kourí Institute of Tropical Medicine and the National Institute of Hygiene, Epidemiology, and Microbiology, obtaining scientific evidence of morbidity of various diseases attributable to climate variability and climate change.

The report includes an overview of the national land management scheme in force until 2030, which includes 21 territorial development policies and 75 decisions, including those related to disaster risk reduction and adaptation to climate change. The above is in line with the political will of the Cuban government to address the strategic areas of the National Development Plan to 2030.

One author examines terrestrial waters as an integrating topic of the hydrographic basin, which fulfill an essential role in connecting coastal ecosystems and how they work in their multiple and complex links with economy and society.

The report places importance on social and human aspects by referencing communities' aspirations to participate in self-management and self-development with environmental sustainability. Thus, social and environmental safeguards, through the public consultation process, are a way to minimize, mitigate, and manage adverse impacts when it is not possible to avoid them.

Losses of property and human life resulting from extreme hydrometeorological events must be reduced. This can be done by implementing climate change adaptation and mitigation measures outlined in national adaptation and mitigation plans that include measures aimed at disaster risk reduction and climate change adaptation. Increased knowledge of risks and actions aimed at building back better will strengthen the Sendai Framework (2015-2030) to achieve sustainable development and resilience of communities and ecosystems. All these factors can help us to better understand the importance of hazard, vulnerability and risk (HVR) studies, which systematize existing theoretical and practical knowledge to inform decision making regarding disaster and climate risk reduction at the governmental, sectoral, and institutional levels and at the national and local levels, so as to make us less vulnerable.

For the Environment Agency it is an honor to prologue this report which, we hope, will be a source of encouragement and guidance to find the creative and innovative solutions we need to reestablish a balance between nature and culture in Cuba, and act as inspiration and sustenance of our future as a nation.

Dr.C. Maritza García García

President of CITMA's Environment Agency (AMA)

INTRODUCTORY WORDS

Since its inception in 2016, RISDoC has promoted opportunities for exchange and learning, convening various actors from Cuba and the region, lowering sectoral and discipline barriers in order to connect the different areas of our complex socio-ecological system and thus strengthen climate resilience. The pandemic caused by COVID-19 forced us to look for other ways to create these opportunities; in this vein, we put together this technical report, which allowed us to exchange information at a distance. The RISDoC coordinating committee identified the complex issue of resilience in coastal zones as a focus for this report and the 4th RISDoC symposium to be held in Havana in April 2022. As the climate crisis intensifies, the urgency to respond becomes even more critical.

This report highlights the importance of both *multidisciplinarity* and *transdisciplinarity*, whereby diverse academic disciplines come together with other forms of knowledge, such as that of communities, to jointly address socio-ecological problems. In line with the key messages that came out of the 3rd RISDoC on local agri-food systems, this report also emphasizes that technologies alone are insufficient solutions; new forms of coordination, participatory and local governance, adaptive management models, and comprehensive methodologies based on complex systems are required. We need new circular and solidarity-based economic methods, plus political and legal frameworks that support needed shifts towards resilient socioecological systems, so as to ensure the health of our ecosystems, economies, and lives. It is an honor to be able to participate in this initiative and to continue learning, struggling, and dreaming together of another world.

Margarita Fernández
Caribbean Agroecology Institute

Since its inception, the Research Initiative for the Sustainable Development of Cuba (RISDoC) has advanced social, economic and environmental sustainability through learning exchanges and a sustained dialogue among a wide variety of actors in the governmental, non-governmental, private and academic sectors. It has broken down artificial barriers and formed enduring friendships across sectors and borders that have led to fresh thinking and new collaborations. While its principal focus has been on sustainable development in Cuba, RISDoC has provided practical lessons in sustainability that can be put into practice not only in Cuba, but throughout the Caribbean and the world. For example, Cuba's own policies and programs on climate change and coastal resilience, many of which are examined in this report, provide particularly relevant and timely guidance to its neighbors in the Caribbean, all of whom are together on the frontline of climate change. So too are Cubans eager to learn from the experiences of others. Addressing the urgent challenges of climate change can only be achieved through vision, innovation, optimism, and partnerships, all of which are embodied in RISDoC. I am honored to be a part of this initiative and look forward to what we will continue to accomplish together.

Daniel Whittle
Environmental Defense Fund

When we joined forces with various organizations to create the *Research Initiative on Sustainable Development in Cuba* (RISDoC), we took it on in the understanding that the Antonio Núñez Jiménez Foundation projects a strong institutional commitment, covering all our perspectives and areas of work to give continuity to the far-reaching project of our founder Antonio Núñez Jiménez, so that Cuba and our Caribbean region can help promote a Culture of Nature.

This ideal of achieving a society with a high level of environmental awareness is a very complex and difficult process in which objective and subjective factors intervene. There is nothing more difficult than changing the mentality of human beings when we carry incompatible patterns of thought, behavior, production, and consumption that have been ingrained for decades.

Another great challenge, after harmonizing our intentions, is to translate the best ideas of sustainability into a practice that balances social, cultural, environmental, and economic advances. This should lead to tangible results for community well-being and contribute to forging a nation that lives in harmony with its ecosystems.

Núñez understood that all this is possible only if there are efforts to coordinate science and culture, action and research, science and community, locally and nationally, while promoting values for regional and multilateral integration.

Hopefully, the knowledge we try to weave together in each phase of RISDoC contributes to these efforts. We seek to adapt sustainability issues to the national and global context, while using this research initiative as an extraordinarily valuable venue for consultation, which we hope will continue.

Our mission to promote a culture of nature with the purpose of harmonizing society and its environment is enriched with the tools of this process. On behalf of the entire team of our Foundation, we thank all the individual and institutional actors who now accompany us in this new endeavor of RISDoC. We are proud to have been part of its birth and continuity.

Liliana Núñez Velis
Antonio Núñez Jiménez Foundation for Nature and Humanity

EXECUTIVE OVERVIEW

The Caribbean is one of the world's most vulnerable regions to the impacts of climate change. Rising sea levels, ocean acidification, increased ambient temperatures, more frequent and more intense hurricanes and storms are affecting coastal and marine ecosystems, threatening communities, livelihoods, and economic sectors that depend on these ecosystems. Building socio-ecological resilience in these areas is critical to the survival of our communities. Cuba has taken important steps to respond to the impacts of the climate crisis and build resilience within a complex context of monetary reform, an economic crisis deepened by the impact of COVID-19, and the consequences of the prolonged U.S. economic and financial blockade, which has intensified in recent years. Given the importance of this topic, the RISDoC committee has compiled this technical report to bring together diverse contributions from prominent Cuban authors covering climate resilience and sustainable livelihoods for Cuba's coastal communities and ecosystems.

The report is divided into five sections: **1.** Background and context; **2.** Legal framework and state plans for Cuba's coastal zone; **3.** Challenges and opportunities for Cuba's coastal communities: economic sectors and ecosystemic social services; **4.** Selection of relevant projects for Cuba's coastal zone; and **5.** Experiences from the Greater Caribbean region. Representatives of ministries, research institutes, civil society associations, and international organizations authored the 32 articles included herein. Below we summarize these five sections.

Background and context

This section contains three articles that discuss the background and context of resilience in coastal zones with insights into social, economic, political, and ecological issues. They provide evidence of the socio-ecological importance of marine and coastal ecosystems, with details on negative climatic and anthropogenic impacts, while proposing solutions to restore, protect, and establish resilient, regenerative, and sustainable socio-ecological systems.

The aforementioned impacts of climate change are increasingly evident in Cuba: more intense and prolonged droughts, an increase in the average annual temperature, precipitation greater than 50 mm, and, nationally, a significant reduction in water availability. The Nationally Determined Contribution report for Cuba, updated in 2020, stated that the Cuban climate is transitioning from tropical humid to tropical dry, with average temperatures above 30^{o} C, approximately 1000 mm of average annual rainfall, and 70 days with rain. Specifically, coastal areas are experiencing a receding coastline, increased erosion, and saltwater intrusion. Studies indicate that permanent flooding in coastal areas may reach 2416 km^2 (2.24 % of the territory) by 2050; and 5645 km^2 (5.33 % of the territory) by 2100.

Ecosystems that predominate in coastal zones, such as coral reefs, mangroves, seagrasses, sandy beaches, rocky shores, and mud bottoms, play an important role in buffering the impacts of climate change. For example, mangroves and seagrasses cushion the impacts of waves and hurricanes, protecting coastal communities. Cuba has the largest extensions of mangroves and coral reefs in the Greater Antilles that are essential for regional sustainability.

The biodiversity of these ecosystems provides invaluable environmental services, such as tourism and fisheries, that support some of the most important economic sectors for coastal communities or even entire island nations. These economic sectors would not be possible without the coral reefs, mangroves, and seagrasses that support biodiversity and generate tourist attractions. At the same time, however, the marine and coastal ecosystems of Cuba and the Caribbean are experiencing accelerated degradation due to pressure from overfishing, pollution, inappropriate coastal development, tourism overload, destruction of key habitats, and the introduction of invasive alien species. These factors generate a positive feedback loop with climate change because they contribute to the accelerated loss of the natural capacity of ecosystems to withstand these threats and recover from impacts.

Thus, Cuba's marine-coastal ecosystems are not only of great value for the livelihood and resilience of the country's coastal communities, they also have an essential regional role because the richness of the Cuban shelf and its adjacent waters are closely connected to those of the rest of the Greater Antilles and beyond. This superb ecological role of regional connectivity entails a responsibility involving the sustainable management of our marine biotic resources that goes beyond national interests and borders. Alternatives such as co-management and ecotourism (whereby local communities make sustainable use of their resources while benefiting economically from them, undertaking evaluations, and implementing solution of environmental problems, among other actions), raise the capacity for resilience and inform the design of management measures that contribute to restoring the natural processes that have been affected.

Several articles here point out the importance of a holistic and comprehensive view when analyzing hazards and searching for solutions. An important point is that all activities that occur at higher elevations ultimately have some impact on the coastal zone. Because the main island is long and narrow, all of Cuba could be considered a large coastal zone, divided into a northern and southern zone by mountain ranges which cross it almost completely from east to west, cutting the main island in half. Thus, very few Cubans live more than 50 kilometers from the coast and none live more than 95 kilometers away in the widest part of Cuba.

Given this island-wide connectivity, and the need for a holistic and comprehensive approach, the concept of resilience guides many of the analyses, methodologies, and programs highlighted in this report. The concept of resilience is used in different disciplines with a diversity of definitions. For our purposes here, resilience is defined as the capacity of a socioecological system (household, community, ecosystem, etc.) to absorb disturbances and reorganize itself to be functional, evolve, and transform through learning and adaptation. Strengthening the climate resilience of communities therefore requires a holistic approach that takes into consideration not only human factors and direct relationships with the hazards they face, but that adequately values socio-ecological interactions and the role of nature in building resilience, and that safeguards the limits it imposes on us. Resilience is an essential framework for disaster risk management and local development management.

One of the greatest challenges for integrated coastal zone management is to attain the socio-environmental resilience of people within this important ecosystem. Addressing this challenge assumes that communities will integrate as active participants in monitoring the

benefits and management of ecosystems and associate them to their lives and livelihoods. This means that people are active subjects in the management of sustainable development in these local and community scenarios. This requires training and education to be able to participate, the coordination of sectoral networks, multi-stakeholder and multidisciplinary platforms that take into account social, environmental, and gender equity safeguards, and the process of public consultation.

Legal framework and state plans for Cuba's coastal zone

Cuba has developed a relatively strong legal and environmental policy framework for the conservation and sustainable use of marine and coastal resources, which offers many opportunities to strengthen the resilience of coastal communities. Notably, Cuba has developed a national and cross-sectoral State Plan to address climate change, called *Tarea Vida* in Spanish, or Project Life, which fills many of the gaps that exist in other instruments. Cuba is also implementing a National Program for Economic and Social Development to 2030 that is committed to an environmentally, socially, and economically sustainable future. This section of the report includes contributions detailing the progress of *Project Life,* strategies for disaster preparedness and risk reduction, relocation of settlements, information on draft Legislation for the System of Natural Resources and the Environment, the new Food Sovereignty and Nutritional Education Plan, and the Plan to Counter Wildlife Crime. Here we provide a brief summary of each.

To address the impacts of climate change on Cuba's ecosystems, productive sectors, and coastal communities, the Cuban government has adopted the New Urban Agenda and the State Plan to Confront Climate Change, *Life Task*, i.e., instruments that target the coastal zone and whose priority is reducing the exposure of human settlements to risks, increase resilience, and adopt nature-based solutions, aiming to promote resilient, sustainable, safe, and prosperous human settlements, adapted to climate change, and low in emissions.

Life Task incorporates the strategic importance of the goods and services provided by coastal resources and ecosystems for key sectors of the economy such as agriculture, fisheries, tourism (e.g. beaches, corals, protection of freshwater resources, among others). For the current strategic cycle (2021 - 2025), efforts are being made to extend the scope of *Life Task* to the entire economic and social life of the country.

Cuba's current economic, social, and environmental conditions demand a legal framework consistent with the new policies, which is why it is pertinent to update Law 81 in the Preliminary Law of the Natural Resources and Environment System. The Preliminary bill helps implement the Bases of the Economic and Social Development Plan to "2030", in a way that reflects the integration of multiple policies linked to natural resources and environmental quality, strengthen the role of CITMA as the lead governing body, and incorporates the crime of environmental damage into the system of civil and criminal liability, among other purposes. New elements are about to be incorporated as a result of specialized and public consultations. The update of this law includes a chapter dedicated to "Marine and Coastal Waters and Ecosystems".

The priority of the Spatial Planning System has aimed mainly at anticipating the expected impacts of climate change on coastal human settlements that will be totally or partially affected by the rise in mean sea level; options will be made available to the

corresponding governments and Central State Administration Bodies (Órganos de la Administración Central del Estado-OACE) for relocation of permanent residents' homes in coastal areas that will be flooded and exposed to a greater extent to the impact of current and future hydrometeorological phenomena, due to flooding from rainfall, seawater penetration through upwelling, saline wedge incursions, and coastline erosion. *Life Task* has delegated two strategic actions to the National Institute of Territorial and Urban Planning (Instituto Nacional de Ordenamiento Territorial y Urbano-OTU): planning the urban reorganization of threatened settlements and infrastructure within the established timeframe, and withholding approval of new housing construction in threatened coastal settlements where structures are predicted to disappear due to permanent flooding. If relocation is required, sufficient infrastructure must be present, for example, roads that connect the new settlement with its sources of livelihood, such as the boathouse, the fishing port, etc.

Cuba's Food Sovereignty and Nutrition Education Plan (Plan de Soberanía Alimentaria y Educación Nutricional de Cuba- Plan SAN) seeks to strengthen the country's food sovereignty by organizing sovereign and sustainable local food systems that promote mobilization and conservation of local resources for food production, transformation, and commercialization with minimal dependence on external inputs. This is done with four key components: sustainable production models with an agroecological approach, supply chain transformation, access to resources that mobilize local resources, and nutritional education for food sovereignty. Plan SAN encourages the sustainable management of natural resources in general, including soil and water, and promotes the use of renewable energy in a way that strengthens both socio-ecological resilience and minimizes climate-change impacts.

In addition to the difficult scenarios we face, increasing criminal acts against our biodiversity, landscapes, and natural resources have become an undesirable trend; to counter this trend, Cuba implemented the *Governmental Plan for the prevention and confrontation of crimes and illegalities that affect forests, flora and wildlife, as well as other natural resources.* The main objective of the Plan is to provide greater coherence and comprehensiveness to the system of prevention and institutional prosecution of these crimes and illegalities, combining administrative, regulatory, control, and operational measures, and also to raise people's awareness of the need to promote a culture in which we coexist harmoniously with nature.

Some legal and policy instruments need to be updated and improved to explicitly apply the precautionary principle, establish mechanisms that favor adaptive management, promote an integrated planning approach that factors in the connectivity of marine ecosystems and of terrestrial ecosystems with the latter, and develop financial mechanisms that favor and encourage local initiative in the sustainable management of biodiversity-related resources.

Challenges and opportunities for Cuba's coastal communities: economic sectors and ecosystem social services.

This section of the report highlights current conditions, opportunities, and challenges in the tourism, energy, agriculture, biodiversity, human health, and freshwater sectors and services. Here we summarize some key takeaways from the main sectors.

Fisheries

Fishing in Cuba is an important source of food, income, and livelihoods. Most fisheries are in the coastal zone, within a mosaic of highly biodiverse mangrove, seagrass, and coral reef habitats that provide numerous ecosystem services, including fisheries. Unfortunately, fisheries have declined over the past 30 years. One study estimates that 20% of fish stocks are fully exploited, while 75% are overfished, and 5% have collapsed. Although overfishing is one of the most important factors influencing low catch levels in Cuba, non-fishing related impacts certainly also have effects and some are probably irreversible. These include environmental changes caused by climatic phenomena and activities such as river damming, changes in agricultural practices, coastal development, and increased tourism. Adaptive management is a key factor of climate-resilient fisheries.

Making fisheries sustainable and resilient urgently requires reducing and effectively controlling fishing, stepping up regulation enforcement, reducing illegal and unreported fishing, eliminating unsustainable practices such as factory fishing of spawning schools, restoring key degraded or altered habitats such as estuarine ecosystems and coral reefs, and promoting and implementing sustainable practices and innovative fisheries management systems, as well as economic alternatives and incentives that help move fishing communities towards sustainability and resilience.

Much effort has been made to promote the scientific principles required by the new 2020 Fisheries Act and apply them to the mosaic of highly biodiverse habitats and their multi-species fisheries, relying on scientific tools (e.g., productivity-susceptibility analysis (PSA), the bio-economic “Upside Model”, fish baskets) as well as capacity and knowledge transfer tools (learning network, university courses, community workshops). The development of multi-species fisheries management requires a high level of stakeholder participation, including fishers, fishing communities, research and planning institutions, and an adaptive-management outlook, as different species will respond differently to climate change impacts and harvest control measures.

Agriculture and Food Security / Food Sovereignty

Agriculture is one of the most vulnerable sectors to climate variability, since changes in temperature and an increase in the frequency and severity of extreme events such as rainfall intensity, droughts, hurricanes, saltwater intrusion in coastal areas, etc., directly influence production and threaten cultural practices in agricultural territories, markets, and people’s food security. In the past 15 years, Cuba has lost almost US$30 billion as a result of the impacts of hurricanes and droughts, especially in the agri-food sector.

A transformation towards resilient agri-food systems in coastal zones requires implementing technological and innovative solutions in an agricultural development model based mainly on endogenous production, with a capacity to apply updated agroecological principles, methods, practices, and knowledge. Such a move will help increase ecological and cultural diversity, lead to more efficient use of locally available natural resources without requiring large amounts of external inputs and fossil fuels in their production and marketing cycle, and thus reduce greenhouse gases (GHG), while strengthening resilience, climate adaptability, and food sovereignty. Having food security and sovereignty is a challenge that conditions its resilience and, despite the fact that Cuba’s proximity to the sea contributes to its vulnerability, this is also an opportunity to diversify

production and consumption of food with high added value.

One of the most undervalued and easily produced crops along Cuba's tropical coasts is coconut, which provides a diversity of food and handicraft goods in various end products. Coconut oil can be one of the leading products that provide identity and income to coastal populations, replacing conventional low-quality oils that are currently imported for human consumption, yet fail to meet demand.

The resilience and stability of a socio-ecological system are determined by biotic or environmental factors, socio-cultural strategies, and economic conditions. Facilitating the change and adaptation necessary to move towards sustainable livelihoods focused on socio-ecological resilience entails profound cultural changes in food production and consumption and economic valuation. Thus, it is essential that all actors in the transition have ways to participate within a general understanding that multilevel collective action is a cross-cutting theme in the process.

The circular economy and cycle closures must be included in local practices and policies. We should eschew continuously being victims of a linear economy in which high volumes of waste are generated, requiring ever more complex systems to treat, producing environmental effects that harm the life of coastal ecosystems and communities in these geographical areas.

Energy

The main energy problem of Cuba's coastal zone is its high dependence on electricity generated in faraway places. Thus, the best way to increase resilience is to create a local energy network. To do so, we must first understand local energy needs now and in the foreseeable future and then determine how best to meet the needs with local energy resources.

Health

Over the past 30 years, the Climate Center of the Institute of Meteorology, together with the Pedro Kourí Institute of Tropical Medicine (Instituto de Medicina Tropical Pedro Kourí-IPK) and the National Institute of Hygiene, Epidemiology, and Microbiology (Instituto Nacional de Higiene, Epidemiología y Microbiología-INHEM), have obtained scientific evidence of the degree of morbidity of various diseases attributable to climate variability and change. In-country studies corroborate that, as a consequence of anomalous variations and changes in Cuba's climate in recent years, there is a short- and medium-term increase in the number of cases and medical attention of several diseases, among them acute respiratory infections (ARI), acute diarrheal diseases (ADE), varicella (V), or chicken pox, as well as a tendency to increase the number of foci of *Aedes aegypti* and other vectors and, therefore, increase the risk of transmission and occurrence of outbreaks of dengue and other arboviruses.

We cannot, then, postpone establishing needed early warning systems that explicitly incorporate climate variability and change if we are to guarantee resilience. One method would be to revise regulations for setting up health institutions, incorporating the principles of resilience, sustainability and biophilic design, as well as creating a national program for systemic management for the resilience and sustainability of health institutions, to ensure their continuity.

Another way would be to implement, in some selected territories, a health surveillance

and early warning system based on climate variables, for which there is already previous experience in some regions of the country. This course of action will have a positive impact on cooperation between professionals, weather entities, and the health sector leading to timely information and forecasting public health events, thus strengthening the resilience of health services. We ought to incorporate a “health in all policies” approach, with civil-society participation in the intersectoral agenda, as well as in preparedness, response, and recovery plans should climate and meteorological disasters strike, while undertaking public health campaigns regarding climate change and health.

Fresh Water

Watersheds play an essential role in the integration and workings of terrestrial and coastal ecosystems, given their multiple and complex links with the economy and society. The hydrological cycle is determined by rainfall, which is the only source of annual renewable water in the archipelago. It is a limited and finite strategic resource, essential for Cuba’s sustainable development. In the archipelago, 642 surface basins larger than 5 km^2 have been documented. Of the total, 87.8% have areas between 5 and 200 $km^{2.}$ Only 2.3%, i.e., 15 basins, have an area greater than 1,000 km^2. The main aquifers are located in karst formations and mostly in hydraulic relation with the sea, while saline intrusions intensify due to inadequate management of the sources.

The development of water infrastructure has made it possible to make available to economic, social, and environmental consumption about 57% of the potential water resources (PWR). The real (average) Availability Index of water per inhabitant per year for all uses, referring to built hydraulic infrastructure, is approximately 1,220 m^3. Cuba’s Water Footprint (WF) is 1,712 m^3 per inhabitant per year and ranks 30th, in descending order, of around 100 countries evaluated. Addressing the current challenges and opportunities for resilience and sustainability in coastal communities requires a comprehensive approach. Comprehensive management includes increasing efficiency in the use of inland waters, employing renewable energy sources in pumping and handling of large, medium, and small water flows, and reusing adequately treated wastewater.

New economic forms

The private sector is a growing presence in the country’s economic development. The most recent and previous reforms authorize the creation of micro, small, and medium-sized enterprises (MSMEs), and previous reforms have authorized private businesses to be established under the license of Self-Employment (TCP), Non-Agricultural Cooperatives (CNoA), and Local Development Projects (PDL). Domestic conditions have led private businesses to shed their initial image as small family enterprises and take on a greater role as the economic actors that are needed to implement an efficient socioeconomic transformation. Given recent reforms, the private sector has more options for further consolidation and thus it should take into account principles of sustainability and resilience. This sector needs access to the same benefits and ought to assume the same responsibilities as state actors to help business owners and employees understand the importance of creating and implementing resilient and sustainable strategies, in order to obtain a balance between economic development, sustainability, and comprehensive resilience.

Any local development project should be cautiously considered. Careful attention

should be given to the trade-offs between the pursuit of economic growth, satisfying immediate needs, preserving biological diversity and ecosystem services that sustain coastal communities, as well as essential activities such as tourism. Innovative and effective ways must be found for policy makers, coastal communities, and marine-resource users to become truly aware of the challenges we face and the urgency of creating development models with nature-based solutions to adapt to climate change, strengthen the resilience of ecosystems and communities, and provide ecologically sustainable, socially just and economically efficient livelihoods, thereby contributing to a prosperous future for the entire Caribbean region.

Selection of relevant projects for coastal zones in Cuba

This section of the report highlights six projects implemented in different regions and at different scales aimed at strengthening coastal resilience. What follows is a brief summary of some of these projects.

The My Coast [*Mi Costa*] project will improve adaptive capacity in coastal populations by comprehensively rehabilitating coastal landscapes and seascapes, their interconnected ecosystems and hydrology; strengthen adaptive capacities of coastal governments and communities; focus on 24 communities on the South Coast of Cuba due to the area's high vulnerability to climate change. The project will establish a new paradigm by including large-scale, ecosystem-based adaptation (EbA) directly into development strategies and actions, allowing for flexible risk management solutions.

The Living Mangrove [*Manglar Vivo*] project was implemented in the provinces of Artemisa and Mayabeque, substantially increasing the health of coastal wetlands, and thus reducing coastal flooding, through restoration techniques, education, awareness-raising, and support for sustainable, mangrove-related, productive activities. Lessons learned from the project have been the basis for new project proposals with an ecosystem and community-based adaptation approach, and all project results are stored in four Training Classrooms.

The Climate Change Impact on Two Fragile Ecosystems in Cuba *(Impacto del Cambio climático en dos ecosistemas frágiles de Cuba-CCamBIO)* Project aimed to improve adaptation in two communities in ecologically sensitive, coastal-marine areas of Cuba - Caletones, in the Zapata Swamp, and Júcaro, near Jardines de la Reina - to minimize the impacts of climate change on the ecosystem services that support the livelihoods of local communities, by studying and monitoring selected biodiversity indicators and disseminating these results and experiences as a means of raising awareness and training local people.

The *Sustainability of fisheries in a key area of the Caribbean basin and improvement of the quality of life of fishing communities* project [*Sostenibilidad de las pesquerías en un área clave de la cuenca del Caribe y mejoramiento de la calidad de vida de las comunidades pesqueras-SOS Pesca*] contributed to the resilience of two communities in eastern Cuba (Playa Florida, Florida municipality, and Guayabal, Amancio municipality) by strengthening capacities to reduce the causes of risks and vulnerabilities associated with the loss of marine and terrestrial flora and fauna due to overexploitation, rising sea levels, and a lower quality of life for the population.

Experiences from the Wider Caribbean Region

The report concludes by highlighting regional initiatives and models in other Caribbean and Gulf of Mexico countries, highlighting the importance of mutual learning to achieve socio-ecological resilience in coastal zones. Regional cooperation becomes even more important when considering the economic and environmental vulnerabilities of Caribbean islands that should work together to protect common environmental resources in a hostile environment that hinders Small Island Developing States (SIDS) from moving towards sustainable development. The Association of Caribbean States (ACS) is a centerpiece in regional cooperation, facilitating consultation, cooperation, and concerted action in the areas of trade, transport, sustainable tourism, and disasters in the Caribbean region.

Regarding civil society, there is a void of attention and action focused on the needs of the most vulnerable coastal communities and groups in the Caribbean. Therefore, the civil society organization Caribbean Natural Resources Institute (CANARI) seeks to engage and empower these vulnerable stakeholders to build resilient coastal and marine ecosystems and livelihoods using a participatory and inclusive approach. It focuses on the following areas: integrating local and traditional knowledge and practices into decision-making; empowering local communities and resource users to act; applying ecosystem-based solutions; and climate-proofing livelihoods and enterprises, focusing on building resilience at the local level to complement important steps taken by regional agencies and national governments around the Caribbean.

The SAMAR protected area in the Dominican Republic has an action plan to monitor the health of coral reefs under the protection of the co-management council, which is composed of governmental and non-governmental entities. The intention is that, over time, the SAMAR co-management model will be a reference in the Caribbean region in which hopefully the business sector, local communities, governmental and non-governmental agencies come together to inform decision-makers with the best available science to achieve a common goal: the sustainable use of the marine-coastal resources of a protected area with high economic and ecological value.

The *Descendants United for Nature, Adaptation and Sustainability* project, [*Descendientes Unidos por la Naturaleza, Adaptación y Sostenibilidad-DUNAS*]. aims to restore the dunes of the Hacienda La Esperanza Natural Reserve (HLE), located on the north coast of Puerto Rico, which were severely impacted by Hurricanes Irma and Maria in 2017 and continue to be affected by subsequent weather events. With the participation of community members, volunteers, and coordinating institutions, support has been given to protect this national ecological treasure and cultural heritage, encouraging the conservation of this and other spaces along the Puerto Rican coast and possibly the rest of the Caribbean.

In Louisiana, USA, EDF's Coastal Zones and Watersheds team focuses on supporting coastal management and community adaptation efforts, in particular the implementation of the state government's Shoreline Master Plan, an iterative and evolving work that is designed for the long-term, strives to incorporate adaptive management principles, and began its development with resource constraints. We have identified six key elements for any successful plan for coastal resilience: define goals and set clear expectations; use the best available science; take collective action; account for uncertainty and residual risk; focus on impacts to human life; and Identify funding and challenges.

Photo by Noel López Fernández

1. BACKGROUND AND CONTEXT

1.1 Environmental and ecological framework

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Despite humanity's economic and technological development, we have not been able to overcome our dependence on the goods and services provided by ecosystems, which allow us to have an environment suitable for life, drinking water, food, fiber, and many other resources necessary for our economies and societies. The interrelationship between human society and nature is so close that both should be considered integral elements of complex interdependent socio-ecological systems. However, this notion is far from being a generalized practice; on the contrary, our tendency has been to gradually separate society and nature, believing that technological advances allow us to dominate the natural world. But there are planetary boundaries, and the trend has led us to overstep them.

As a consequence, the asymmetrically developed, globalized, and cyclically crisis-ridden world in which we live presents humanity with ever greater and more urgent challenges: an increasingly unjust distribution of wealth, unsustainable development paradigms based on a consumerist lifestyle, hunger and growing poverty in most countries are just some of them. Two of the most striking consequences of the mainstream development model are the accelerated loss of biodiversity and the ecosystem services on which life depends, and global climate change driven by the high rate of greenhouse gas emissions and transformations in the landscape. Some indicators illustrate these crises: The global Living Planet Index shows an average decrease of 68% in the size of mammal, bird, amphibian, reptile, and fish populations between 1970 and 2016[1] between 2001 and 2020 Earth lost 411 million hectares of tree cover, equivalent to a decrease of 10% and the emission of 165 gigatons of CO_2[2] in 2014, 9.855 billion tons of CO2 were emitted into the atmosphere, a historic peak, as a result of consumption of fossil fuels alone and cement production[3] in 2019, atmospheric CO_2 concentrations were higher than at any time in at least two million years, and there is very high certainty that CH_4 and N_2O concentrations during that same year were higher than at any time in at least 800,000 years.[4]

The conclusions of the latest report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) show beyond doubt that the scale and pace of recent changes in the global climate system and its state are unprecedented for many centuries or thousands of years.[5] Some of the most striking conclusions are:

- Each of the last four decades has been successively warmer than any preceding

[1] WWF. (2020). Living Planet Report 2020 - Bending the curve of biodiversity loss. Gland, Switzerland: WWF. Retrieved 02 06 02 2021, from https://www.zsl.org/sites/default/files/LPR%202020%20Full%20report.pdf

[2] Global Forest Watch (November 20, 2021). *Global Forest Watch Dashboard*. Retrieved from https://www.globalforestwatch.org/dashboards/global

[3] Boden, T. A., Marland, G., & Andres, R. J. (2017). *Global, Regional, and National Fossil-Fuel CO2 Emissions.* Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory. Oak Ridge, Tenn., U.S.A.: U.S. Department of Energy. doi:10.3334/

[4] IPCC (2021). *Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.). Cambridge, UK: Cambridge University Press. In Press.

[5] Ibid.

decade since 1850, and the global temperature during the first two decades of the 21st century was almost 1 °C higher than in the 1850-1900 period.

- It is virtually certain that the upper layer of the global ocean (up to 700 m depth) has warmed since 1970, and it is very likely that human influence is the main cause.
- Oxygen levels have declined in many regions of the upper ocean since the mid-20th century.
- Global mean sea level rose by 0.20 m between 1901 and 2018.
- Both the rate of global warming and sea-level rise have been accelerating steadily since the beginning of the 20th century.
- Global surface temperature will continue to rise until at least the middle of the 21st century under any of the proposed emission scenarios. Global warming will exceed the 1.5 °C – 2 °C limit during the 21st century unless drastic reductions in CO_2 and other greenhouse gas emissions are achieved in the next two decades.
- With growing global warming, increases are expected in the frequency and intensity of extreme warming, marine heat waves, intense rainfalls, and, in some regions, agricultural and ecological droughts. We should also expect an increase in the number of intense tropical cyclones, along with reductions in sea ice, snow cover, and Arctic permafrost.
- Due to past and future greenhouse gas emissions, many changes will be irreversible for centuries or millennia, especially changes in the ocean, ice sheets, and global sea level.
- If drastic measures were taken, changes in global temperature trends could be seen in about 20 years, but longer periods would be needed for many other climate drivers to recover.

All of these future trends and projections are reflected in and will affect the Caribbean, which is particularly vulnerable to the impacts of climate change and biodiversity loss, and thus prone to losing the ability to sustain our economies and lives.

The Antilles comprise only 1.4% of the planet's land and the Caribbean Sea represents only 0.8% of the global oceans, but in this small space we find an incredibly diverse and unique biota of global importance, where endemic species represent 61% of flowering plants,[6] 51.3% of terrestrial vertebrates,[7] and 26% of species belonging to the best known marine taxa.[8] The coastal zone of the large Caribbean marine ecosystem is dominated by key ecosystems such as coral reefs, mangroves, and seagrasses, although other important features, such as sandy beaches, rocky shores, and soft bottoms also have a prominent presence. Despite their naturally fragmented geographical context, these

[6] Acevedo-Rodríguez, P., & Strong, M. (2008.). Floristic Richness and Affinities in the West Indies. *The Botanical Review, 74*(1), 5-36.

[7] Myers, N., Mittermeier, R., Mittermeier, C., da Fonseca, G., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature, 403*, 853 - 858. Retrieved from https://sdmmp.com/upload/SDMMP_Repository/0/038n1thz2kcdwfpqs7jy6mrvg4xb59.pdf

[8] Miloslavich, P., Diaz, J. M., Klein , E., Alvarado, J. J., Diaz, C., Gobin, J., ... Ortiz, M. (2010). Marine Biodiversity in the Caribbean: Regional Estimates. *PLoS ONE, 5*(8), e11916. doi:10.1371/journal.pone.0011916. doi:10.1371/journal.pone.001191

islands are closely linked through the dispersal of nutrients,[9] seeds,[10] and larvae[11] that are carried by ocean currents and winds; and by the periodic migration of insects, fish, sea turtles, birds, and marine mammals. This is essential ecological connectivity needed to ensure healthy and productive ecosystems. The rich and dynamic biodiversity of the Caribbean is subject to diverse pressures and threats, which means that the region can be categorized as an important global hotspot for both terrestrial[12] and marine biodiversity.[13]

Regional biodiversity also provides Caribbean nations with invaluable environmental services that maintain some of the most important economic sectors (e.g., tourism and fisheries) for coastal communities, or even entire island nations. The Caribbean is the world's most tourism-dependent region, according to data from the World Travel and Tourism Council showing that in 2019 this sector contributed 14% of the region's total GDP and 15.4% of all its jobs.[14] Many of the most important tourist attractions of the Caribbean islands and coasts are directly related to the health of their seas and their rich biodiversity. Beaches, diving and snorkeling, recreational fishing, cruises, yachting, and other nautical activities would not be possible without the coral reefs, mangroves, and seagrasses that maintain biodiversity and generate tourist attractions. Yet at the same time, Caribbean marine and coastal ecosystems are experiencing accelerated degradation due to pressures from overfishing, pollution, inappropriate coastal development, and excessive tourism,[15] factors that generate a positive feedback loop with climate change, because they contribute to the accelerated loss of the natural ability of ecosystems to respond to this threat.

Since its introduction in scientific literature,[16] the concept of resilience has had multiple interpretations, definitions, and conceptual frameworks, but academics have yet to decide on a universally accepted classification.[17] In the context of global changes, it is defined as the capacity of a socioecological system to absorb disturbances and reorganize itself to be functional and evolve through learning and adaptation.[18] Strengthening the climate resilience of communities therefore requires a holistic approach that considers not only human factors and the direct relationships with the hazards they face, but also an adequate appreciation of socio-ecological interactions and the role of nature in building resilience, and that the limits it imposes on us be safeguarded. Unbalanced human-wildlife relations only lead to new crises, such as the current pandemic of COVID-19 that has

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[9] Acevedo-Rodríguez, P., & Strong, M. (2008.). Floristic Richness and Affinities in the West Indies. *The Botanical Review, 74*(1), 5-36.

[10] Santiago-Valentin, E., & Olmstead, R. (2004). Historical biogeography of Caribbean plants: introduction to current knowledge and possibilities from a phylogenetic perspective. *Taxon, 53*(2), 299-319.

[11] Paris, C., Cowen, R., Claro, R., & Lindeman, K. (2005). Larval transport pathways from Cuban snapper (Lutjanidae) spawning aggregations based on biophysical modeling. *Marine Ecology Progress Series, 296:*, 93 - 106.

[12] Myers et al., 2000.

[13] Miloslavich, et al., 2010.

[14] World Travel & Tourism Council (01 June 2021). *Regional Overview 2019*. Retrieved from World Travel & Tourism Council: https://wttc.org/Research/Economic-Impact

[15] Burke, L., & Maidens, J. (2005). *Reefs at Risk in the Caribbean.* Washington, DC: World Resources Institute (WRI).

[16] Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics, 4*, 1-23.

[17] Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change, 18*, 598-606. doi: 10.1016/j.gloenvcha.2008.07.013.

[18] Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockstrom, J. (2005). Social- ecological resilience to coastal disasters. *Science, 309*(5737), 1036–1039.; Klein, R. J., Nicholls, R. J., & Thomalla, F. (2003). Resilience to natural hazards: how useful is this concept? *Environmental Hazards, 5*(1–2), 35–45.

paralyzed the world. The global risks we face are so great that continuing with business-as-usual development models is no longer a viable option. If we do not change our paradigms and act responsibly and efficiently everywhere on Mother Earth, we will be plunged into unprecedented and deeper crises in the not-too-distant future.

Although the climate and socioeconomic resilience of communities is mainly determined by internal processes at the local level, it is also influenced by both individual and household activity, as well as by driving forces of change originating at higher levels, for example, national policies or globalized market forces.[19] Therefore, building resilience in Caribbean coastal communities implies not only acting collectively at the community level, but also changing individual and household behaviors and modifying policies and market demands. It also implies the need for a new vision in the management and conservation of the biodiversity resources on which community livelihoods depend. It is here where the existence of common threats, the dependence on shared resources, and complex connectivity at local and regional scales, make searching for natural solutions a priority. Such solutions must improve the resilience of marine and coastal ecosystems and thus communities' capacity to adapt to the global changes we are facing. Without a different approach to the use of biodiversity resources based on knowledge of how ecosystems work and recognition of how they are threatened, it will be difficult to forge a sustainable future for our coastal communities. This new approach must take into account shared responsibilities at the regional level and the need to maintain ecological integrity, incorporating ecological connectivity through a holistic, comprehensive, and coordinated approach to intervention at different scales of action.

Cuba plays a fundamental role in the regional connectivity of the Greater Antilles and other surrounding ecoregions.[20] Cuba's marine-coastal ecosystems are therefore not only very valuable for the livelihood and resilience of the country's coastal communities; they also play an essential regional role because the richness of the Cuban shelf and its adjacent waters is intimately connected to those of the Greater Antilles and beyond. I cite some examples: Cuba's coral reefs may be essential for the survival of reefs in foreign waters,[21] since they export larvae to other areas of the Caribbean, such as the Mesoamerican reef, the Bahamas, and Florida,[22] which in turn allows the genetic exchange needed to improve the resilience of these important ecosystems. There is also strong connectivity between coral reefs, mangroves, and seagrass meadows,[23] so that populations of marine species that are important to fisheries cannot be maintained without comprehensive management of these ecosystems. Also, Cuban beaches are nesting sites for sea turtles that then regularly migrate to feeding spots in waters as far away as

[19] Berkes, F., & Ross, H. (2016). Panarchy and community resilience: Sustainability science and policy. *Environmental Science & Policy, 61*, 185-193. doi:http://dx.doi.org/10.1016/j.envsci.2016.04.004.

[20] García-Machado, E., Ulmo-Díaz, G., Castellanos-Gell, J., & Casane, D. (2018). Patterns of population connectivity in marine organisms of Cuba. *Bulletin of Marine Science, 94*(2), 193-211. doi:doi.org/10.5343/bms.2016.1117.

[21] Galford, G., Fernández, M., Roman, J., Monasterolo, I., Ahamed, S., Fiske, G., . . . Kaufman, L. (2018). Cuban land use and conservation, from rainforests to coral reefs. *Bulletin of Marine Science, 94*(2), 171-191.

[22] Schill, S., Raber, G., Roberts, J., Treml, E., Brenner, J., & Halpin, P. (2015). No Reef Is an Island: Integrating Coral Reef Connectivity Data into the Design of Regional-Scale Marine Protected Area Networks. *PLosONE, 10*(12: e0144199), 1 - 24. doi:10.1371/journal.pone.0144199.

[23] González-Díaz, P., González-Sansón, G., Aguilar Betancourt, C., Álvarez Fernández, S., Perera Pérez, O., Hernández Fernández, L., . . . de la Guardia Llanso, E. (2018). Status of Cuban coral reefs. *Bulletin of Marine Science, 94*(2), 229-247. doi:10.5343/bms.2017.1035.

Nicaragua, Colombia, and Barbados;[24] our shelf hosts the largest number of snapper and grouper nesting sites in the insular Caribbean that disperse larvae and help maintain fish populations in neighboring countries;[25] and Cuba has the largest mangrove and coral reef tracts in the Greater Antilles that are essential for regional sustainability.[26] This prominent role in regional connectivity carries with it a responsibility for the sustainable management of our marine biotic resources that transcends national interests and borders.

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National studies[27] warn that "in recent years important changes have been observed in Cuba's climate." Most proven evidence points to the increase in average annual temperature, linked to the increase in minimum temperature; the decrease in cloudiness; more intense and prolonged droughts, although less frequent; increase in precipitation greater than 50 mm, and a greater anticyclonic influence.

Other details of current and projected changes include an increase in the annual air temperature for Cuba of more than 1.0° C by 2030 and 3.5° C by 2070, relative to the 1961-1990 reference period. Rain is predicted to decrease around 10% during the rainy season. Updated sea-level projections for 2030-2100 indicate values that rise to 29.3 and 95.0 cm by 2050 and 2100, respectively. In addition to these average values, specific calculations are available for 66 locations along the Cuban coasts.

Between 2001 and 2017, Cuba was hit by 12 hurricanes, 10 of them classified as intense (category 4 or 5). In the last ten years, the percentage of intense hurricanes affecting the country has grown from a historical average of 26% to 78%, with consequent material losses. This increase in hurricane intensity coincides with very high temperatures in Atlantic waters.[28]

Other very serious impacts of climate change are related to water. Experts predict that there will be a significant loss in water potential nationally, regionally, and locally, such that usable water resources could be 60% less than today, thus increasing competition over water availability, given growing human demand and the need to maintain the equilibrium of ecosystems.[29]

The information available on current and projected climate change leads to a conclusion of transcendental importance. "... it is certain that the Cuban climate is changing from tropical humid to tropical dry, with average temperatures above 30° C, approximately 1000 mm of average annual rainfall, and 70 days with rain, conditions that will favor the displacement of the dry landscapes of the eastern region towards other areas of the

[24] Moncada, F. G., Hawkes, L. A., Fish, M. R., Godley, B. J., Manolis, S. C., Medina, Y., . . . Webbf, G. J. (2012). Patterns of dispersal of hawksbill turtles from the Cuban shelf inform scale of conservation and management. *Biological Conservation, 148*, 191-199. doi:10.1016/j.biocon.2012.01.011.

[25] Paris, Cowen, Claro, & Lindeman, 2005; Russell, M. W., Sadovy de Mitcheson, Y., Erisman, B. E., Hamilton, R. J., Luckhurst, B. E., & Nemeth, R. S. (2014). *Status Report - World's Fish Aggregations 2014.* California, USA. International Coral Reef Initiative: Science and Conservation of Fish Aggregations (SCRFA).

[26] Viña-Dávila, N., & Gerhartz-Muro, J. L. (2021). *Nueva Demarcación del Corredor Biológico en el Caribe.* Santo Domingo. Dom. Rep.: CBC Secretariat. Retrieved from http://cbcbio.org/documentos-estrategicos-programas-y-planes/

[27] CITMA. 2020. Tercera Comunicación Nacional a la Convención Marco de las Naciones Unidas sobre el Cambio Climatico.

[28] Cuba UNDP GCF. 2021. Coastal Resilience to Climate Change in Cuba through Ecosystem Based Adaptation - "*MI COSTA*. Funding Proposal.

[29] Cuba. 2020. Contribución Nacionalmente Determinada (Updated).

country. Similarly, air temperature will continue to increase, consistent with the results of previous modeling in Cuba, and could reach 4.5° C. The greatest warming will occur mainly during the warmest period of the year, a sign that will become clearer as time progresses."[30]

These tendencies have a clear impact on Cuba's ecosystems, productive sectors, and coastal communities. Cuba's marine and coastal landscapes are a succession of ecosystems that have co-evolved under current climatic conditions, including the current distributions of extreme events. The coral reefs, seagrass meadows, beaches, coastal mangroves, and forest or grassland marshes are a balance that confers resilience to each ecosystem separately, but also to the coast as a whole. The current resilience of Cuban coastal ecosystems to extreme events and the rise in mean sea level is being undermined both by the effects of climate change (increase in extreme events) and by other anthropogenic pressures, affecting their capacity to provide protective services.[31]

The Cuban coastal zone has received particular attention in national studies that conclude that it may suffer significant modifications due to climate change. The main impacts are expected to be a gradual increase in erosion, the retreat of the coastline, and the deterioration of coastal ecosystems in the short, medium, and long term.

In general, coastal municipalities and their respective settlements in Cuba are extremely vulnerable to climate change, due to the increase in mean sea level and extreme weather events, which cause severe flooding. In general, studies indicate that permanent flooding in coastal areas could reach 2416 km^2 (2.24% of the territory) by 2050; and 5645 km^2 (5.33% of the territory) by 2100.[32]

There are 19 human settlements along the coast that over time will have to be relocated because the progressive effects will lead to completely unlivable conditions by 2100. Excluding Havana, the permanent effects on population and housing caused by climate change would occur totally in 19 settlements (15 in 2050 and 4 in 2100) and partially in 89 settlements in 2050 and 93 in 2100. In Havana, no areas are estimated to become permanently flooded and only current effects are occurring in the popular councils of Guanabo and Santa Fe. By 2050, 21 councils are expected to be partially flooded, rising to 26 by 2100.[33]

The situation described above explains the high priority given to the vulnerable coast and its settlements in *Life Task*, which emphasizes reducing the exposure of human settlements to risks, increasing the resilience of human settlements, and adopting constructive solutions based on nature, in order to promoting sustainable, safe, and prosperous human settlements, adapted to climate change and low in emissions. Cuba's adoption of the New Urban Agenda[34] encourages synergies between both instruments and making them the common platform for the national strategy during 2021-2025.

Patricia González Díaz

[30] Cuba. Contribución Nacionalmente Determinada. Updated 2020.

[31] Coastal Resilience to Climate Change in Cuba through Ecosystem Based Adaptation - *MI COSTA.*

[32] Cuba 2020. Third National Communication.

[33] Cuba 2020. Third National Communication.

[34] UN-Habitat 2018 Implementando la Nueva Agenda Urbana en Cuba ALINEACIÓN DE LA VIVIENDA EN CUBA Y LA NUEVA AGENDA URBANA, March 2018.

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Coral reefs are coastal marine ecosystems characterized by high biodiversity, maturity, and vulnerability.[35] At the same time, although they occupy approximately 0.1% of the oceans, they generate goods and services that are estimated to be worth billions of dollars annually.[36] These ecosystems, however, receive the synergistic effect of natural and anthropogenic impacts, which has led to a marked loss of resilience in recent decades. Among the most damaging impacts are overfishing, land-based waste discharges, mechanical damage, rising sea temperature and mean sea level, and an increase in the frequency and intensity of extreme meteorological events.

Almost 98% of the Cuban platform is bordered by coral reefs. Their condition differs depending on their proximity to the coastline and large cities, accessibility to the reef, and nearby activities.[37] The deterioration of Cuban reefs is mainly due to the effect of overfishing and pollution from large cities, such as those that are near Havana.[38] Others, however, such as Jardines de la Reina and Guanahacabibes, show signs of health and high biodiversity.

Research to document how resilience occurs in the examples cited above helps to design management measures that aid in restoring the natural processes that have been affected. In addition, natural resource management has evolved over time, shifting first from management based on individual species to ecosystem-based management and, more recently, resilience-based management.[39] The latter approach is based on:

- Managing ecosystem services to provide human welfare
- Change managed on a large scale, with UNCERTAINTY and surprise.
- Change to preserve the socioecological properties of the system and apply ADAPTIVE MANAGEMENT
- Maintaining variability, diversity, and multiplicity of species and ecological functions
- Human beings are part of the system, carrying out changes, adaptations, and transformations therein.

It is now vital that Cuba shift to resilience-based management. The fact that this model conceptually includes human beings as a fundamental part of the system, opens new possibilities in the search for solutions to the growing impacts on our reefs. Options such as co-management and ecotourism can contribute to the preservation of coral reef resilience, such that communities themselves can make sustainable use of their resources while benefiting economically.

Another option would be to develop volunteer campaigns for the evaluation of whitening,

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[35] Harborne, A. R.; A. Rogers; Y. Bozec; P. J. Mumby. 2017. Multiple Stressors and the Functioning of Coral Reefs. Annu. Rev. Mar. Sci. 9: 5.1-5.24. doi: 10.1146/annurev-marine-010816-060551.

[36] Mumby, P. J.; J. Flower, et al. 2014. Towards reef resilience and sustainable livelihoods: A handbook for Caribbean coral reef managers. University of Exeter, Exeter,172 pp.

[37] González-Díaz, S.P, G. González-Sansón, C. Aguilar, S. Álvarez, O. Perera, L. Hernández, V. M. Ferrer, Y. Cabrales, M. Armenteros, E. de la Guardia. 2018. Status of Cuban coral reefs. Bull. Mar. Sci. 94(2): 229-247. https://doi.org/10.5343/ bms.2017.1035.

[38] Duran, A., A.A. Shantz, D.E. Burkepile, L. Collado-Vides, V.M. Ferrer, L. Palma, A. Ramos, S.P. Gonzalez-Díaz. 2018. Fishing, pollution, climate change, and the long- term decline of coral reefs off Havana, Cuba. Bull. Mar. Sci. 94(2):000-000. https://doi.org/ 10.5343/bms.2017.1061.

[39] McLeod E, K.R. Anthony, P.J. Mumby, J. Maynard, R. Beeden, N.A. Graham, S.F. Heron, O. Hoegh-Guldberg, S. Jupiter, P. MacGowan, S. Mangubhai. 2019. The future of resilience-based management in coral reef ecosystems. Journal of Environmental Management. 233:291-301.

plastics, and sargassum, or seaweed, (during the upwelling season). All three of these problems are currently on the rise, causing sub-lethal damage to marine-coastal food chains and even to human beings. These campaigns could include not only evaluations and scientific research, but also activities to solve the problem through the collection of plastics and sargassum. This can link productive sectors while creating new jobs in the community related to the collection, sorting, and recycling of plastic and sargassum. Exploring variants such as those mentioned above would undoubtedly increase the resilience of both our coral reefs and the surrounding marine-coastal ecosystems and coastal communities. Certainly, we need to move urgently from science to action if we really want to preserve the resilience of our reefs. Let's do it now to avoid regretting our inaction tomorrow.

1.2 Social and human framework

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One of the greatest challenges for achieving comprehensive management of the coastal zone is people's socio-environmental resilience and their interrelationship with this important ecosystem. This assumes the integration of communities as active participants in monitoring the benefits and management of ecosystems and connecting them to their lives and livelihoods. Thus, people should be active subjects of sustainable development management in local and community spaces.

Community participation

If we aspire to self-management and community self-development as a means of promoting environmental sustainability, we need to raise awareness and involve governmental and institutional actors, civil society organizations, knowledge management centers, and the community itself in education outreach and ensure that local development strategies include environmental concerns with community participation. This helps people to become involved in environmental management in a conscious and proactive manner, encouraging transformations in their attitudes and behaviors that will last over time.

Participation requires motivation, i.e., wanting to participate; training to be able to participate and know how to do so; and organization so that people feel involved in the activity, assume roles, contribute based on their knowledge and experiences, and make decisions on issues that concern them.

Community participation requires raising people's awareness of their environmental reality, needs, and the factors that condition them; providing skills and abilities to make decisions that solve environmental needs; achieving people's commitment to undertaking transformative action based on their contributions, knowledge, and experiences; and facilitating the self-management of the transformative action, all of which should be considered when organizing people's participation.[40]

Some issues to consider for organizing are:

[40] Muñoz Campos, MR and Romero Sarduy, MI, 2021. "Relaciones sociedad-naturaleza: la participación comunitaria en los procesos de educación ambiental." In: *Educación en Cuba Criterios y experiencias desde las ciencias sociales.* Acuario Publications, Félix Varela Center, Havana. ISBN 978-959-7226-67-3.

- Form a community environmental management team with a collective work concept.
- Identify local stakeholders (government, institutions, organizations, groups, individuals) interested in environmental management.
- Identify community leaders.
- Organize analyses to identify community strengths, weaknesses, opportunities, demands, and contributions 'to manage the environmental dimension of development.
- Define the roles and forms of social participation of local stakeholders and population groups (boys, girls, youth, women, men, older adults, people with disabilities) in the environmental management process. .
- Plan education courses at school (formal education) or other venues (non-formal education) to give local stakeholders a chance to participate.
- Design attractive participation announcements to engage different audiences.

Social and environmental safeguards and public consultation:

The United Nations Development Program (UNDP) methodology states that the objectives of safeguards are:

1- Strengthen the social and environmental effects of programs and projects.
2- Avoid adverse impacts on people and the environment.
3- Minimize, mitigate, and manage adverse impacts when it is not possible to avoid them.
4- Strengthen UNDP's social and environmental risk management capabilities and associated capabilities.
5- Ensure the full and effective participation of key stakeholders.[41]

In Cuba, safeguards are another tool that helps guarantee compliance with the principles and objectives of environmental and social policies for sustainable development. In addition, they avoid, reduce, and compensate for possible negative effects that could be caused by the implementation of different interventions; they also help achieve efficiency and excellence that should characterize the implementation of actions aimed at raising environmental culture.

The first step in public consultation is to sensitize and motivate the community. Among the objectives are:

- Identify how local stakeholders and different population groups perceive climate change and its impacts on the community where they live.
- Identify the opinions/suggestions of key stakeholders, particularly local communities, regarding the project's planned activities.
- Define the possible roles of local stakeholders and different population groups in the public consultation process and project implementation.

[41] UNDP (1993). United Nations Development Program, Human Development Report.

To meet these objectives, public consultation involves investigating perceptions, based on people's knowledge of climate change and its impacts on the community where they live; the ways climate change will affect their lives; the impacts and changes in people's daily lives; traditional and current cultural practices that contribute to mitigating the effects of climate change; water resource management and protection practices; water recycling and reuse practices; the relationship between climate change and land use plans and processes. Similarly, the population's opinions and suggestions are drawn from their questions, doubts, concerns, and suggestions for improving project implementation. Once the stakeholders have been defined in participatory workshops, their roles in the consultation and in the project are specified, as well as the changes expected for each stakeholder group.[42]

Locally relevant capacity building programs and strategies

These programs and strategies are based on strengthening community capacities and ecosystem services to ensure that adaptation is based on the local and national situation. It also includes information products such as a protocol for measuring coastal resilience that will enable communities to make decisions based on their exposure to climate hazards. Training and awareness-raising activities with community stakeholders (women, men, girls and boys, people with disabilities, older adults), including experiences with environmentally sustainable production practices, are carried out by:

- Developing a technical skill building program geared toward climate adaptation for coastal communities and local stakeholders (governments and economic sectors) to enable adaptation actions and capacities.
- Raising awareness and training local community stakeholders, including environmentally sustainable productive practices that reduce or avoid anthropogenic pressure on ecosystems, while guaranteeing their access to natural resources (honey collection, control of invasive exotic species, etc.) and contributing to local employment generation.
- Identifying, designing, and developing course content for coastal communities and stakeholders to increase coastal and ecosystem-based adaptation (EbA) and its uptake into local and national coastal-management planning.
- Improving the physical and operational capacity of the Skill Building Centers (CCCs) in key coastal municipalities, and establishing annex classrooms to provide adequate space for community and key stakeholders for capacity building, community monitoring, and coordinating local adaptation activities.
- Community training to provide public monitoring of coastal ecosystems and local conditions (socioeconomic indicators, environment, climate, health, and drinking water quality) as part of the community monitoring system to complement information derived from the EbA monitoring system and better assess coastal vulnerability and resilience.

[42] Muñoz Campos, MR, Romero Sarduy, MI and Carballo, JA (2019). La consulta pública como herramienta de las salvaguardas sociales y ambientales. Propuesta metodológica para proyectos con enfoque de adaptación basada en ecosistemas y adaptación basada en comunidades. *Estudios del Desarrollo Social*: Cuba y América Latina, Vol. 7, pp. 40-52.

Integrated and participatory knowledge management

- Capacity building in local communities for adaptation and their integration into local and national planning frameworks for coastal management. Knowledge management that takes into account different scientific and academic institutions, municipal university centers, the GUCID network (University Knowledge Management), local structures, annexed classrooms.
- Models to generate local, community, and inter-sectoral capacities through Skill Building Centers and the establishment of annex classrooms in intervention sites for a local, relevant, and impactful adaptation approach.
- Creation of locally relevant environmental and climate information products to improve decision making.

Network Coordination

The sectoral, multi-sectoral, institutional, and multidisciplinary networks and their corresponding coordination mechanisms will be managed through the Municipal Administration Councils (Consejos de Administración Municipal-CAM). This will help to promote and enable intersectoral integration and the reception of environmental investments for coastal protection and adaptation in sectoral planning mechanisms within *Life Task* (State Plan to Address Climate Change) and thus ensure the long-term sustainability of ecosystem-based adaptation measures.

Gender Action Plan

Gender analysis is a theoretical-practical instrument for gendered research of male-female roles, as well as the responsibilities, access, use, and control over resources, problems or needs, properties, and opportunities, so as to plan development with equity to overcome prevailing discrimination.[43] It includes the following:

Participation of women with gender equality in the implementation of community monitoring systems and in projects and experiences locally and nationally.

Sensitization and training of local government officials to respond to issues related to vulnerabilities (of women, female-headed households, older adults, children, and people with disabilities), including training in environmentally sustainable production practices that reduce or avoid anthropogenic pressure on ecosystems.

Strong participation of women in monitoring marine ecosystems, coastal wetlands, and wells.

Training of key stakeholders at the local community level on topics such as the following:

- Printing of documents on best practices for communities to engage in applying the Ecosystem-based Adaptation (EbA) approach, rational use of water, livelihood diversification methods and lifestyles, sustainable use and enjoyment of ecosystems.
- Awareness raising and training with local community stakeholders (women, men,

[43] Hernández, 2008, cited by: Romero Sarduy, MI, Danay Díaz, Verónica Polo, Yiglen Salazar, Tania Caram (2019). Enfoque de género en la adaptación al Cambio Climático: contribución desde FLACSO-Cuba. In: Revista Estudios del Desarrollo Social: Cuba Cuba y América Latina. RPNS 2346 ISSN 2308-0132 Vol. 7, Special issue, 2019.

boys and girls, people with disabilities, the elderly) will include environmentally sustainable production practices that reduce or avoid anthropogenic pressure on ecosystems, taking into account gender equity (e.g., honey collection, control of invasive exotic species).

- Training on social and environmental safeguarding and gender and how it relates to coastal ecosystems and coastal resilience, to encourage the active involvement of local community stakeholders.

1.3 Economic and political framework

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Resilience refers to the ability of social, economic and environmental systems to cope with a hazardous event, trend, or disturbance by responding or reorganizing in ways that maintain their essential function, identity, and structure, while maintaining the ability to adapt, learn, and transform.[44] For coastal ecosystems, resilience is closely associated with their ability to respond to diverse events such as changes in land use, climate change, exploitation of natural resources, pollution, introduction of invasive species, accidents (e.g., fuel spills), among others; or a combination of the above. This capacity to respond depends in turn on various factors such as the availability of economic and financial income, natural resource endowment, appropriate technologies, inter-institutional networks, local development community networks, the existence of legislation that duly incorporates sustainability criteria and the means to enforce them, and political will at different governmental levels.

As an archipelago located in the Caribbean Sea, Cuba's coastal ecosystems are highly vulnerable to climate change and other adverse environmental events, making them a pillar of sustainability. This is reflected in the country's legal framework for environmental protection and the rational use of natural resources. Thus, for example, the state plan *Life Task*,[45] approved in 2017, outlines the strategic importance of coasts and coastal resources for the sustainable development of the country, based on the goods and services provided by these ecosystems for key sectors of the economy such as agriculture, fishing, tourism (e.g. beaches, corals, protection of freshwater resources, among others.) These ecosystems play a strategic role in the responses to climate change (both in adaptation, a priority for Cuba, and in mitigation).

The resilience of Cuban coastal ecosystems and the sustainability of life around them, especially in the 262 existing coastal settlements, is closely linked to local development, where economic (investments, economic growth), social (health, education, cultural development, employment and wages, safety and social assistance, equity in a broad sense and gender equity in particular,...), and environmental (forest cover, environmental investments, pollution levels, pressures on natural resources,...) variables are interrelated.

[44] Agard, J. and Schipper, E.L.F et al. (2014). Glossary. Annex III, In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [Field, C.B., et al. (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[45] CITMA (2017). Enfrentamiento al cambio climático en la República de Cuba. Life Task (booklet), Havana.

In the process of updating the Cuban economic model, local development is a key component, with an approach that favors a greater degree of autonomy, as well as a more active interrelation between local actors and leverage points, without losing the link with the national development project.[46] In this context, coastal ecosystems are very valuable spaces, and simultaneously very fragile elements, where the complex interrelationships between the different components of the environment unfold.

46 [46] CIEM-UNDP (2021). Cuarto Informe Nacional de Desarrollo Humano Cuba 2019: Cuarto Informe Nacional de Desarrollo Humano Cuba, Havana, 2021

Photo from Lista Quinta Caibarien (16).

2. LEGAL FRAMEWORK AND STATE PLANS FOR CUBA'S COASTAL ZONE

2.1 *Life Task* - objectives and current status

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The State Plan for Confronting Climate Change *Life Task* is - especially as originally intended when approved in April 2017 - a program focused on the coastal zone. This is better understood taking into account that its scientific basis is included in the "Macro-Project on Coastal Hazards and Vulnerability (2050-2100)", undertaken by the Ministry of Science, Technology, and Environment and whose results – ongoing since 2011 - are presented annually to the government.

In 2016, responding to Macro-Project's information, the government mandated, among other details, that the zones, areas, and locales where it was most urgent to act be identified, that efforts and resources be directed to them, and that recovery of beaches and coasts be prioritized. This is how *Life Task* came about.

A quick look at the State Plan confirms how this approach works. Actions 1, 2, and 5 address vulnerable coastal settlements, disallow new housing construction in threatened coastal settlements that are predicted to disappear due to permanent flooding, and encourage reduced population density in coastal low-lying and most vulnerable areas (SA 1); develop construction designs for infrastructure adapted to coastal flooding in low-lying areas (SA 2); and plan urban redevelopment for threatened settlements and infrastructure, starting with lower-cost measures such as induced natural solutions (beach restoration, reforestation). (SA 5).

Task 1 of the Plan (of 11) complies with the mandate to prioritize vulnerable areas, identified in Annex 1 of the State Plan, all referring to the coastal zone. These include measures to manage the most vulnerable human settlements, recover beaches, mangroves and other natural protective ecosystems, plus hydraulic and coastal engineering works, among others.

Many of the remaining Tasks place the same importance on the coastal, as seen by the treatment of beaches (Task 3), reforestation with emphasis on coastal vegetation (Task 5), and protection of coral reefs (Task 6). Task 7 addresses territorial and urban planning, and mentions including the scientific results of the Macro-Project on Hazards and Vulnerability of the coastal zone (2050-2100) in the previously mentioned tasks.

Even when the *Life Task* addresses other issues (food security, water resources management), the coast remains a priority. An example is the priority given to agricultural activities in or near coastal areas, such as rice cultivation, which requires much water. Tourism, also prioritized by *Life Task*, is concentrated along our Cuban coasts.

Although the coastal zone will continue to be a priority scenario for addressing climate change in Cuba, for the new strategic cycle (2021-2025), efforts are being made to further extend the scope of *Life Task* to the entire economic and social life of the country.

2.2 Relocation of settlements

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According to the Third National Communication to the United Nations Framework Convention on Climate Change,[47] in recent years there have been significant changes in the climate of the Caribbean region, particularly in Cuba.

In the future, besides the impact of increases in temperatures (minimum and average annual temperature), rainfall, and intense and prolonged droughts, the average sea level will rise. After all, Cuba is an island state, subject to permanent impacts on coastal areas and, thus, on marine resources, agriculture, forests, human settlements, population, human health and tourism, among other natural and economic resources.

Based on Cuban meteorological models adjusted to world climate representations in geographical detail and on new tide measurements, experts have estimated that along Cuba's coastal areas, there will be an average sea-level rise of 29 cm by 2050 and 95 cm by 2100.[48] Currently in some areas, the coastline has already retreated some 2 to 3 meters.

According to the results of Project 8[49] regarding coastal human settlements, 19 residential areas will be affected by 2050, of which 16 are rural, while 13 will be affected by 2100, eight of which are rural. These areas will transition from emerged to permanently submerged.

In both scenarios, the greatest impacts will be felt by small rural settlements, mainly hamlets (less than 200 inhabitants) and third-order towns (not exceeding 500 inhabitants), with 14 hamlets in 2050 and five in 2100; also, the permanent impact on Havana is only partial: A number of areas will undergo a partial transformation in their use, some of which today are residential.

There are many factors that contribute to the resilience of people and territories: political will, the availability of economic resources, knowledge of the foreseen processes and phenomena, and access to more appropriate technologies, among others. These factors facilitate the search for the most appropriate response and adaptation strategies in light of climate challenges.

Among them is the National Territorial Planning Scheme (ENOT),[50] a territorial planning Instrument that complements the National Economic and Social Development Plan until 2030.

The ENOT, valid until 2030, authored by the National Institute of Territorial Planning

[47] CITMA (2020a). Tercera Comunicación Nacional a la Convención Marco de Naciones Unidas sobre Cambio Climático. Ed. Planos Gutiérrez, E; Gutiérrez Pérez T. Digital version.

[48] CITMA (2020b). Peligros y vulnerabilidad costera (2050-2100). Informe ejecutivo, versión 2.

[49] IPF (2020a). Informe del Proyecto 8. Profundización de las vulnerabilidades al cambio climático en asentamientos humanos costeros y otras áreas a los años 2050 y 2100 y la búsqueda de soluciones de adaptación. Internal document.

[50] Instrumento de Planeamiento Territorial que complementa el Plan Nacional de Desarrollo Económico y Social hasta 2030.
IPF (2014). Esquema Nacional de Ordenamiento Territorial (ENOT). IPF: Unpublished;
IPF (2021). Evaluación anual de la Gestión en la implementación del ENOT. Internal document

and Urbanism (OTU) and approved by the Council of Ministers in 2018, discusses 21 territorial development policies and 75 decisions. The latter include several that address risk-reduction management and adaptation to climate change. For purposes of annual management evaluation, they have been linked to the objectives of the Sustainable Development Goals (SDGs). In addition, each goal has been associated with the objectives of the National Action Plan.

The guiding principle of this process is the protection of the population from current severe hydrometeorological events and from the rise in mean sea level linked to future climate change. Faced with a combination of hazards, the response must always be comprehensive.

The Cuban government has promoted several climate-resilience programs in coastal areas. These include the State Plan for addressing climate change, i.e., *Life Task*, approved by the Council of Ministers in 2017. *Life Task* covers five strategic actions and 11 tasks. It proposes to counteract the impacts of climate change in 15 vulnerable regions of the Cuban archipelago along coastal areas, through adaptation and mitigation measures in the short, medium, and long term.

Life Task mandated the OTU with two general strategic actions, i.e., disallow construction of new housing in threatened coastal settlements that are predicted to disappear due to permanent flooding, and plan the urban reorganization of threatened settlements and infrastructure within a given timeframe, in keeping with Cuba's economic situation.

The Cuban government's resolute political will to address environmental issues is also materializing with the inclusion of natural resources and the environment in one of the strategic areas of the National Development Plan to 2030, and there is a macro-program, which includes two agendas: one for national environmental strategy, with several projects, and another for addressing climate change and early warning systems.

Studies that address disaster preparedness and risk reduction include the Hazard, Vulnerability and Risk Assessment, directed by the Civil Defense General Staff and the Ministry of Science, Technology and Environment (CITMA), with broad participation of specialists from various economic sectors and research centers throughout the country.

Topics such as drought, coastal flooding, heavy rains, landslides, or others related to technology and health, are developed and become mandatory tools for drawing up disaster reduction plans in current scenarios, to update investment feasibility studies and help strengthen government decision-making.Based on the socioeconomic consequences of mean sea-level rise and extreme events, adaptation plans are needed that, based on current scenarios, help reduce vulnerability and increase social, economic, and ecological resilience in coastal areas.

The main priority of the Physical Planning System is anticipating the expected impacts of climate change on coastal human settlements that will be totally or partially affected by the rise in mean sea level, making available to local governments and Central State Administration Bodies (OACE) possible solutions for relocating permanent residents' homes in coastal areas that will be flooded and greatly exposed to the impact of current and future hydrometeorological phenomena, such as flooding from rainfall, sea penetration by upwelling, salt-wedge incursions, and the retreat of the coastline.

Land use planning has regulations for coastal areas, where most of the population is located, not always in the best buildings, with poor drainage, where properties have been affected by saltpeter of varying intensity and sea incursions, sometimes without natural protective barriers, often eliminated by people who want to settle by the sea.[51]

In many municipalities, plans for new development zones (identified within the General Land Use Plan previously updated with the PVR and climate change studies) designated higher and less vulnerable areas of the settlements, or their definitive relocation to other areas in new or existing development zones. Relocation is an extreme option, yet the cost of not relocating is not always economically feasible. In situ solutions require, for example, the existence of efficient drainage; if the area is swampy, deep pillars are required, a very costly option for the state or the population.

Planning requires an updated micro-location study of potential plots for housing construction and an assessment of locational factors (dimensions, physical-geographical conditions, access, and transportation facilities, etc.), together with a description of their routes and all technical infrastructure and basic service solutions in the relocation area. The impacts and scope of any extreme weather event must also be described. This includes a sociological study of the makeup of the settlement and its relationship with key activities such as fishing. If decision makers decide to relocate, a series of locational factors must be resolved - i.e., road infrastructure to connect the new settlement with people's livelihoods, such as a boathouse, a fish processing plant, etc. For example, Surgidero de Batabanó is to be relocated to Batabanó; there is a direct connection between the two locales; another example, Tunas de Zaza will be relocated to Guasimal, and although somewhat far away, a number of roads guarantee its connection to the coast.

The Land Use Plan also calls for surveys to be conducted regarding settlers' preferred relocation options; a consensus is reached with the provincial and municipal housing authorities and other agencies vis-à-vis the areas to be urbanized; partial plans are prepared or updated for habitat development, identifying plots for housing construction. This includes observing urban regulations, preparing all technical documentation, designing the executive project for the housing to be built, and estimating the budget.

This intervention strategy involves applying different housing typologies for better land use and higher densities, progressively and sustainably consolidating existing urban space, and achieving better land management. New construction designs are more resilient than previous ones, since they improve people's living conditions. Although an intervention can seem to proceed slowly, this is due to the care taken in considering resource limitations and the ongoing housing deficit attributable to other situations that hinder the country.

Other options include adaptive ecosystem-based solutions, land-use regulations, building of infrastructure, on-site accommodation, and settlement growth control, among other aspects, for areas affected today and in the long term.

Local governments must include strategies for adaptation and protection against the

[51] IPF (2020b). Informe Balance sobre la implementación del Plan de Estado para el enfrentamiento del Cambio Climático. Internal document.

impact of climate change and associated events in their annual economic plans. This is especially true of the housing program to relocate resident populations exposed to the danger and who will inevitably lose the land on which their buildings sit today.[52]

In relation to good practices and lessons learned, we know that having various projects on tap can lead to establishing a set of policies, regulations, measures, actions, investments, and management plans that are likely to be incorporated into future development plans of municipalities, settlements, or protected areas.

The OTU has also participated in other projects financed by the Adaptation Fund and implemented by UNDP (with support from CITMA and MINAG) for mangrove restoration, such as the concluded *Living Mangrove* project (Manglar Vivo, i.e., reduction of vulnerability to coastal flooding through ecosystem-based adaptation in southern Artemisa and Mayabeque provinces), designed to mitigate climate change exposure of settlements along the southern coastal areas of both provinces.

The objective of the *BIOFIN* project, a multi-institutional platform led by CITMA, is mobilizing financial resources to ensure sustainable management by helping to implement *Life Task* and develop the National Biodiversity Program. Cuba joined in 2016 and resource mobilization strategies have also helped to achieve Sustainable Development Goals.

ECOVALOR, a project in which numerous institutions participate, led by the National Center for Protected Areas (Centro Nacional de Áreas Protegidas-CNAP), facilitates decision making from an environmental-protection perspective and promotes the generation of multiple environmental benefits. The project's premise is based on comprehensive economic valuation of ecosystem goods and services for effective decision making in land, water, and forest polygons and tourist centers in several municipalities and protected areas.

The project called *Increasing climate resilience of rural households and communities through the rehabilitation of productive landscapes in selected localities of the Republic of Cuba* (IRES), implemented by the Ministry of Agriculture (MINAG) with FAO's technical assistance, designed to strengthen resilience during climate change in vulnerable rural communities in Cuba, informs the National Food Sovereignty Plan and *Life Task*. Its objective is to improve food and nutritional security and increase the resilience and stability of local food production systems, as well as employment and access to water.

The *My Coast* Project, implemented by UNDP and designed to last 30 years, will encompass interventions in coastal areas to increase resilience to climate change through ecosystem-based solutions. The project, initially financed by the Green Fund and implemented by CITMA with UNDP support, focuses on protecting coastal ecosystems, building on the results of the coastal resilience project, *Living Mangrove*, while helping to implement *Life Task* and achieve the 2030 Sustainable Development Goals. Actions will seek to increase the adaptive capacity of vulnerable human settlements due to rising mean sea level and extreme weather events. Other adaptations will rehabilitate coastal ecosystems, seagrasses, and coral reefs.

[52] Ibid.

Lessons learned from all projects (conducted by the OTU and other institutions) point to the utmost importance of:

The assistance they lend to vulnerable populations, the real possibilities for adaptation to climate change in all sectors of the economy, and the strength of the ENOT as a mandatory territorial planning instrument.

Replicating experiences to other Cuban coastal zones in the medium and long term.

Having access to economic-financial mechanisms that will strengthen the success of *Life Task* and fulfillment of the SDGs.

Promoting intersectoral work to provide positive practices that contribute to better decision making at all levels of government.

The timeliness of these national and international projects contributes to environmental, economic, and social development, and to strengthening legal and regulatory frameworks, given the irreversibility of this process.

Recognizing the opportunity to implement environmentally valid projects that are also technically feasible, economically viable, socially acceptable, and provide multiple benefits.

2.3 Preliminary Draft Law of the Natural Resources and Environment System

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Background

The history of Cuban environmental legislation dates back to the triumph of the Revolution in 1959, when regulations were issued, also in 1959, to promote reforestation and the creation of National Parks.

Very early on, Cuba included the concept of environmental protection and the rational use of natural resources in its Constitution of February 24, 1976, being the second country in Latin America to incorporate these issues in its Fundamental Law. In 1981, Cuba enacted environmental Law No. 33, "Protection of the Environment and Rational Use of Natural Resources."[53]

To better implement Law No. 33, in 1990 Decree Law 118 was enacted, which regulated the structure,[54] organization, and operation of the institutional system for environmental protection and gave it higher priority by placing the National Commission for Environmental Protection and Rational Use of Natural Resources (Comisión Nacional de Protección del Ambiente y el Usos Racional de los Recursos Naturales-COMARNA), created in 1976, under the Executive Committee of the Council of Ministers.

In 1994, the Central State Administration underwent a reorganization, leading to the closure of the Cuban Academy of Sciences and COMARNA, and the creation of an agency specializing in environmental matters with a broader scope, i.e., the Ministry of Science, Technology, and Environment (CITMA), the governing body of the country's environmental policy with various mandates in this sphere.

To date, Cuba has passed two environmental laws, Law No. 33 and Law No. 81 of the Environment.[55]

The current socioeconomic and environmental conditions driving the country's development require a legal framework consistent with new policies and particularly as a response to the implementation of the inclusive and participatory economic and social model, making it pertinent to update Law 81.

Basics of the proposed law on the system of natural resources and environment

Changes in Cuba's economic and social model as well as profound modifications to the country's institutional and legal framework are the premises for this project. These economic and social changes require the approval and implementation of a group of guiding economic and social policy documents, while legal modifications have a direct impact on the passage of environmental policies. Therefore, these conditions have been included in the draft bill of the Natural Resources and Environment System Law.

The more important approved documents include:

[53] Enacted January 11, 1981.

[54] A structure that currently exists where the steering role over natural resources is decentralized in different OACE.

[55] Enacted on July 11, 1997.

- The Constitution of the Republic;
- The documents of the 7th Party Congress approved by the 3rd Plenary Session of the Central Committee of the Cuban Communist Party (PCC) on May 18, 2017 and endorsed by the National Assembly of People's Power on June 1, 2017, "Conceptualization of the Cuban Economic and Social Model of Socialist Development", the "Basis of the National Economic and Social Development Plan until 2030: Vision of the Nation, Strategic Concepts and Sectors" and the "Guidelines of the Economic and Social Policy of the Party and the Revolution for 2016-2021";
- The 2017 version of the State Plan to Combat Climate Change and the new programmatic documents for its implementation, and the *Life Task* Projections are defined for 2021-2025;
- The State Plan for the prevention and confrontation of crimes and illegalities affecting forest resources, wild flora and fauna, and other natural resources;
- The Economic and Social Strategy for boosting the economy and confronting the world crisis caused by COVID-19;
- Experience in the implementation of the Environmental System Improvement Policy;
- Law No. 131 Law on the Organization and Functioning of the National Assembly of People's Power and the Council of State of the Republic of Cuba.
- Law No. 132 on the Organization and Functioning of the Municipal Assemblies of People's Power and the People's Councils.
- Law 138 of 2020 of the National Assembly of People's Power "On Organization and Functioning of the Provincial Government of People's Power".
- Law 139 of 2020 of the National Assembly of People's Power "On the Organization and Functioning of the Municipal Administration Council".
- Decree Law 6 of 2020, "On the Government Information System".
- Decree Law 10 of 2020, "On National Regulatory Authorities".

INTERNATIONAL CONTEXT

Another basis of the Law is to comply with obligations arising from the multiple international agreements on environmental matters to which Cuba is a party. In recent years, the following have been the most relevant:

- Sustainable Development Goals 2030, the 2030 Agenda for Sustainable Development, was adopted by UN Member States at the 2015 World Summit for Sustainable Development. Aimed at eradicating poverty, protecting the planet, and ensuring prosperity for all people, it set out 17 goals, 169 targets, and a political declaration.
- The Paris Agreement (2015) is a legally binding international treaty on climate change, which establishes the premises and commitments to establish a global strategy to address climate change post 2020.
- The Minamata Convention on Mercury (in force since 2017), establishes a series of international rules on cooperation and measures limiting the use of mercury and

its compounds. A further objective is to control and reduce anthropogenic releases (discharges and emissions) of mercury and mercury compounds into the atmosphere, air and soil.

Objectives of the proposed law

The draft bill of the Natural Resources and Environment System Law is the result of implementation of the "Policy for the Improvement of the Country's Environmental System."[56] It also helps:

- Provide substantive elements for the protection and sustainable use of natural resources and the environment, which serve as a basis for the exercise of the "right to a healthy and balanced environment", embodied in the Constitution of 2019.[57]
- Implement the Bases of the Economic and Social Development Plan to "2030", and in particular the three General Objectives and the 21 Specific Objectives of the "Natural Resources and Environment" Area.
- Provide greater integration in the implementation of other policies related to natural resources (water, fisheries, aquaculture, among others), or related to environmental management and quality (recycling, among others).
- Legally reflect various elements of the environmental dimension of development, as included in the 2030 Sustainable Development Goals.
- Increase the participation of territorial governments in environmental management, while contributing to the empowerment of local popular power, particularly municipalities as the highest authority in the territory.[58]
- Reflect an advance with respect to the current framework established in Law 81/1997, in light of the institutional, economic, and social changes that occurred in Cuba during these two decades and the evolution of worldwide environmental thinking.
- Strengthen CITMA's role as the lead agency for the systemic integration of policies for the protection and sustainable use of natural resources and the environment.
- Improve the instruments of environmental policy and management in accordance with domestic and international contexts.
- Implement the ecosystemic approach to environmental management.
- Position the concept of the Natural Resources System, covering all areas of attention related to natural resources and the environment, without duplicating or overlapping other institutional responsibilities, while respecting all sectoral and subject-specific responsibilities established by previous regulations, but providing an integrating framework for all responsibilities to be expressed in a systemic and coordinated way, with respect to the management of the environment and natural resources.
- Assimilate the best ideas and concepts coming from the evolution and practice of international environmental thought, which are included due to their coherence with

[56] Approved in January 2019.

[57] Article 75 of the Constitution of the Republic of Cuba, approved by the National Assembly of People's Power, in its Second Ordinary Period of Sessions, of the IX Legislature on April 10, 2019 and previously ratified by popular referendum on February 24, 2019.

[58] Article 185 of the 2019 Constitution.

the objectives and principles of the Guidelines and the Model for the development of socialism in Cuba.

- Incorporate obligations assumed by the state as a party to multiple international agreements on environmental matters.
- Incorporate new environmental issues. Climate change, sustainable production and consumption; pollution control; environmental accounting; economic valuation of ecosystem goods and services; access and benefit sharing of genetic resources; among others.
- Incorporate environmental damage into the civil and criminal liability system.

Due to the scope and content of application of this "Law", numerous complimentary provisions are needed, which is why it is an "umbrella" or "framework" law, following the model currently used in Cuba. Thus:

- It is complemented by the regulations issued under Law No. 33, which remain in force.
- It includes the complementary regulations issued under Law 81 for its implementation.
- It aligns with all existing provisions related to natural resources, including the recent Land Water Law, the Fisheries Law, Law on Conservation, Improvement and Sustainable Management of Soil and the use of fertilizers.

Based on the principle that everything "environmental" is a dimension of development, the draft bill proposes that it should involve Cuba's entire legal system, starting with the Constitution itself, where the principle is already enshrined with greater authority.

STRUCTURE OF THE PRELIMINARY DRAFT BILL

The structure of the bill is based on 186 articles, 23 more than Law No. 81, grouped as follows. We briefly comment on its most relevant aspects:

Expository Part: Three foundations that describe the objective and purpose of the Law, highlighting the premises that make the constitutional right to a healthy and balanced environment a reality, in an ideological political context that defines the Cuban model.

Dispositive Part: Eight titles, each with chapters and some with sections.

a) **TITLE I SCOPE, OBJECTIVES, AND PRINCIPLES**

This title contains important additions and modifications, particularly those that extend the regulatory scope to all "natural and legal persons, nationals or foreigners who are within the national territory" without discrimination of their legal or temporary status.

The general and specific objectives are broader and more comprehensive, incorporating emerging environmental law issues such as climate change and plastics, to mention just a few.

Also highlighted is the development of principles announced in Law No. 81 (precautionary principle, principle of participation with transparency, access to information and spaces and means for participation, among others). Also underscored is the incorporation of new principles (sustainable production and consumption, circular economy and the principle of non-regression, responsible

financing, being the most prominent).

b) **TITLE II INSTITUTIONAL FRAMEWORK**

Under this heading there are several novel aspects, including the creation of the "Natural Resources System"; strengthening CITMA's governing role on the environment; decentralization of environmental management in local entities of popular power in the territories; and mechanisms for conflict resolution in matters related to the protection of the environment and the rational use of natural resources.

c) **TITLE III NATURAL RESOURCES SYSTEM**

This is one of the most extensive sections, since each chapter deals specifically with a natural resource and sets forth the law regarding the special legislation in force, so that on relevant occasions one can refer to this legislation for rules of reference.

This section highlights the incorporation of a chapter "Marine and Coastal Waters and Ecosystems", with a section on the specifics of these ecosystems; this means there has been significant progress in relation to the current law in force by incorporating the ecosystem approach to environmental management. Several new aspects are included, the most important of which are:

a) The coastal zone and its protection area are also regulated, which backs up replacing current Decree Law 212 on Coastal Zone Management and the need to establish regulations.

b) It defines obligations in relation to protection, conservation, and sustainable use for the Ministry of Food Industry;

c) It conditions licenses issued by the Ministry of the Fishing Industry for the introduction of species, subject to the express authorization of the Ministry of Science, Technology, and Environment.

d) It establishes specific obligations for the Ministry of Science, Technology, and Environment in relation to the coastal zone and its protection area.

d) **TITLE IV NATURAL DISASTERS**

This section incorporates greater use of science and technology and effective and efficient integrated risk management, with the active participation of communities, entities, local bodies, and society in general, to minimize damage, reduce coastal vulnerability for settlements threatened by rising sea levels, enable better economic assessment of the impact of disasters and the costs of adapting to the effects of climate change, thus making it possible for affected areas and populations to recover rapidly in an organized fashion.

e) **TITLE V ENVIRONMENTAL QUALITY**

This section includes actions related to environmental quality and pollution prevention and control; regulations on emissions and technology transfer. Atmospheric pollution is included as an area that needs attention and thus the responsibilities of individuals and Órganos de la Administración Central del Estado regarding atmosphere pollutants are defined.

In addition, a fund operated by the Ministry of Science, Technology, and the Environment was established to strengthen skills for safe management of wastes generated by any legal entity.

Plastics and environmental liabilities are regulated for the first time.

f) **TITLE VI ADDRESSING CLIMATE CHANGE**

For the first time the issue of climate change is given legal protection in Cuban environmental legislation; as an umbrella regulation it establishes norms and general provisions for development of the State Plan to Confront Climate Change, while regulation is defined in the Decree on Climate Change that accompanies the draft bill of the Law on the System of Natural Resources and the Environment.

The law designates the Ministry of Science, Technology, and Environment to propose and control policies that address climate change, which includes actions to reduce greenhouse gas emissions, increase their absorption, reduce vulnerabilities, and increase adaptation and resilience, given their impacts on Cuba's economy and society.

It provides for the incorporation of new tools for environmental management in the field of climate change, among them the "Nationally Determined Contribution", the "National Greenhouse Gas Inventory", the "National Reports", and the "Measurement, Registration, and Monitoring System".

g) **TITLE VII NUCLEAR AND RADIATION SAFETY**

Due to the relevance of the subject and the number of legal norms that are included in its normative framework, the subject is grouped under one section and its main objective is to define CITMA's competence in the matter.

h) **TITLE VIII INSTRUMENTS OF ENVIRONMENTAL MANAGEMENT**

This is the longest section of the project. It pulls together the instruments of environmental management and establishes specific rules for each one. Most of the instruments have important modifications, updates, and additions.

Final Part: Two Special Provisions and Five Final Provisions

In these special provisions, coordination between the environmental authority and the agency in question are regulated as a mandatory requirement when it is necessary to carry out state environmental inspections, grant or control an environmental license, and undertake an environmental impact assessment, when developed regarding areas or activities of the ministries of the Revolutionary Armed Forces or of the Interior. This means that there is never any exemption to performing these control activities.

The provisions also provided that the rules for the operation of rescue and rehabilitation centers shall be established within two years following the implementation of this law.

New elements incorporated into the draft bill as a result of specialized and public consultations

- Extend the scope of the law to new forms of non-state management of the economy.
- Broaden the scope of the Forest Heritage protections, to include not only cutting down trees, but also the entire tree cover, including trees outside forests.
- CITMA's role vis-à-vis the other OACEs that by law manage natural resources and the role of the Council of Ministers in settling discrepancies in environmental matters.
- CITMA's actions in the face of environmental damage, declaring such damage, as well as the power to arrange for rehabilitation or repair measures.
- A proposal would add the circular economy.
- Address the issue of sustainable use and management of karstic resources.

Challenges

- Establish the prevalence of the Law on the System of Natural Resources and the Environment vis-à-vis approval of high-ranking regulations, as a response to public policies on natural resources (Law No. 124 on Land Waters, of 2017; Law No. 129 on Fishing, of 2019; Law No. 145 on Land and Urban Planning and Land Management, of 2021; Decree Law No. 50 on the Conservation, Improvement and Sustainable Management of Soils and Fertilizer Uses).
- Exercise CITMA's leading role in environmental management and manage natural resources with an ecosystemic approach within the country's institutions.
- Incorporate science and technology transfer for solving environmental problems.
- Source the necessary funding to implement the law.
- Build capacity to implement the law.

2.4 Food Sovereignty and Nutritional Education Plan

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The concept of food sovereignty was developed by Via Campesina and brought to a public debate at the World Food Summit in 1996. It offers an alternative to neoliberal policies by providing people with the tools for their struggle for the right to land and fair food.

Article 77 of the Constitution of the Republic of Cuba states that "*All persons have the right to healthy and adequate food. The state creates conditions that strengthen food security for the entire population*".

To fulfill this commitment, the state has promoted a Cuban Food Sovereignty and Nutrition Education Plan (Plan de Soberanía Alimentaria y Educación Nutricional de Cuba-SAN Plan) with organized, sovereign, and sustainable local food systems to promote the mobilization and conservation of local resources for food production, transformation, and commercialization. This is a challenge that can be transformed into successes for the resilience and sustainability of these systems in all of Cuba's municipalities and coastal areas.

Taking into account Cuba's socioeconomic conditions, food sovereignty is defined as: "*The capacity of the nation to produce food in a sustainable manner and provide access to the entire population to sufficient, diverse, balanced, nutritious, safe, and healthy food, reducing dependence on external means and inputs, with respect for cultural diversity and environmental responsibility*".

The conceptual basis of this definition is based on four components containing the essential elements that favor resilience to climate change. They can be broken down as follows:

1) **Sustainable production model** with an agroecological approach to production and conservation of natural resources, strengthening socio-ecological resilience, adaptation, increasing technological sovereignty, and climate change mitigation.

2) **Transformation and commercialization** to guarantee the health, safety and quality of food, affordable prices for consumers, reduced harvest and post-harvest losses, use of by-products, accessibility and diversity of packaging, formats and presentation of products, increase in local processing capacity.

3) **Access to resources** that mobilizes local resources to minimize dependence on external inputs, conservation of phyto- and zoogenic resources, local management of productive inputs, integration of scientific management and innovation, increased incentives to reverse internal rural migration, and continuing job stability.

4) **Nutritional education for food sovereignty** deals with the contribution to nutritional education within the health and education systems, communication by the entities and means available at all levels, and value formation to shift towards sustainable lifestyles.

The cross-cutting components of the SAN Plan address the equity of women and men in food production, and engagement of a greater number of young people into agricultural activities.

Cuba's Food Sovereignty and Nutritional Education Plan is implemented in the municipalities through a Municipal Commission with all sectors of the economy participating, in addition to social organizations, education, health, and sports systems. In the country's 89 coastal municipalities, with a population of approximately 5,247,000, these commissions work harmoniously, grounded in a local diagnosis according to the geographic and cultural characteristics of each municipality, and carry out activities that contribute to food sovereignty.

Some of the four components refer to the expansion of the agroecological approach in all food production and transformation, mobilization of local resources to promote diversity, and conservation of native zoo and phytogenic resources and their use with respect for cultural diversity. They also encourage the sustainable management of natural resources in general, as well as soil and water, while promoting the use of renewable energy in order to strengthen socio-ecological resilience and minimize the effects of climate change.

2.5 State plan to counter wildlife trafficking

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Antonio Núñez Jiménez Foundation for Nature and Mankind (FANJNH)

According to the Sixth National Report of Cuba to the Convention on Biological Diversity (CBD), submitted in 2019, the factors affecting the loss of biological diversity involve habitat fragmentation, environmental pollution, rural and forest fires, unsustainable agricultural practices, illegal fishing, hunting, and tree cutting, illegal trade in flora and fauna species, introduction and inadequate control and management of invasive species, as well as the insufficient attention to genetic resources.

Crimes against natural resources threaten not only biodiversity conservation, but also state security and the well-being of inhabitants. One of the difficult scenarios we face is the undesirable upward trend in criminal activity against our biodiversity, landscapes, and natural resources. Thus, it became necessary to implement in Cuba the *Governmental Plan for the prevention and confrontation of crimes and illegalities that affect forests, wild flora and fauna, as well as other natural resources.*

This Plan was approved on March 20, 2020 by the Council of Ministers. In that session, Colonel Manuel Lamas González, head of the Forest Ranger Corps and coordinator of the Plan, highlighted the frequency with which criminal acts occur related to logging, possession, transportation, and commercialization of timber; illegal hunting, fishing, and illegal capture for sale of terrestrial and marine species. There is also unauthorized artisanal mining, extraction of sand, filler, pottery clay, and slate slabs; contamination from illegal dumping, damming, and diversion of rivers for crop irrigation; plus, trafficking of flora and fauna species at border checkpoints.

The Plan's main objective is to provide greater coherence to how institutions counter these crimes, combining administrative, regulatory, control, and operational measures for greater comprehensiveness and effectiveness to combat illegal activities that damage natural resources. This also involves direct coordination with CITMA and a group of civil society entities to work on awareness raising, communication, and citizen education to raise awareness of the need to protect our biodiversity, ecosystems, and landscapes. We call the interaction with this group Geosilvestre.

This government Plan is the result of a rigorous study of deficiencies in the management of natural resources and is the starting point and theoretical support for these activities. It is a comprehensive and cross-cutting program for the entire society, giving state organizations and institutions a leading role in implementing social objectives such as protection and sustainable use of the environment. This state policy seeks to curb the impacts of the illegal capture, collection, use, and trade of wildlife species on the density, demography, behavior, phenology, gene pool, and viability of native, endemic, and endangered biota populations.

After the approval of the Plan, coordinated groups were formed in all provinces that incorporated different sectors: Ministries of Tourism, Construction, Education, and Agriculture, the National Institute of Land and Urban Management, the Customs Administration, and CITMA.

In the case of Matanzas, it joined with the 2030 Economic and Social Development Agenda, specifically through the Natural Resources and Environment Macro-Program. This falls within the Environmental Strategy Implementation Program, specifically the Biodiversity Protection, Use, Access, and Conservation Project, in line with policies such as the National Environmental Strategy, the National Biodiversity Plan, and *Life Task*.[59]

The Office of Environmental Regulation and Security**,** ORSA, is also in charge of enforcing this plan. Joint state inspections carried out in protected areas deter illegalities committed against wildlife, protected by Resolution 160 and several international conventions to which Cuba is a signatory. In the process of implementing the government plan, numerous legal norms were updated to give priority to this issue, including the new Animal Welfare Law, with the approval of Decree Laws 31 and 48, which regulate how to treat this aspect of the plan.

In line with implementing Geosilvestre to coordinate the communication efforts that accompany executing the state Plan, CITMA issued Resolution No. 365 of 30 December 2020; this resolution approved the communication activities that accompany the *government Plan for the prevention and confrontation of crimes and illegalities that affect forest resources, wild flora and fauna, and other natural resources.*[60]

The Resolution indicated the main problems: lack of interaction between the agencies responsible for managing resource protection; some cadres lacked awareness of the importance of environmental conservation; lack of attractive and systematic media coverage of the issue; and the disconnection between the governing bodies, academia, and civil society. The Resolution also stressed the need to promote a culture that allows people to live together without damaging nature and prevent infractions that cause environmental damage, such as forest fires, indiscriminate logging, illegal and undeclared fishing, poaching, and commercialization of endemic and migratory birds, extraction of sand from rivers and beaches, diversion of riverbeds, artisanal and small-scale mining, lime kilns, and importation of exotic species.

Since the Resolution was issued, our group of Cuban civil society organizations coordinates activities with CITMA that focus on communication and awareness-raising, while providing relevant information on the damage to diverse Cuban biodiversity and landscapes. The Antonio Núñez Jiménez Foundation for Nature and Mankind, the Cuban Zoological Society, the Cuban Botanical Society, and the Ariguanabo Foundation are the principal actors in this group. We are also trying to obtain resources from international cooperation agencies to implement the products identified at numerous planning sessions and coordinate a communication strategy aimed at society as a whole.

We recognize the need to change certain laws to abolish the false and ingrained idea that these acts are not crimes and to stress that they are punishable by substantial penalties that aim to deter violators. Ongoing consultation and discussion of the draft bill of the Law of Natural Resources and the Environmental System of the Republic of Cuba are defining environmental crimes and resulting damages; these considerations are to be

[59] Nelvis Elaine Campos Gómez, subdelegate of the Environment of CITMA in Matanzas.

[60] Extraordinary Official Gazette No. 5 of 20-1-2021.

included in the changes being made to the new Cuban Penal Code. This Code will define individual and institutional responsibilities, restitution of damages, and corresponding prison sentences.

Our Foundation has already held several events to coordinate the Geosilvestre implementation strategy, so that diverse actions complement each other and are synergistic. Our hope is that they will fill existing information and knowledge gaps and identify the target audiences for each action. Further, ideally our communications must have a large educational content and promote knowledge. We held a workshop at our headquarters with several specialists and contributors to refine the work strategy, identify knowledge gaps, and plan our next steps.

No less important was our joint background work with other national specialists to draw attention to the impact of illegal international trade (trafficking) of endemic Cuban arboreal land snail shells. This genus of snails, *Polymita*, includes six species with multiple color forms that are in great demand among collectors. Due to the danger and threat posed to the species *Polymita sulfurosa,* which presents a low population density and has almost disappeared from its traditional localities, we managed to include the entire genus in CITES, at the request of the Cuban authority. Polymites and other arboreal mollusks also experience the impacts of illegal timber extraction when the trees they inhabit are cut down. Wood from felled trees is used in carvings and other handicrafts sold to tourists.

We hope that this plan will keep many of our most charismatic species from becoming listed in CITES, avoid serious threat to fragile ecosystems, sensitize our population that we have to coexist harmoniously with nature in order to receive the benefits of these ecosystems, and increase our resilience as a nation in times of climate change. We needed a plan like this; now that we have it, let us work together to implement it.

Our Foundation believes it is essential for us to continue our founder's legacy of fostering in Cubans a culture of nature, promoting values of harmonious coexistence with all life, resources, and landscapes of our archipelago.[61]

[61] **References: 1.** Official Gazette No. 5 (extraordinary) of 2021. Resolution 365 of 2021, of the Ministry of Science, Technology, and Environment of Cuba, grants approval of the communication activities that accompany the *Governmental Plan for the prevention and confrontation of crimes and illegalities that affect forest resources, wild flora and fauna and other natural resources*. **2.** Juriscuba website. Main legal provisions related to the Ministry of Science, Technology, and Environment, of interest to our users, Resolution No. 365 of 12-30-2020 grants approval of the communication activities that accompany the *Governmental Plan for the prevention and confrontation of crimes and illegalities that affect forest resources, wild flora and fauna and other natural resources*. (Official Gazette No. 5 (extraordinary) of 20 January 2021).

Photo by Dan Whittle

3. CHALLENGES AND OPPORTUNITIES FOR CUBA'S COASTAL COMMUNITIES: ECONOMIC SECTORS AND SOCIAL AND ECOSYSTEM SERVICES

3.1 Biodiversity conservation

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Due to Cuba's regional ecological connectivity, we face a challenge of building resilience in coastal communities. We need to understand local interests expressed through comprehensive and collective action at that level, but we also need management with a regional perspective that protects biodiversity resources and natural processes that have implications for all Caribbean coastal communities. The changes we promote in individual and family behavior and the modifications in policies and regulations for access and use of resources can have positive or negative repercussions on the resilience and sustainability of coastal communities' livelihoods in other areas of Cuba or neighboring countries.

Cuba has developed a relatively strong legal and environmental policy framework for the conservation and sustainable use of marine and coastal resources, and thus has many opportunities to strengthen the resilience of coastal communities. However, this framework lacks a comprehensive national ocean policy, generally does not explicitly consider climate change, and some of its key features for resilience and adaptation need improvement.[62] Other key attributes, however, such as the role of science and multiple dimensions of ecological organization, coordination among different user groups, and attention to multiple spatial dimensions, have been thoroughly considered.[63]

Cuba's system of protected areas is representative of the diversity of the main marine-coastal ecosystems, protects more than 25% of these systems,[64] and is in the process of incorporating climate change into its planning; nonetheless, it has yet to strengthen management effectiveness in some areas. At the same time, the country is engaged in developing a fishing system whose

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http://juriscuba.com/organismos-estatales-2/ciencia-tecnologia-y-medio-ambiente/ **3.** Granma Newspaper, August 19, 2020. Díaz-Canel: Defender nuestra Patria es también proteger su flora y fauna. Cuba cuenta con un Plan gubernamental para enfrentar los delitos que atentan contra la integridad de nuestros recursos naturales Author: *Abel Reyes Montero.* **4.** Cuban News Agency, March 27, 2020. Council of Ministers Session: frente a la adversidad, Cuba saca a flote sus fortalezas. *Author*: *Leticia Martínez*. **5.**TV Yumurí, January 4, 2022. Enfrenta Plan gubernamental ilegalidades contra los recursos naturales. Author: Lyl Jiménez Rodríguez. **6.** Granma Newspaper, June 25, 2021. Denuncian aumento del comercio ilícito de especies de la biodiversidad. *Author: Redacción Nacional internet@granma.cu* **7.**Periodismo de Barrio (independent platform) 30 March 2021 By Olivia Marín Álvarez ¿Cuáles son los delitos contra los recursos naturales en Cuba? **8.**Sixth National Report of Cuba to the Convention on Biological Diversity (CBD), presented in 2019 https://www.cbd.int Spanish version **9.**Journal 26 de las Tunas, December 15, 2021. Publica el CITMA actualización de la legislación sobre recursos naturales y medio ambiente. *Author: Yuset Puig Pupo.*

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[62] For example, mechanisms to implement marine spatial planning, adaptive management, and the precautionary approach. For a more complete analysis of the framework for marine conservation policies in Cuba see: Gerhartz-Muro, J. L., Kritzer, J. P., Gerhartz-Abraham, A., Miller, V., Pina-Amargós, F., & Whittle, D. (2018). An evaluation of the framework for national marine environmental policies in Cuba. Bulletin of Marine Science, 94(2), 443-459. doi:https://doi.org/10.5343/.

[63] Ibid.

[64] Perera Valderrama, S., Hernández Ávila, A., González Méndez, J., Moreno Martínez, O., Cobián Rojas, D., Ferro Azcona, H., ... Rodríguez Farrat, L. F. (2018). Marine protected areas in Cuba. *Bulletin of Marine Science, 94*(2), 423-442. doi:https://doi.org/ 10.5343/bms.2016.1129

legal framework is committed to sustainability and has explicitly included the precautionary principle, although the climate dimension is not included in this legislation.[65] Significantly, Cuba has developed a national and cross-sectoral State Plan to confront climate change, i.e., *Life Task*,[66] which fills many of the gaps that other instruments have, and is implementing a National Program for Economic and Social Development to 2030, which is committed to an environmentally, socially, and economically sustainable future. Yet, the way in which these policies and the legal framework may or may not facilitate building resilience in marine ecosystems and communities will depend on how these instruments are interpreted and implemented.

The path to sustainability in a changing climate in Cuba, which involves building resilient communities, is by no means free of obstacles or gaps. There are numerous threats to marine and coastal biodiversity that need to be mitigated to improve the resilience of coastal communities, but which add complexity to possible solutions. The more outstanding challenges include marine and land-based pollution, destruction of key habitats, invasive species, illegal fishing and harvesting of threatened species, coastal development and tourism practices that affect the environment or have a high ecological footprint, unsustainable fishing practices, altered freshwater flow systems, and climate change itself.[67] To deepen the complexity of the challenges posed by these threats, take for example one of the fundamental economic activities for the livelihood and resilience of the country's coastal communities: fishing.

Due to a combination of multiple factors, Cuban fisheries have been experiencing a continuous decline that threatens their resilience.[68] Overfishing and unsustainable practices, the drastic reduction in the flow of freshwater and nutrients to estuarine ecosystems, which are key to the reproduction and sustainability of many commercial species, hurricanes, the deterioration and loss of key habitats due to various causes, direct or overlapping incentives for overfishing, and insufficient control and effective enforcement of regulations have contributed to the critical state of most of Cuba's fishery resources.[69] All these factors have led to the fact that 20.2% of fishery resources in Cuban maritime waters are fully exploited, 74.4% are overexploited, and 5.2% have collapsed.[70] Making fisheries sustainable and resilient urgently requires reducing and effectively controlling fishing, renewing enforcement of regulations, reducing illegal and unreported fishing, eliminating unsustainable practices such as mass fishing of spawning schools, restoring key degraded or altered habitats such as estuarine ecosystems and coral reefs, and promoting and implementing sustainable practices and innovative fisheries management systems. We should also mention economic alternatives and incentives that help move fishing communities towards sustainability and resilience.

To ensure that marine and coastal ecosystems can withstand the predictable battering brought by climate change, and thus build resilience and adaptive capacity in coastal

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[65] National Assembly of People's Power (2020). Law 129 of 2019 - Fisheries Law. *Official Gazette (*No. 11 Ordinary), 313-320.

[66] CITMA (June 2, 2021). *Life Task:* Plan de Estado ante el Cambio Climático / *Cuba.* Retrieved from https://www.citma.gob.cu/ tarea-vida-plan-de-estado-de-enfrentamiento-a-cambio-climatico-en-cuba/

[67] Gerhartz-Muro, et al., 2018.

[68] Baisre, J. (2018). An overview of Cuban commercial marine fisheries: the last 80 years. *Bulletin of Marine Science, 94*(2), 359-375. doi:10.5343/bms.2017.1015.

[69] Baisre, J., & Arboleya, Z. (2006). Going against the flow: effects of river damming in Cuban fisheries. *Fisheries Research, 81*, 283-292. doi:10.1016/j.fishres.2006.04.019; Baisre, 2018)

[70] Baisre, 2018.

communities, marine conservation should be front and center in a country where 75% of its territory is in fact sea. Threats that put pressure on marine-coastal ecosystems and populations of species critical to the ecology and the economy must be reduced to a minimum. We also need to update and improve various legal and policy instruments so that they can explicitly apply the precautionary principle, establish mechanisms that favor adaptive management, promote an integrated planning approach that focuses on marine-ecosystem connectivity and that of terrestrial ecosystems with the latter, thus leading to the development of financial mechanisms that favor and encourage local initiatives in sustainable resource management associated with biodiversity. In addition, much work still needs to be done to strengthen the technical capacity for spatial planning and conservation, integrated, sustainable and adaptive marine-resource management with a participatory and holistic approach.

A major challenge will be to achieve the voluntary, open, and cooperative participation of local communities in integrated resource planning and management. This requires a better understanding of the relationships between stakeholders in communities and at other levels, and the possible alignment, overlap, and competition of their interests. Without this it will be difficult to identify and assess barriers and enabling conditions that may hinder or lead to stakeholder engagement and cooperation in management.[71] Yet perhaps the greatest challenge will be to urgently and efficiently solve the aforementioned gaps and problems, and to achieve the necessary paradigm shifts in a context of monetary reform and economic crisis deepened by the impact of the COVID-19 pandemic and the consequences of the prolonged economic and financial blockade by the United States that has intensified in recent years. In today's complex political and socio-economic environment, policy makers may find it difficult to decide in favor of long-term sustainability and resilience when day-to-day needs and urgencies are pressing. In a more favorable economic scenario, for example, high demand for food might induce agricultural intensification. This, however, could cause widespread negative impacts on marine-coastal biodiversity,[72] which has already happened to fish and shellfish populations in the Gulf of Mexico in the southern United States.[73]

Any development project should be approached with caution, with careful consideration of the trade-offs between the pursuit of economic growth to satisfy immediate needs and the conservation of biological diversity and ecosystem services that sustain coastal communities and essential activities such as tourism. Innovative and effective ways must be found for policy makers, coastal communities, and marine-resource users to become truly aware of the challenges we face and the urgency of creating development models with nature-based solutions that allow us to adapt to climate change, strengthen the resilience of ecosystems and communities, and provide ecologically sustainable, socially just, and economically efficient livelihoods, thereby contributing to a prosperous future for the entire Caribbean region.

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[71] Gerhartz-Abraham, A., Fanning, L., & Angulo-Valdés, J. (2016). ICZM in Cuba: Challenges and opportunities in a changing economic context. Marine Policy, 73, 69-76. doi:http://dx.doi.org/10.1016/j.marpol.2016.07.009.

[72] Roman, J. (2018). The ecology and conservation of Cuba's coastal and marine ecosystems. Bulletin of Marine Science, 94(2), 149-169. doi:10.5343/bms.2017.1164.

[73] Rabalais, N., Turner, R., & Scavia, D. (2002). Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. Bioscience., 52, 129 -142. doi:doi.org/10.1641/0006-3568(2002)052[0129: BSIPGO]2.0.CO;2

3.2 Fisheries

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Beyond its economic importance as a source of foreign exchange and its modest contribution as a food source, fishing in Cuba has a long history and a rich cultural heritage, dating back to our indigenous ancestors, later enriched by people from Galicia and the Canary Islands, and most recently manifested in the limitless ingenuity of today's fishers. Before 1959, however, fishing held a very difficult socio-economic position because of the scant payment fishers received for their catch. In addition, fishers did not always return to port with a good "tide," despite the enormous physical effort that they often made on their daily trips to the sea. Back then, solitary fishers in small boats would drag their trolling lines in the waters of the Doce Leguas Archipelago in search of a few mackerel. Oyster collectors in canoes or flat-bottomed barges would troll the waters of the dense mangroves, and, according to their own accounts, "paid for their catch with blood", either because they cut their hands trying to detach oysters from where they were anchored or they incurred bites from mosquitoes and gnats that abounded in such places. Even officials were forced to recognize the dramatic situation faced by fishers: "... It is a human overflow that, lacking land for cultivation and other resources, improvises dwellings by the sea and with rudimentary gear sets out to conquer a livelihood. In the hazardous work of fishing, with the limited means at fishers' disposal, they have no guarantees of any kind for their personal safety or to provide for their families' most basic needs".[74]

The first years of the revolutionary government saw numerous measures implemented that aimed to radically change the prevailing situation for fishers. Initial steps included:

- Grouping the labor force into fishing cooperatives
- Building communities for fishers
- Elimination of middlemen
- Raising and stabilizing fish prices
- Manufacturing boats and fishing gear
- Developing deep-sea fishing

After more than six decades of intensive exploitation, Cuba's fishery resources and marine ecosystems are threatened by overfishing, pollution, climate change, deterioration of coastal areas, and drastic transformations in the river systems that drain into the coast. While locally we can do little to halt or change global warming trends, policies to protect and rationally use the country's marine resources can help increase resilience to climate change and other disturbances, thus contributing decisively to their sustainability. In addition, increasing the resilience of coastal ecosystems can also increase the resilience of coastal communities. For most people residing in many of these communities, fishing is almost the only source of income and there are few economic opportunities that can improve their quality of life without

[74] Gerardo Canet, an official at Cuba's Agricultural and Industrial Development Bank, which in 1952 created the Center for Fisheries Research.

negatively affecting environmental and marine resources. The vulnerability of these settlements is also due to extreme weather events, given that they are located in low-lying areas near the coast. Furthermore, the solution to many of the problems that affect fishing and marine ecosystems are intimately related to what happens in higher coastal areas. Throughout history, coastal areas, including the largest and most important estuaries, harbors, and bays in the world and in Cuba, along with beautiful, unique white sand beaches, have attracted humans to visit, settle, fish, set up industries, and extract minerals. Also, practically all inland socioeconomic activities, i.e., agriculture, industry, mining, tourism, commerce, health, and education, have some influence on coastal areas. In one way or another, the waters flowing from rivers, through surface or subterranean runoff, plus sewage and graywater from sewage systems, all end up in coastal areas. Because all activities that take place at higher elevations eventually influence coastal areas, and accounting for the main island's long and narrow shape, all of Cuba could be considered a large coastal area, split into northern and southern regions by a divide that practically crosses it from east to west, cutting the main island in half. Thus, very few Cubans live more than 50 kilometers from the coast and, at Cuba's widest point, none live more than 95 kilometers away.

Given these considerations, policies aimed at achieving rational utilization of living marine resources should focus on: 1) reducing the fishing effort and definitively eliminating catching methods that use unselective gear; 2) integrated management of river basins, taking into account the decisive importance of rivers for estuaries and coastal lagoons, as well as their substantial influence on the sustainability of fisheries, ecosystems, and coastal areas; 3) reducing marine pollution, especially in the large bays, as well as pollutants that accumulate in the food chain and pose serious risks to human health; 4) development and consolidation of marine reserves as a key element for preserving aquatic spaces that contain most of the marine biodiversity, thus increasing the resilience of neighboring areas. Last, but no less important, efforts will be needed to reconcile the conflicting interests and needs of various economic interests that exert increasing pressure on marine resources and ecosystems, as is currently the case with commercial, state and private fishing, recreational sport fishing, and the needs of the tourism industry.

None of these measures, however, would be effective without adequate control and surveillance mechanisms to enforce compliance and reduce the impacts of illegal fishing, unregulated fishing, the use of prohibited fishing methods and devices, the cutting down of mangroves, and the pollution of coastal areas. To counteract any initial negative effects caused by implementing such measures, other ways of communing with nature could be developed, such as SCUBA diving and recreational catch-and-release fishing and, above all, linking these activities to the domestic and international tourism industry. The growing boom of this industry, whose strongest attractions include natural beauty, particularly beaches and seas, involve increasing space for sport fishermen or for those who practice contemplative diving or underwater photography. The marine protected area located at the Doce Leguas Archipelago is an example of what can be achieved and an alternative that could be scaled up very quickly.

Identifying Pathways for Climate-Resilient Multispecies Fisheries: Multispecies Finfish Fisheries Management in Cuba

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Fishery Characteristics

Fisheries in Cuba are an important source of food, income, and livelihoods. Most fisheries occur in the coastal zone, within a mosaic of high biodiversity mangrove, seagrass, and coral reef habitats that provide numerous ecosystem services, including fisheries.[76] The tropical waters around Cuba are very diverse, and fisheries exploit more than 150 different species.[77] Landings can be divided fundamentally into fish (e.g., finfish, sharks, and rays), lobster, shrimp, mollusks, and sea cucumber, among other resources. Fish represent the largest volume of total landings (62%), but from an economic perspective, spiny lobster and shrimp are the most important.[78]

The Cuban fleet is very diverse and consists of approximately 9,500 vessels, divided into three categories: state-owned fleet, private fleet, and recreational vessels, but only the first two operate commercially. Within the state-owned fleet, 385 vessels are between 15 and 20 m in length and target the multispecies fish fisheries, accounting for approximately 90% of the total catch of these species (Table 1). The private fleet is comprised of 3603 smaller private vessels, most of them less than 15 m in length, with commercial access only to fish fisheries under a strict contract with state-owned companies. While most private vessels operate close to their home ports, this fishery has no territorial use rights (TURFs).

The most typical fishing gears are purse seines, gillnets, pots, bottom and surface longlines, and hook and line. Fixed nets or trammel nets were banned in 2008 and trawls in 2012[79] (Table 1). Many landing ports and the wide diversity of vessel types, fishing gear, and target species make it difficult to create and implement monitoring programs and estimate fishing effort, reference points, and resource status. Previous status estimates have been limited to descriptions of fisheries and catch series trends for all species together or of certain species or groups.[80] Consequently, only minimal management measures are implemented for the multispecies fishery, such as legal

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[75] Esta contribución es una selección del artículo “Identifying Pathways for Climate-Resilient Multispecies Fisheries” publicado por la revista Frontiers in Marine Science. Citación completa: Karr, K.A., Miller, V., Coronado, E., Olivares-Bañuelos, N.C., Rosales, M., Naretto, J., Hiriart-Bertrand, L., Vargas-Fernández, C., Alzugaray, R., Puga, R., Valle, S., Osman, L.P., Chamorro Solía, J., Ide Mayorga, M., Rader, D. and Fujita, R. 2021. Identifying Pathways for Climate-Resilient Multispecies Fisheries. Frontiers in Marine Science, p.1491.

[76] Kritzer, J. P., and Liu, O. R. (2014). “Fishery management strategies for Addressing Complex S patial Structure in Marine Fish Stocks,” in *In Stock Identification Methods*, eds S. X. Cadrin, L. A. Kerr, and S. Mariani (Boston: Academic Press), 29–57. doi: 10.1016/B978-0-12-397003-9.00003-5.

[77] Valle, S. V., Sosa, M., Puga, R., Font, L., and Duthit, R. (2011). “Coastal Fisheries of Cuba,” in *Coastal Fisheries of Latin America and the Caribbean, FAO Fisheries and Aquaculture*, Vol. 544, eds S. Salas, R. Chuenpagdee, A. Charles, and J. C. Seijo (Rome: FAO), 155–174.

[78] Claro, R., Baisre, J. A., Lindeman, K. C., and García-Arteaga, J. P . (2001). Cuban fisheries: historical trends and current status. *Ecol. Mar. Fishes Cuba* 2001, 194–219.

[79] Puga, R., Valle, S., Kritzer, J. P., Delgado, G., de León, M. E., Giménez, E., et al. (2018). Vulnerability of Nearshore Tropical Finfish in Cuba: Implications for Scientific and Management Planning. *Bull. Mar. Sci.* 94, 377–392. doi: 10.5343/bms.2016.1127.

[80] Baisre, J. A. (2000). *Chronicle of Cuban Marine Fisheries, 1935-1995: Trend Analysis and Fisheries Potential.* Rome: FAO, 394.; Baisre, J. A. (2018). An Overview of Cuban Commercial Marine Fisheries: The Last 80 Years. *Bull. Mar. Sci.* 94, 359–375. doi: 10.5343/bms.2017.1015; Claro et al., 2001; Claro, R., de Mitcheson, Y. S., Lindeman, K. C., and García-Cagide, A. R. (2009). Historical Analysis of Cuban Commercial Fishing Effort and the Effects of Management Interventions on Important Reef Fishes from 1960–2005. Fish. Res. 99, 7–16. doi: 10.1016/j.fishres.2009.04.004; V alle et al., 201 1

minimum sizes, seasonal closures during reproductive cycles, and fishing gear restrictions.[81] An exception is the Maximum Allowable Catch Quotas established for the lane snapper (*Lutjanus synagris*) during its spawning aggregation period in the Gulf of Batabanó. In addition, there is a National Action Plan to protect sharks and rays.[82] Cuba has taken necessary steps toward the implementation of ecosystem-based fisheries management (EBFM). Research (e.g., Centro de Investigaciones Pesquera, CIP) and management (e.g., Ministerio de la Industria Alimentaria, MINAL) institutions are embracing EBFM approaches through capacity building and the development of international projects. This work advances the evaluation of coastal socio-ecological systems subject to fishing and other forms of exploitation, helping inform the establishment of special management zones, primarily through the creation and management of an island-wide MPA network.[83] Unfortunately, finfish fisheries have declined over the last 30 years. In general, catch trends have experienced two phases, an upswing between the 1950s and 1980s, followed by a marked decline to the present.[84] Baisre (2000) showed that the average trophic level and average size of catches have declined in Cuban fisheries. One study estimates that 20% of the fishery resources are fully exploited, while 75% are overexploited, and 5% have collapsed.[85]

Although overfishing is one of the most important factors influencing low catch levels in Cuba, non-fishing impacts certainly also have an effect, and some of them are probably irreversible.[86] These include environmental changes caused by climatic phenomena[87] and activities such as damming of rivers,[88] changes in agricultural practices,[89] coastal development, and increased tourism.[90] Puga et al. (2013)[91] concluded that the degradation of coastal habitats in Cuba should be taken into account in stock assessments and the development of management strategies. The likelihood of overfishing and detrimental non-fishing impacts has led to a drastic reduction of fishing effort in Cuban fisheries. On the other hand, single-species fisheries management offers limited options for rebuilding overfished stocks given the multispecies nature of Cuban fish fisheries.[92] Moreover, recent studies in Cuba[93] indicate issues with illegal fishing,

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[81] Valle et al., 2011; Karr, K. A., Fujita, R., Carcamo, R., Ep stein, L., Foley, J. R., Fraire-Cervantes, J. A., et al. (2017). I ntegrating Science-Based Co-Management, Partnership s, Participatory Processes and S tewardship Incentives to Improve the Performance of Small-Scale Fisheries. *Front. Mar. Sci.* 4:345. doi: 10.3389/fmars.2017.00345; Puga et al., 2018.

[82] PAN-Tiburones (2015). *Plan de Acción Nacional de Conservación y Manejo de Condrictios de la República de Cuba.* La Habana: Ministerio de la Industria Alimentaria.

[83] Kritzer y Liu, 2014.

[84] Valle et al., 2011; Baisre, 2018.

[85] Baisre, 2018.

[86] Baisre, 2000.

[87] Claro et al., 2009.

[88] Baisre, J. A., and Arboleya, Z. (2006). Going Against the Flow: Effects of River Damming in Cuban Fisheries. *Fish. Res.* 81, 283–292. doi: 10.1016/j.fishres.2006.04.019; Puga et al., 2018.

[89] Baisre, 2006.

[90] Claro et al., 2009.

[91] Puga, R., Piñeiro, R., Alzugaray, R., Cobas, L. S., De León, M. E., and Morales, O. (2013). Integrating Anthropogenic and Climatic Factors in the Assessment of the Caribbean S piny Lobster (*Panulirus argus*) in Cuba: implications for Fishery Management. *Int. J. Mar. Sci.* 3, 36–45. doi: 10.5376/ijms.2013.03.0006.

[92] Claro et al., 2001.

[93] p. ej. Gerhartz-Muro, J. L., Kritzer, J. P., Gerhartz-Abraham, A., Miller, V., Pina-Amargós, F., and Whittle, D. (2018). An Evaluation of the Framework for National Marine Environmental Policies in Cuba. *Bull. Mar. Sci.* 94, 443–459. doi: 10.5343/bms.2017.1058; Puga et al., 2018;Alzugaray, R., Puga, R., Valle, S., Morales, O., Grovas,A., López, L., et al. (2019). Un Enfoque Multiinsttiucional para Modelar el Beneficio Bioeconómico de Perspectivas de Manejo Pesquero en Cuba. *Rev. Cub. Inv. Pesq.* 36, 52–61.

which have been contributing to the decline of fish stocks and continued overfishing.

Tools and Pathways for Climate-Resilient Multispecies Fishery Management

Cuba published a new national Fisheries Law in 2020. The law recognizes the need to recover fish populations and calls for science-based management measures to guide these efforts. It mandates that fishery resources be managed using the principles of conservation, sustainable use, the precautionary approach, the implementation of scientific-technological criteria and the protection of ecosystems, in correspondence with national and international standards and the principles of food security and sovereignty of the nation.[94] Many efforts have been taken to advance the science- based principles required by this new law. In 2015–2016, productivity-susceptibility analyses (PSA) were conducted to define priorities for research and management measures to improve the sustainability of finfish fisheries in Cuba. These analyses ranked species, in each of Cuba's four fishing zones, based on their relative vulnerability to overfishing, prioritizing the most vulnerable species for data collection, stock assessment, or conservation and management interventions.[95]

A multi-institutional working group including the main scientific and administrative institutions of Cuba adapted the "Upside" bioeconomic model, developed by Costello et al.[96] This approach provides a holistic view of the potential benefits obtained from sustainable fisheries based on biological and economic information and management questions. Preliminary results were obtained for a small group of nine priority species (Supplementary Table 6), showing that these populations were all depleted, and most of them were experiencing overfishing. The model projects increased profitability and biomass under sustainable management strategies.[97] This work considers the Cuban context, including estimated fishing mortality from the state-owned and private fleets, and illegal fishing. Scientists are incorporating these initial results and currently working to implement climate-resilient and science-based management for 34 fish species that represent the highest percentages of total catches in the multispecies fisheries, vulnerable species and those of greatest economic importance (Supplementary Table 6). Additionally, these initial results are helping to inform the elaboration of stock complexes (fish baskets) with related groups of species formed according to different characteristics (biological and fishing operations) to avoid serial depletion and optimize yield. The working group also plans to include climate variability in the projections of biomass, catch, and economic benefits over time.

Another fundamental tool to achieve sustainable fisheries management is a learning network that serves as a platform for capacity building involving all key stakeholders and allows exchange and collaboration between different institutions and fishing communities

[94] Ley 129/2019 Ley de Pesca, República de Cuba, 2020.

[95] Puga et al., 2018; EDF (2021a). FISHE: Framework for Integrated S tock and Habitat Evaluation. New York, NY: Environmental Defense Fund (EDF).

[96] Costello, C., Ovando, D., Clavelle, T., Strauss, C. K., Hilborn, R., Melnychuk, M. C., et al. (2016). Global Fishery Prospects Under Contrasting Management Regimes. Proc. Natl. Acad. Sci. 113, 5125–5129. doi: 10.1073/pnas.1520420113.

[97] Alzugaray et al., 2019.

during the different stages of fisheries management. Multispecies fishery management issues and solutions have been part of university courses and community workshops.[98]

A "Sustainable Fisheries Management" university short course was offered in 2018 and 2019 for researchers, resource managers, conservation practitioners and fishing industry workers from almost all the provinces across the country.[99] This course equipped fisheries-related professionals with tools and models for fisheries assessment, shared successful examples of single-species management, highlighted the problems related to managing multi-species fisheries, reviewed main environmental problems, and emphasized the importance of EBM approaches. Participants conducted finfish stock assessments using real data during the course and practiced applying the fish baskets approach to multispecies fishery management. Participants also created a draft management plan for six species in the northeast fishing zone.

The 2018 "Encuentro Pesquero" (Fishers' Forum) and the "Taller de Escama" (Finfish Workshop) brought together representatives from 10 fishing communities who examined scientific results on the vulnerability and current status of different species involved in the multispecies fisheries.[100] Together they discussed current management problems and possible solutions through dynamic activities such as "The Fishing Game," which also allows them to try out the construction of fish baskets.[101] These workshops allowed scientists, resource managers, and conservation specialists to discuss possible management strategies with the fishermen and gather their opinions and reactions.

Next Steps for a More Climate-Resilient Multispecies Fishery

Centro de Investigaciones Pesqueras (CIP) and the working group plan to incorporate climate change impacts into the fisheries bioeconomic model and discussions in future learning network activities. MINAL and CIP will continue to engage fishers and fishing communities in developing of multispecies fisheries management that will consider grouping species together according to their habitats and fishing gear, noting which species are caught together. Stakeholders and fishery managers will then select indicator species for each fish basket, considering their commercial and/or social importance to issue harvest control rules on these indicator species that can influence the rest of the species in the basket, facilitating management focused on one or more indicators but influencing all of them. This process requires high stakeholder participation and a vision for adaptive management as different species will respond to the impacts of climate change and harvest control measures in different ways. Adaptive management is another key foundation of climate- resilient fisheries.[102] The fish baskets approach recognizes, in the face of uncertainty, that it is impossible to determine the perfect management strategy. There is a great deal of uncertainty concerning climate change; therefore, adaptive management is an essential tool.

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[98] Boné-Morón, E., Vejarano, R. B., and Miller, V. (2019). Cuba: Netting Fishers. *Samudra Rep.* 81, 4–7.

[99] EDF (2021b). *Engaging with Cuban fishing communities.* New York, NY: Environmental Defense Fund (EDF).

[100] Boné-Morón et al., 2019.

[101] EDF (2021c). "*What's the Catch?*" *fishing game.* New York, NY: Environmental Defense Fund (EDF).

[102] Bahri, T., Vasconcellos, M., Welch, D. J., Johnson, J., Perry, R. I., and Ma, X., et al. (eds) (2021). "Adaptive management offisheries in response to climate change," in *FAO Fisheries and Aquaculture Technical Paper No. 667*, (Rome: F AO).

3.3 Agriculture, Food Security, and Food Sovereignty

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Agriculture is one of the sectors most vulnerable to climate variability, since temperature changes and the increase in the frequency and severity of extreme events such as rainfall intensity, droughts, hurricanes, saltwater intrusion in coastal areas, etc., directly influence production and weaken cultural actions in agricultural territories, markets, and people's food security. In the last 15 years, Cuba lost almost 30 billion dollars due to hurricanes and droughts, especially in the agri-food sector.[103]

In this challenge that is the Cuban environmental, climate, and productive context, the progressive shift of agroecosystems towards resilient, sovereign, and sustainable scenarios is a priority.

This shift is possible through applying technological and innovative solutions in the agricultural development model based, fundamentally, on endogenous production with the capacity to apply updated agroecological principles, methods, practices, and knowledge, which will help increase ecological and cultural diversity, more efficient use of locally available natural resources without requiring large amounts of external inputs and fossil fuels in their production and marketing cycle, thus leading to reducing greenhouse gases (GHG) and strengthening resilience, climate adaptability, and food sovereignty.

In this context, coastal communities, due to their geographic location, are more exposed to, and more affected by, extreme weather events. Thus, they may have a greater need for good practices for socio-ecological resilience and climate change adaptation and mitigation. In this sense, having food security and sovereignty is a challenge that affects their resilience. Despite the fact that their proximity to the sea contributes to their vulnerability, it is also an opportunity for diversification in the production and consumption of high value-added foods.

The agricultural spaces of these communities can be fostered in rural farms and in urban agriculture systems with numerous sustainable practices and designs, which will depend on the local culture, the predisposition of rural families, and on established decision-making and legal norms that favor the economic stability of local agriculture using agroecological concepts. Adopting technologies and rural experimentation and innovation depend on institutional arrangements and their ability to encourage, promote, and disseminate them.[104][105]

Based on a study in several rural communities, family agriculture in Cuba shows a potential production capacity to feed more than eight persons per hectare per year with

[103] ONEI, 2021. Anuario Estadístico de Cuba 2020. Oficina Nacional de Estadística e Información. La Habana-Cuba, 540 p.

[104] González de Molina M. 2012. Algunas notas sobre agroecología y política. Agroecología, Volumen 6, pp. 9-21.

[105] Casimiro Rodríguez, L and Casimiro, JA. 2018. How to make prosperous and sustainable family farming in Cuba a reality. Elem Sci Anth, 6: 77. DOI: https://doi.org/10.1525/elementa.324.

protein and other foods. Family farms also have been demonstrated to have high biodiversity.[106] Communities close to the sea can multiply this potential given their ability to implement other cultural practices, such as marine aquacultures, artisanal fishing, tourism as a complementary activity, and the production and use of sea salt to make preserves and artisanal products with added value.

One of the undervalued crops in Cuba and of easy production in the tropical coasts is coconut, which provides many, differently prepared, food and handicraft products. Coconut oil could be a leading product that provides identity and income to coastal populations, replacing low-quality conventional oils that are currently imported for local consumption but without meeting demand.

If the means to acquire simple infrastructures for cold-press processing is forthcoming, coconut oil can be used in a variety of ways: for local food, natural cosmetics, producing handmade soaps, health products, and goods to care for certain ailments or diseases. On average, 14 small coconuts produce one liter of oil. Empirically, the least productive palm tree in Cuba produces more than 200 coconuts per year, or about 15 liters of oil per plant.

Cuba has been taking steps to transform its agrarian system, given its dependence on imported foodstuffs that amount to around US$2 billion each year, or approximately 60% of the foodstuffs in a typical local basket of products.[107] At the same time, there is potential in unproductive or poorly utilized land, close to many communities and settlements in coastal areas.

Structural reforms are currently underway and work is being done to develop Local Food Systems. Here, local governments coordinate the food production process with the horizontal organization of all forms of land ownership and tenure that exist at the territorial level, a structure that is poised to become the Municipal Agroindustrial System.

Furthermore, political will exists within the country's top management to stimulate and recognize the importance of innovation both at the organizational level, which addresses the role of the government together with other structures that manage agrarian matters, and at the technological level, which aims to stimulate the application of local and scientific knowledge in food production under the Food Sovereignty and Nutritional Education Plan (SAN Plan).

Given this background and the need to produce food in harmony with the environment, to have healthy and safe food, and reduce emissions to mitigate the effects of climate change, Cuba has potential technologies and production systems that should be valued and promoted in order to achieve food sovereignty and nutritional education.

Agroecology, which already has a policy pending approval and a Decree Law being drafted for its phased implementation, should be the basis for sustainable food production systems to be developed in coastal areas and in general. Cuba has initially proposed to include two million hectares of land with agroecological productive systems and principles, producing more than 10 million tons of food by 2030.

Agroenergy, the integrated production of food and energy from renewable sources, must be present in all production and also socially within coastal communities in order to shift towards societies with sustainable lifestyles, i.e., producing their own food and

[106] Ibid.

[107] Nova A. 2020. Análisis de la dependencia Alimentaria en Cuba a partir del Anuario Estadístico de CUBA 2017, 2018 (publicado en 2019) y Principales indicadores Sector Agropecuario ONEI, Ene-dic 2017, 2018, junio 2019.

achieving technological and energy sovereignty, without risking the resources they depend on.

The circular economy and the closing of cycles must be undertaken as local practices and policies; we cannot continue to be victims of a linear economy in which high volumes of waste are generated and the systems to treat them become increasingly complex, generating environmental effects that harm coastal ecosystems and communities.

We must strengthen capacity building among people and public and private organizations, so as to introduce concepts such as agroecology, agroenergy, and circular economy that will improve food and energy security/sovereignty, reduce the pollution load of our ecosystems by reusing waste, thus adding new value to production processes and services, toughen resilience to bioclimatic phenomena, and facilitate sustainable lifestyles.

The resilience and stability of a social-ecological system are determined by biotic or environmental factors, socio-cultural strategies and economic conditions. Facilitating the change and adaptation necessary to move towards sustainable livelihoods focused on socioecological resilience entails profound cultural changes in food production and consumption, and in the language of economic valuation; thus, methods that encourage participation of various actors in the transition are essential, understanding multilevel collective action as a cross-cutting theme in the process.

3.4 Energy

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CUBASOLAR

Rapid rises in temperature and their direct, extreme climatological consequences, such as hurricanes, heavy rains, droughts, sea-level rise, and others that directly modify environmental conditions affecting the lives of coastal ecosystem populations, force these communities to quickly prepare and adapt in order to survive.

The point of departure in coastal communities affected by Hurricane Irma and participating in the Irma Networks project was understanding that people's living conditions must account for essential socioeconomic, political, cultural, and other activities. There was also acknowledgement that when people defend their community, they also protect their means of production and own life reproduction, since a designated production area cannot be saved if the community that toils therein disappears.

Therefore, community resilience is linked to other very complex processes in which people's culture develops, through which they relate to the environment and guarantee their subsistence. Thus, the following factors must be taken into account:

First, the basic elements of life such as locally sourced energy cannot be separated from food and water, since they must be addressed in a holistic manner; without them, life cannot exist.

Second, the community must be understood within a framework of mitigation and adaptation, the former as environmental sanitation and closing productive cycles, increasing efficiency and sustainable management of local resources. The latter refers directly to resilience, which requires greater scientific knowledge to monitor a community's most diverse variables: climatological, environmental, productive and social, to foresee and act in anticipation of environmental threats. This requires internal and external synergies within and outside the community to be able to protect resources and recover rapidly from damages.

Third: To respond to these complex situations, a community requires social participation with equity, continuous dialogue with government bodies, and a model of democracy that enables the complex construction of the common good always and everywhere.

A locale's energy supply can be affected when hit by some climatic event; this can also happen if the climate event occurs faraway and affects the electrical or fuel networks supplying that site. The main energy problem that Cuban coastal areas have is their tremendous dependence on electricity generated in distant locations. Thus, the best way to increase local resilience is to build a local energy network. If a coastal area has a local power grid, even if there is no electricity in the general power grid, its local equivalent could work independently and thus not

affect activities in the area.

Local networks in coastal areas must satisfy all local energy needs, be they electricity, heat, cold, light, kinetic or potential, with their own local energy resources to avoid relying on imported energy from abroad or distant places.

Building a local, coastal energy network begins by determining current and future energy needs, and then determining how best to meet those needs with the area's own energy resources: Thus, the steps to be taken are:

1. Determine current energy consumption of primary sources (fossil fuels, electricity, firewood, coal, solar radiation, wind, biogas, other biomass, etc.).
2. Determine current and predictable future energy needs according to end use, i.e., to ensure agricultural, livestock, and industrial production, fishing, water supply, food preparation, refrigeration, domestic air conditioning, water heating, transportation, etc.
3. Determine the renewable energy sources available in the area, starting with waste that is or could be a source of pollution, biogas and other biomass, solar radiation, wind, hydro, and thermo-marine.
4. Analyze how energy needs might be satisfied. For example: preparing food could be done with biogas, sawdust pellets, charcoal, firewood, and electricity. It could even be met with various energy sources.
5. Determine the different available forms of energy storage.
6. Propose an action plan for building a local, coastal-area energy network.

We should note that a local energy network must meet the following requirements:

- It should work linked to a larger network, but if necessary, it should work alone and meet the energy needs of the entire coastal area.
- It should work with local energy sources, i.e., not depend on any imported energy resources.
- It must work as efficiently as possible. Energy waste is forbidden.
- It must accumulate enough energy to guarantee the energy needs at any given moment from renewable energy sources. Several of these can be intermittent, such as solar radiation and wind, and others seasonal, such as hydropower and crop residues.
- It must fight all environmental pollution and ensure sustainable local development.

Energy efficiency must begin with the investment vision. The principles of environmental physics and bioclimatic architecture must be applied. Unnecessary absorption of solar radiation that causes hot spots should not be allowed, especially when they are on roofs and walls of premises people inhabit for extended periods, such as bedrooms or living rooms. Premises should use natural

lighting and fresh air ventilation.

The accumulation of energy should be done intelligently and preferably in its final form. For example, if water is needed, water should be allowed to accumulate at sufficient heights and in sufficient quantities. If hot water is needed, accumulate hot water. If air conditioning is needed, store chilled water. If you need to store frozen products, store the cold in frozen eutectic plates. If you need to cook food, store gas or biogas or sawdust pellets. If electricity is needed, store it in batteries and hydro-accumulators. Thus, the most economical and resilient storage systems can be in place before natural disasters strike.

Transport vehicles must be powered by batteries which must be charged with solar electricity, i.e., produced from renewable energy sources.

Following these steps, a coastal energy supply can be created with high resilience to natural disasters, ready to guarantee sustainable development.

This scenario will be possible only if the energy management capabilities at the local and municipal levels are developed; otherwise, we will continue to talk about potentials and hypotheticals, rather than real scenarios.

3.5 Public health

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Introduction

Cuba's status as an archipelago and its geographic location in the Caribbean Sea make it highly vulnerable to events of climate variability. The rise in sea level due to thermal expansion and the melting of ice, together with intense hurricanes and other extreme weather events, will continue to be the main climate change risk for Cuba due to coastal flooding and the destruction of nature and human infrastructure near the coast. In addition, climate variations can lead to the spread of diseases and their causal agents, leading to a significant loss of human life.

In economic terms, extreme weather events cause considerable losses. The destruction brought by Hurricanes Matthew and Irma amounted to around 2.431 billion pesos and 13.185 billion pesos, respectively, which had a significant impact on the Cuban economy.

Over the last 30 years, the Climate Center of the Institute of Meteorology, together with the Pedro Kourí Institute of Tropical Medicine (IPK) and the National

Institute of Hygiene, Epidemiology, and Microbiology (INHEM), have obtained scientific evidence of how much disease morbidity can be attributed to climate variability and change. During the last decade, we obtained a better understanding of the effects of climate on infectious diseases, changes in their morbidity, and how climate effects some viral and bacterial agents causing infectious diseases. Since then, several analyses of associations between climate anomalies and disease patterns have highlighted impacts and vulnerabilities due to climate variability and change.

Facing challenges

Studies carried out in Cuba corroborate that, due to recent changes in our climate, the number of cases and medical care of several diseases have increased in the short and medium term, among them acute respiratory infections (ARI), acute diarrheic diseases (ADD), chicken pox (CP), as well as a tendency to increase the number of foci of *Aedes aegypti* and other vectors and, therefore, increase the risk of transmission and occurrence of outbreaks of dengue and other arboviruses. Similarly, studies have shown changes in the seasonal rise of several diseases. Thus, guaranteeing resilience requires establishing early warning systems that explicitly incorporate climate variability and change.[108]

Climate scenarios indicate that sea levels are expected to rise by between 0.29 m in 2050 and 0.95 m by 2100 as a result of climate change. This will continue to be the main danger from climate change due to coastal flooding, salinization of aquifers and soil, alteration of rainfall patterns and freshwater supply, as well as the destruction of the natural environment and dangers to the human population near the coast. Health facilities have been directly affected by extreme weather events in recent years, affecting their capacity to provide services when most needed, and with significant losses for the sector. In a country with economic limitations and restricted access to international credit and financing, assistance is required to implement the adaptation and mitigation measures that are

[108] Ortíz PL, Pérez A, Rivero A, León N, Díaz M, Pérez A, 2006 Assessment of human health vulnerability to climate variability and change in Cuba. Environmental health perspectives, vol. 114, no 12, p. 1942-1949 Disponible en: https://ehp.niehs.nih.gov/doi/ abs/10.1289/ehp.8434 ; Ortíz PL, PérezAR, Rivero AV, León NV, Díaz M, PérezA, 2006 Mini- Monograph «Resulted to assessing the human health vulnerability to climate variability and change in Cuba. «Environmental Health Perspectives. EU doi:10.1289/ ehp.8434 (available at http://dx.doi.org/); Ortíz Bultó PL et al., 2008 Assessment of Human Health Vulnerability in Cuba due to Climate or Weather Variability and Change. In: book «Global Warming and Climate Change: Kyoto - Ten Years and Still Counting Vol 1-2. Editor Velma I Grover. Publisher Science Pubs Inc- UK. ; Ortiz PL, PérezAR, Rivero AV, Pérez AC, Vázquez JRC, Lecha LE (2008). La Variabilidad y el Cambio Climático en Cuba: Potenciales Impactos en las Salud Humana. Rev Cubana Salud Pública, ene.-mar. 2008, vol.34, no.1, [online]. ene.-mar. 2008, p.0-0. Disponible en: http://scielo.sld.cu/scielo.php ; Ortiz, P L, Pérez A.R, Rivero A.V, Pérez A y Guevara V., 2009. Salud Humana. En: Libro Geo Cuba. Estado del MedioAmbiente Cubano. PNUD. Editores Fernández A M y Pérez RR. Consultado: 24/2/2021 Disponible en: https://wedocs.unep.org/handle/20.500.11822/9354 o https://isbn.cloud/9789593000024/evaluacion-del-medio-ambiente-cubano-geocuba/ ; Ortiz Bultó PL, Pérez A, Rivero A, Pérez A, Canga R., 2013 Salud humana. En: Planos E, GuevaraAV, Rivero R, ed. Impactos del cambio climático y medidas de adaptación en Cuba. La Habana: Programa de las Naciones Unidas para el Desarrollo, Instituto de Meteorología. p.401-29. Consultado: 24/ 2/2021.

required.[109]

All indicators in southern Havana show a tendency to increase and modify seasonal patterns. Thus, warmer, more humid winters (low rainfall period) and summers (rainy period) with higher temperatures favor environmental dangers that accelerate the life cycle of microbial agents and vectors risking human health.[110] In addition, high temperatures can also affect people's own metabolism and immune response, leading to increased vulnerability and thus a higher number of the problems mentioned above (Table 1).

Available at: http://www.undp.org/content/dam/cuba/docs/Medio%20Ambiente%20y%20Energ%C3%ADa/BASAL/S%C3%AD ntesis%20informativa%20sobre%20el%20Cambio%20Clim%C3%A1tico%20%28PARA%20VER%29.pdf o http://www.revistaccuba.cu/index.php/revacc/article/view/247 ; Vega YL, Ramirez OV, Herrera BA, Ortiz Bulto PL., 2017 Impact of climatic variability in the respiratory syncytial virus pattern in children under 5 years-old using the Bulto climatic index in Cuba. Int J Virol Infect Dis, vol. 2, p. 14-19.

Available at: https://www.researchgate.net/profile/Ortiz_Bulto/publication/323497675_Impact_of_Climatic_Variability_in_the_Respiratory_Syncytial_Virus_Pattern_in_Children_Under_5_YearsOld_Using_the_Bulto_Climatic_Index_in_Cuba/links/5a986751a6fdccecff0d2be9/Impact-of-Climatic-Variability-in-the-Respiratory-Syncytial-Virus-Pattern-in-Children-Under-5-Years-Old-Using-the-Bulto-Climatic-Index-in-Cuba.pdf; Vega YL, Ortiz PLB, Acosta BH, Valdés OR, Borroto SG, et al., 2018 Influenza's Response to Climatic Variability in the Tropical Climate: Case Study Cuba. Virol Mycol 7: 1000179. doi:10.4172/2161-0517.1000179.

[109] Republic of Cuba, Council of Ministers, 2017 *Project Life*. Plan de Estado para el enfrentamiento al cambio climático. Havana: Ministry of Science, Technology and Environment; Available at: https://www.ecured.cu/Tarea_Vida. Accessed November 27, 2019.; Ministry of Public Health, 2019 Informe anual al Ministerio de Ciencia, Tecnología y Medio Ambiente. Havana. Ministry of Public Health; Planos Gutiérrez, EO. Tercera comunicación nacional y primer reporte bienal a la convención marco de las Naciones Unidas sobre el Cambio Climático. Editora Geotech, 2016. http://repositorio.geotech.cu/jspui/handle/1234/2782.

[110] Republic of Cuba, 2015 Segunda Comunicación Nacional a la Convención Marco de las Naciones Unidas sobre Cambio Climático (CMNUCC). La Habana.

Table 1. Current (C), Medium (MT) and Long Term (LT) Potential Impacts of variability and change in some health indicators in South Havana.

Transmission	Indicator	Location	Expected Impacts	Impact Period
Air or respiratory	ARI	Melena del Sur	Increase. Supporting this prediction are seasonal trimodal increases with a higher peak in October and at the end of the year, with a higher risk for adults and children subjected to warmer environmental conditions, with less rain, changes in biodiversity, population dynamics, among others.	**MT**
Hydro-Food	ADD	Melena del Sur	Increase in the winter months and displacement of the peak in May to July through August, under environmental pressures of low water availability, marine intrusion, favorable conditions for the life cycle of microbial agents and parasites, deterioration of sanitary and hygienic conditions, among others.	**MT**
Vectors	Number of *Ae* outbreaks	Melena del Sur	Tendency of high-density outbreak peaks throughout the year. Increased seasonal range and acceleration of the vector's life cycle due to warmer conditions and probable water scarcity.	**C, MT, LT**
		Güira de Melena	Increase of outbreaks throughout the year, even during the low rainfall period, thus increasing vector density. Acceleration of the vector's life cycle due to warmer conditions and probable scarcity of water with an increase in possible breeding sites.	**C, MT, LT**
		Batabanó	Three periods of maximum increase in outbreaks, tending to be present almost all year. Acceleration of the vector's life cycle due to warmer conditions and probable water shortage.	**C, MT, LT**

LT Long Term (2031-2050), **MT** Medium Term (2026-2030), **C** Current Impact (2020-2025)

Another health hazard that affects coastal areas are hurricanes, which vary greatly in how frequently they occur, characterized by periods of high, or low, activity. However, since 1996 a new period of high activity began, with a trend in increased hurricane activity

and intensity over Cuba.[111]

The municipalities of Baracoa, Caibarién, and South Havana, just to mention three areas, are among the most affected in recent years by severe weather events. The first was hit directly by Hurricane Matthew in 2016. Hurricane Irma, category 5, affected Caibarién in September 2017. In both cases, health institutions were affected, with significant structural damage, interruptions in electricity and drinking water service, among others, which affected how these institutions were able to respond.

Opportunities

The main opportunity in the human health sector is to adapt to climate change by focusing on vaccination, early warning, and training. Improvements have continued in the vaccination program against 13 diseases (hepatitis B, tuberculosis, meningococcus BC, tetanus, *Haemophilus influenzae*, rubella, measles, polio, diphtheria, pertussis, mumps, typhoid fever, and influenza). The entomological surveillance plan for the detection of vectors was restructured and strengthened, and public communication campaigns have been implemented to prevent the mosquito that transmits dengue and other arboviruses, as well as a public awareness campaign on the danger to health and the economy posed by the invasion of the giant African snail (*Lissachatina fulica*). The early warning system has also been improved, particularly for tracer diseases such as acute respiratory infections (ARI), acute diarrheal diseases (ADD), and arboviruses, while hospitals and health institutions have undergone structural transformations.[112]

According to the study, health institutions in coastal areas should be renovated to prevent and reduce structural vulnerabilities (foundations, columns, load-bearing walls, beams, roofs), nonstructural ones (false ceilings, windows, doors, electrical systems, hydraulic and sanitary systems, engineering systems, reserves), and functional ones (existence and updating of standards and procedures manuals). Actions are in line with mitigation objectives, which include electricity generation from renewable energy sources, building renewal, and installing energy efficient equipment, as well as guaranteeing resilient water supply and waste management systems in health institutions.

Another activity involves empowering the sector in climate change issues, by training health personnel on the impacts of climate change on health, warning signs and appropriate responses, plus training engineers, architects, and other construction professionals on standards for building climate change resilient and environmentally friendly institutions. It also means revising regulations for the design of health institutions, incorporating the principles of resilience, sustainability, and biophilic hospitals, and the creation of a national program for systemic management for the resilience and sustainability of health institutions, to ensure the continuity of all these actions.

The adaptation plan will improve the overall adaptive capacity of coastal municipalities by having climate change resilient health institutions. The community and local authorities will have increased awareness on climate change adaptation and mitigation measures, health promotion, and disease prevention, to ensure that these approaches are part of the territorial development plans and to protect the project's results.

[111] Ortiz, et al., 2013; Planos Gutiérrez, 2016; Segunda Comunicación Nacional 2015.

[112] Ortiz, et al., 2013; Segunda Comunicación Nacional 2015.

The main adaptation requirement for the health sector is to strengthen existing surveillance systems to identify the presence or appearance of diseases based on environmental variables, particularly climate variables. The project foresees implementing a health surveillance and early warning system based on climatic variables in selected territories, based on previous experience in other regions of the country. This activity will have a positive impact on coordination between meteorological professionals and agencies and the health sector for timely information and prediction of public health events, thus strengthening the resilience of health services.[113]

Summary of Actions, measures, and adaptations to achieve resilience in the health sector.

Promote and implement adaptation measures, based on assessments of health vulnerability to climate variability and change.	Strengthen national and local capacities to deal with emergencies, weather-related disasters, and large-scale epidemics based on evidence and attributes. Strengthen primary health care to improve the adaptive capacity of communities facing risks related to climate variability and climate change. Develop evidence-based resilient activities.
Empower health leaders and strengthen institutions dealing with health and climate variability and change.	Establish a special inter-programmatic working group within the Ministry of Health with various stakeholders to prepare the Ministry of Health and cross-sectoral plans and actions.
	Strengthen national partnerships and work in collaboration with civil society on climate change and health.
Promote health issues in the intersectoral agenda on climate variability and change.	Increase the participation of the Ministry of Health and the inclusion of health issues through national participation in the UNFCCC and other relevant forums.
	Ensure the integration of health into national climate change policies and strategic development plans, through a “health in all policies” approach, with civil society participation.
	Incorporate climate change and health issues into national health reports or equivalent documents.

Strengthen educational capacities in the areas of climate change and health.	Increase national technical capacities to address climate change and health issues.

[113] *Project Life*, 2017.

Improve communication	Launch public health campaigns on climate change and health issues.
Establish early warning systems for diseases and conditions related to climatic and weather phenomena.	Create and test new early warning systems for extreme weather and climate events and climate-sensitive diseases and conditions, and strengthen existing systems.
Create and deliver climate-related health services.	Strengthen existing climate-sensitive disease and risk surveillance systems by including indicators related to climate or weather-related events.
Incorporate health into disaster preparedness, response, and recovery plans for climate and weather-related disasters.	Strengthen the capacity of the health sector and formulate plans and procedures for preparedness, response, and recovery from climate and weather-related disasters.
Promote safe and environmentally friendly (“green”) infrastructure.	Improve the resilience of health care facilities to climate variability and change by applying PAHO’s Smart Hospital Tools.
	Modify building codes to address climate change impacts on infrastructure.

3.6 Fresh water

Jorge Mario García Fernández and Joaquín Gutiérrez Díaz

The Cuban archipelago and especially its main island, Cuba, has very peculiar characteristics. Its elongated and narrow shape, together with its topographical layout and structure, define the existence of a central watershed along the entire principal island in the direction of its longitudinal axis and its two slopes: the northern and southern slopes. Its geology is complex, with a predominance of carbonate rocks. The hydrological cycle is governed by rainfall, i.e., the only source of annual renewable water in the archipelago. It is a limited and finite strategic resource, essential for the country’s sustainable development.

Terrestrial (fresh) water is the basis of the hydrographic basin’s connectivity, understood as such, according to article 8.1 of Law 124 of Terrestrial Waters: *an area delimited by the division of surface and ground waters that make up a water system, which channels water to a main river, lake, infiltration zone, or coasts. The borders separating surface water and groundwater do not always coincide, and therefore extend to include aquifers or underground sections, whose waters flow into a particular basin, for the purposes of integrated land water management.*

Watersheds play an essential role in connecting terrestrial and coastal ecosystems and determining how they work in their multiple and complex links with the economy and society.

In the archipelago, 642 surface watersheds larger than 5 km^2 have been documented.

Of the total, 87.8% have areas between 5 and 200 km^{2} ^{2}. Only 2.3%, 15 basins, have an area greater than 1,000 km^{2}. The main aquifers are in karst formations and, for the most part, in a hydraulic relationship with the sea, along with saline intrusions, intensified by inadequate resource management. There is also an intense quantitative and qualitative relationship between surface water and aquifers.

Cuba's water infrastructure has made it possible to supply around 57% of economic, social, and environmental demands on the potential water resources (PWR). The real (average) Availability Index of water per inhabitant per year for all uses, *in terms of built hydraulic infrastructure*, is approximately 1,220 m³. Cuba's water footprint (WF) is 1,712 m³ per inhabitant per year and is in 30th place, in descending order, of about 100 countries that participated in an evaluation.

Addressing the current challenges and opportunities for resilience and sustainability in coastal communities requires a comprehensive approach. Because of the conditions outlined above, this approach must be viewed in relation to the entire archipelago. We could not easily determine the sustainability of coastal communities if it were a segregated assessment that excluded the dynamic, complex, and binding linkages and interactions from the central watershed to the coastal zone.

Terrestrial waters are one of the best and clearest examples. We should evaluate which tasks, practices, and solutions proposed by governmental institutions, professional associations, non-governmental organizations, experts, and others for achieving sustainability of coastal and other communities, have been evaluated from a "how we are" perspective or from a "how these problems really are" viewpoint. An insular system requires stripping away the close links we have with belonging to a particular place and thinking in a comprehensive way, without borders between the "coast" and the "mainland". *They are different features of the same terrain.*

The negative impacts of climate change on the Cuban islands will not occur in a partial or segmented manner, in this or any other ecosystem or equivalent. They will manifest with a high degree of interactivity and synergy, becoming explicit in terrestrial waters through sea level rise, loss of biological diversity and other phenomena, simultaneously, with varying intensity.

If we admit that there will be (or are already occurring?) negative effects with greater relative incidence in the amount of available water resources, more frequent extreme events, and deteriorating water quality, will these only occur in the communities or coastal freshwater sources and not in "non-coastal" localities and sources, or only, for example, in those to the west or in the center of the main island? At this point, evidence suggests that there is no differentiation in potential impacts.

Is the coastal zone the first line or the last? Do we live on a piece of land surrounded by sea or in the sea on pieces of land? What are we trying to solve? Are they inadequate practices applied in the coastal zone for years (which, moreover, were also practiced inland), and therefore the deterioration and negative impact are even greater in both places? Are accumulated problems reanalyzed with new knowledge? Are there also new and more serious problems?

If the Cuban island system is to be resilient and sustainable, its coastal communities and others, without being exhaustive, will have to evaluate, qualitatively and quantitatively, the role of knowledge, science, innovation, the application of appropriate and adequate

technologies, the holistic approach in conjunction with the appreciation of relative intensities depending on the location and the integrated management of terrestrial waters and coastal zones, among many other factors.

In addition, effective actions need to be undertaken whatever current and future scenarios are with respect to terrestrial waters, climate change, resilience and sustainability. Among them:

- Increasing efficiency in the use of land water, both in socioeconomic sectors and for environmental protection, would involve raising relative annual water availability by several hundred million cubic meters, without the need for new infrastructure;
- The use of renewable energy sources for pumping and handling large, medium, and small water flows would be an important incentive for their rational use, in addition to offering other advantages;
- Reusing properly treated wastewater would have positive effects on various economic activities.

Substantive and profound change is required. We cannot attain resilience and sustainability in coastal communities and take on the current challenges and opportunities in any of the areas highlighted in this report without a global vision and evaluation of the entire archipelago, based on the integrated management of watersheds and the coastal zone. Other calls to convene around this subject, greater participation, and broader horizons are also needed, with financial, organizational, and other types of resources.[114]

3.7 Resilience management in a context of disasters and risk reduction

Jorge Luis Rodríguez Viera
Capital Integral Development Group (GDIC)

Even though resilience was already a term being used with scientific precision in the 1970s in socioeconomic scenarios with an incipient integrative approach, the concept and its manifestations existed beyond their use in social settings. The etymology of “resilience” (from the Latin word *resilio*, meaning to go back, jump back, stand out, bounce back),[115] reveals the path the word took to its tacit and exact social acceptance. In physics, it refers to the capacity of certain materials to recover their original shape after being subjected to pressure that deforms them. This is perhaps the most accepted genesis in the construction of the concept. Ecology, psychology, and the social and economic sciences, among others, have also adopted their own definitions, which, due to space limits here, we cannot discuss in detail.

Clearly, the concept of resilience is an intrinsic and inseparable part of any risk management process and even influences how risk is defined, just as water exists in soil particles and within the human body. It even existed in Ancient Mesopotamia (3000 B.C.), in risk management techniques etched on clay disks, according to evidence from

[114] References: 1) García Fernández, Jorge Mario, and Cantero Rosales, Luis. Indicadores globales para la evaluación del uso sostenible del recurso agua; caso cubano. Voluntad Hidráulica No. 100, pages 12 - 19, Year 46, December 2008. ISSN 0505-9461; 2) García Fernández, Jorge Mario. La Gestión de Cuencas Hidrográficas en Cuba. Voluntad Hidráulica No. 102, pages 10 - 19, Year 47, June 2009. ISSN 0505-9461; 3) García Fernández, Jorge Mario, and Gutiérrez Díaz, Joaquín B. La Gestión de Cuencas Hidrográficas en Cuba. INRH, CNCH. Havana, Cuba. Havana, Cuba. November 2006. ISBN 978-959.300-114-4.; 4) Gaceta Oficial de la República de Cuba. No. 51 Extraordinary, November 16, 2017. Law No. 124/2017.

[115] Kotliarenco, Cáceres and Fontecilla, 1997.

archaeological research.[116]

There is currently a high level of consensus regarding the close relationship between risk management and resilience, which is well established in definitions from ECLAC and UN-HABITAT:

ECLAC: Highlights the background of the multidimensional concept of resilience by placing it at the center of its Disaster Risk Management (DRM) matrix. Its conception involves many factors and a broad spectrum of characteristics, actions, and strategies that seek to prevent or mitigate the effects of exposure to risk factors.

UN-HABITAT:[117] The concept of resilience is the ability of any urban system to maintain continuity after catastrophes or shocks, while contributing positively to adaptation and transformation.

The GDIC has been working since 2004 on the integrated adoption of these concepts. The following definition is its most recent:

GDIC/SERVI-GDIC:[118] In the broadest sense, resilience is the capacity, inherent and/or possible to build, of the components of a territory / ecosystem; a settlement/ building / an institution / organization; a community / family / individual; or even of a physical component (natural or built), to adapt and overcome critical events (identified or unknown hazards), which generate an unusual and/or undesired, foreseen, or unexpected situation; this should be done following the principles of validating associated potentialities, in a planned or unplanned manner, in order to minimize known vulnerabilities and restore the initial conditions and/or the altered normality, while enhancing the possibilities of continuity and development in the event of multi-hazards.

We ought to visualize that this risk-resilience interrelationship requires implementation through integrated territorial development strategies, to apply its cross-cutting approach from the local to the global. However, we should also remember some of the basic definitions regarding the strategic management of socioeconomic development.

PROJECT MANAGEMENT:[119] The set of techniques for planning, controlling, and directing projects, with the goal of limiting risk and uncertainty. It involves everything that must be done to ensure that a project achieves its objectives, subject to the variables: cost, time and quality; functionality and/or performance, depending on the object and nature of the project.

STRATEGIC MANAGEMENT:[120] A systemic approach involving an increasingly important responsibility of general management (director, managing director of a functional group: project, program, system, or institution), i.e., to link the managing group and its subordinate groups to their environment, establishing their position, to guarantee their continued success and protect them from shocks.

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[116] Oppenhein, 1977 and Mumpower, Menkes and Covello, 1986, p. 520.

[117] https://onuhabitat.org.mx/index.php

[118] Viera / 2020

[119] Cleveland, David. William R. King. System Analysis and Project Management. Mc Graw-Hill, 1985.

[120] H. Igor, Ansof. Edgard, J Mc Donell. La Dirección Estratégica en la Práctica Empresarial. San Diego International University, California, 1996.

INTEGRATED RISK MANAGEMENT[121]: A management framework for decision making in situations where stakeholders are faced with uncertainty regarding the consequences of such decisions, which forms the concept of risk.

The GDIC, as a result of its almost 35 years following a strategic path in Havana with an inclusive and resilient approach, provides the following definitions:

INTEGRAL STRATEGIC MANAGEMENT OF INTEGRATED RISKS:[122] The constant search for a strategic concurrence among all implemented strategies in a defined environment, using agreement in its broadest sense (levels and types of participation, interests of actors and/or managers, processes, decisions, tools, etc.), with the goal of minimizing the probable risks, which in their holistic dimension could prevent or limit achieving a desired future.

STRATEGY FOR BUILDING RESILIENCE:[123] A new concept of **resilience** that embraces the fundamental bases of the Tools of Proactive Strategic Management, with emphasis on management by means of rapid and flexible responses, which encompass the well-known techniques of contingency planning; management of strategic problems; management by weak signals; and management of shocks, all applicable to managing uncertainties, in the complex scenarios of discontinuous acceleration of changes, characterized by a significant increase in the degrees of turbulence in the behavior of the variables and indicators that govern development. Yet, at the same time, within the associated spectrum of proactivity, it implies continuous learning in terms of foresight and prevention, as a result of valuing lessons learned, in a conscious process of learning by doing, with a high degree of citizen participation, in the diagnosis and decision making linked to building resilience in real time.

As an example, we review here some of the elements of control and corroboration that, in my opinion, have a significant impact on building resilience, as shown by the conservation and construction of new buildings in Havana today.

1. The construction typologies used and the integrated risk approach (e.g., a light asbestos roof typology cannot be classified as “regular”, much less “good”, given the threat of strong winds, even if it is in excellent technical condition, due to the possible impacts of wind-driven elements).
2. The technical building condition and the type of hazard analyzed (e.g., ETC declared “regular” or even “good” (buildings with more than five levels and carpentry finishing in poor condition and/or aged), which are equivalent to poor or even uninhabitable ETC in high wind conditions.
3. The housing located in coastal and protection zones and the priorities of the investment projects.
4. Housing located in basements or first floors in areas at high risk of flooding due to sea penetration and/or heavy rain, and the short, medium, and long-term housing investment program.
5. Properties located in areas that will be potentially impacted by the increase in mean sea level due to climate change and the coastal settlement relocation program.

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[121] Scholz, Roland W. Olaf Tietje. Integrating Quantitative and Qualitative Knowledge. Embedded Case Study Methods. California, 2002.

[122] GDIC, Viera/2009, Lo Vedado de El Vedado, Herramientas Metodológicas, Ejemplos y Caso de Estudio para la Gestión Estratégica Integral de Riesgos Urbanos Integrados.

[123] Viera, 2011. Propuesta de Estrategia Proactiva de crecimiento de La Habana hacia el Oeste, en un proceso de construcción de resiliencia, en función de un Ordenamiento Territorial Inclusivo y Sostenible.

6. The results of technical opinions prepared and their modification to accommodate the actual vulnerability assessment.
7. The availability of updated and accurate data and their entry in the Geographic Information Systems (GIS), with an adequate system of variables and indicators that measure vulnerability and indicate priorities for building resilience.
8. The easing of restrictions and the facilitation of project servicing and technical support given the demand for integrated risk mitigation solutions.
9. The real capacity to assimilate the costs of adaptation at the institutional, local government, and family level.
10. Deficits in appropriate technologies, including the production of various materials that build resilience.
11. The credit system and policies involving insurance need to adapt to the demands of resilience building processes, including exceptional bonuses, fiscal stimulus, and creation of emergency solidarity funds, as well as uncertainty management funds.
12. Coordination between new forms of economic management and their roles in building resilience.

Finally, in what follows I briefly identify barriers associated with territorial development management, which I believe hinder an inclusive and resilient management of conservation and new construction of real estate, with emphasis on residential use.

1. Lack of correspondence between the most used management variables and those that characterize vulnerability and resilience in real time.
2. Lack of correspondence between recently approved municipal strategies and the results of institutional diagnoses and sectoral policies.
3. Current vulnerability data are not correlated with risks resulting from recent hazardous events.
4. Potential results from the productive linkage with new forms of economic management and desirable public-private coordination are neither enhanced nor predicted.
5. Fund management alternatives with an emphasis on inclusive and sustainable credit are not promoted.
6. Cost-benefit analyses and comprehensive feasibility studies are scarce.
7. The relevance of indicators is compromised due to the lack of comprehensive and encompassing sustainability approaches.
8. Risks are approached reductively, without focusing on their multidimensional nature.
9. Future vulnerability and risk scenarios are not developed, which makes analyses extemporaneous.
10. The results are not linked, in a practical, measurable, and achievable way, to the Country Strategy and the SDGs.
11. Weaknesses persist in the current Land and Urban Planning system, which is the anthropic baseline for risk creation and the absence of resilience in the urban habitat.

12. Lack of sufficient citizen participation in integral habitat management, as the main cross-cutting weakness in strategic risk management and resilience building.
13. Computerization, e-government, and the new digital management are still unresolved issues, a fact that hinders foresight of a desired future and making of accurate real-time decisions.

3.8 Tourism in Gardens of the Queen National Park (Jardines de la Reina)

Fabián Pina Amargós and Tamara Figueredo Martín
Avalon-Marlin Gardens of the Queen

Tourism at the Gardens of the Queen began in the late 1980s, but it was not until the early 1990s that it became systematic following a tourism joint venture between Avalon (foreign counterpart) and Puerto Sol (Cuban counterpart, replaced later and to date by Marlin). The company promoted a tourism model based on well-preserved nature, with low-impact activities, recreational catch-and-release fishing in shallow waters, autonomous and free diving, with few visitors (less than 3,000 visitors per year).[124]One of this company's first actions was to encourage declaring a part of Gardens of the Queen a protected area. The Decree Law 164: Fishing Regulations acted as the needed legal support. The Special Use and Protection Regime Zone (ZBREUP) of Gardens of the Queen (about 1,000 km^2) was one of the first of these designated areas to be approved[125] and one of the best implemented, through company supported patrols carried out by fishing inspectors that are maintained to this day. The only commercial fishing activity authorized in the protected area since 1996 is lobster fishing, with management informed by science.

The joint tourism work in Gardens of the Queen with national and foreign economic, scientific, and conservation actors led to the 2010 declaration (Agreement 6803/2010) of the Gardens of the Queen National Park (PNJR) (about 2000 km^2). Despite the socioeconomic ups and downs and the current pandemic, continuous tourism in Gardens of the Queen for more than 25 years has been a key element for nature conservation in the archipelago.

To get a better idea of the positive effect of tourism on the conservation of Jardines de la Reina, we should discuss the impact of fishing, i.e., the main, historically developed economic activity in the area and its surroundings. Until 1996, Gardens of the Queen was for many years one of Cuba's main fishing areas, following similar trends of deteriorating scaled fish operations.[126] Reproductive schools of biajaiba (*Lutjanus synagris*) and yellowtail (*Ocyurus chrysurus*) were heavily fished, with catches of the latter amounting to

[124] Figueredo Martín, T., F. Pina Amargós, J. Angulo Valdés y R. Gómez Fernández. 2010a. Buceo contemplativo en Jardines de la Reina: caracterización y percepción sobre el estado de conservación en el área. Revista de Investigaciones Marinas. Vol. 31(1): 23-32.; Figueredo Martín, T., F. Pina Amargós, J. Angulo Valdés and R. Gómez Fernández. 2010b. Pesca recreativa en Jardines de la Reina, Cuba: caracterización y percepción sobre el estado de conservación del área. Revista de Investigaciones Marinas. 31 (2): 141-148.; Perera S, Hernández A, González J, Moreno O, Cobián D, Ferro H, Milián E, Caballero H, Alcolado P, Pina-Amargós F, Hernández Z, Espinosa L and Rodríguez LF. (2018). Marine protected areas in Cuba. BMS. Vol. 94, No. 2 423-442.

[125] Resolution 562/1996.

[126] Claro, R., I Sadovy de Mitchenson, K.C., Lindeman, A. Garcia-Cagide. Lindeman, A. Garcia-Cagide (2009). Historical analysis of Cuban commercial fishing effort and the effects of management interventions on important reef fishes from 1960-2005. Fisheries Research 99:7-16.

35-40% of the national total.[127] Although the area's scaled fish operations declined substantially in 1996 and almost completely in 2010, numerous species are still caught around the PNJR. Because of the connectivity between these zones, these fishing activities impact inhabitants in the protected area. Cuba's southeastern shelf accounts for almost 100% of the wild shrimp catch,[128] 44% of the total national catch,[129] up to 35% of scale fish,[130] between 36-70% of the sea cucumbers,[131] 40% of the shark, and 45% of the ray catch.[132] This has led to shrimp, lobster, and most fish showing signs of overfishing in southeastern Cuba.[133]

Despite such intense fishing pressure, according to scientific research protecting Gardens of the Queen, promoted and supported by tourism and other stakeholders, has paid off. For example, this is the only region in Cuba where the nesting of three species of sea turtles is increasing.[134] The goliath grouper (*Epinephelus itajara*) is more abundant inside the PNJR than outside.[135] Research on this species carried out in the PNJR led to a ban on catching it throughout Cuba.[136] Sharks are also more abundant inside the PNJR than outside.[137] Densities and biomasses of commercial fish (mainly *Lutjanidae* snappers and *Serranidae* groupers) have increased in the PNJR over the years.[138] All of these investigations have received significant support from tourism developed largely (or entirely) by Avalon.

As if the scientific evidence were not enough, visitors see the benefits of protecting Gardens of the Queen, promoted and supported by tourism and other stakeholders. Divers and recreational fishermen consider the natural habitats within Gardens of the Queen to be excellent and in better condition when compared to previous visits[139]. Gardens of the Queen is considered among the best destinations for recreational fishing and diving worldwide, and most visitors want to return to this archipelago.[140] Studies show that tourism activities in the PNJR do not cause ecosystem deterioration.[141]

However, these results would not be complete if they did not have an impact on

[127] Ibid.

[128] Pérez A, Puga R (1982). Evaluación de la pesquería del camarón del área de Santa Cruz del Sur. Rev Cub Inv Pesq 7(3):58-60.

[129] Puga R, Valle S, Kritzer JP, Delgado G, Estela de Leon M, Gimenez E, Ramos I, Moreno O, Karr KA (2018). Vulnerability of nearshore tropical finfish in Cuba: implications for scientific and management planning. Bull Mar Sci. 94(2):377-392.

[130] Giménez E, Ramos I, Valle S (2016). Análisis de la productividad pesquera de la plataforma suroriental de Cuba. Rev Cub Inv Pesq 33(1):43-52.

[131] Hernández-Betancourt A, Puga Millán R, Borroto Vejerano R. (2018). Conservation strategy for the sea cucumber (Isostichopus badionotus) fishery in Cuba. BMS. Vol. 94, No. 2: 409-421.

[132] PAN-Tiburones (2015). Plan de Acción Nacional de Conservación y Manejo de Condrictios de la República de Cuba. Ministry of the Food Industry. Havana, Cuba. 49 p.

[133] (Pérez and Puga 1982; Giménez et al. 2016; Alzugaray R, Puga R (2010) Dinámica poblacional de la langosta Panulirus argus (Latreille, 1804) en la región suroriental de Cuba. Rev Cub Inv Pesq 27(1):1-6.

[134] Azanza Ricardo J, Gerhartz Muro JL, Forneiro Martín-Viaña J, Moncada Gavilán F, Bretos F, Medina Cruz Y, Nodarse Andreu G, Pérez Martín R, García Alfonso E. (2018). Achievements and challenges of marine turtle conservation in Cuba. Bull Mar Sci. 94(2):297-312.

[135] Perera et al., 2018.

[136] Resolution 178/2018, MINAL.

[137] Perera et al., 2018.

[138] Several papers summarized by Pina-Amargos et al. 2021.

[139] Figueredo Martín et al. 2010a, Figueredo Martín et al. 2010b.

[140] Ibid.

[141] Hernández-Fernández L, Olivera Espinosa Y, Figueredo-Martín T, Gómez Fernández R, Brizuela Pardo L, Pina-Amargós F (2016). Incidencia del buceo autónomo y la capacidad de carga en sitios de buceo del Parque Nacional Jardines de la Reina. Rev Mar Cost 8:9-27.

resilience and sustainability in coastal communities. Forty percent of the tourism workers in Gardens of the Queen come from the surrounding coastal communities, mainly Júcaro and Santa Cruz del Sur.[142] Every year, diving alone in the coral reefs of Gardens of the Queen contributes $356,000 per km^2 of coral reef to the economy.[143] The environmental goods and services of the PNJR have a total annual economic value that exceeds the $4 million from the ZBREUP and a net present value that exceeds it by almost $34 million.[144] The environmental goods and services provided by the PNJR justify the management costs, since the benefits generated by the park exceed $16 million and management costs absorb just 8% of those benefits.[145] Thanks to the sustainable economic activities developed in Gardens of the Queen, mainly tourism, the economic contribution of these activities exceeds by more than $13 million the contribution of economic activities, mainly fishing, in the surrounding areas of the archipelago.[146]

In summary, the leadership of the tourism sector, together with other national and foreign actors, has produced positive results in the environmental, social, and economic fields in this archipelago and its surroundings. These results encourage conservation of biological diversity, while contributing to the resilience and sustainability of coastal communities that depend on the environmental goods and services that nature provides.

3.9 Tourism

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Introduction:

Santa Lucía Beach, located 110 km from the city of Camagüey, is one of the main sun-and-beach tourist destinations in the country, with numerous hotels, shopping centers, and resorts. As part of a marine-coastal ecosystem, it has an extensive coral reef along the northern Cuban archipelago, from Punta de Hicacos (Varadero) to beyond the eastern limit of Camagüey province.

As part of the province's tourism development strategy, studies will be conducted in settlements located within consolidated tourist areas such as Santa Lucía beach.

Previous studies in this developing tourist destination showed that it was necessary to

[142] Figueredo Martín, T., F. Pina Amargós, J.A. Angulo Valdes (2014b). Economic feasibility of the implementation of the Jardines de la Reina Nacional Marine Park. Handbook on the Economics of Biodiversity and Management of Ecosystem Services. Edited by Paulo A.L.D. Nunes, Pushpam Kumar and Tom Dedeurwaerdere. ISBN: 9781781951507; eISBN: 9781781951514 DOI: 10.4337/9781781951514. 27 Jun 2014

[143] Spalding, Mark, Lauretta Burke, Spencer A. Wood, Joscelyne Ashpole, James Hutchison, Philine zu Ermgassen (2017). Mapping the global value and distribution of coral reef tourism. Marine Policy 82 (2017) 104-113.

[144] Figueredo Martín, T., F. Pina Amargós, I.M. Ramirez Roque, A.M. Perez Machado (2014a). Vínculos entre el bienestar humano y servicios ambientales que prestan las áreas protegidas marinas del sur de Ciego de Ávila y Camagüey. In "Áreas protegidas y comunidades humanas. Una mirada desde el Sur" collective of authors (Havana). Ministry of Science, Technology and Environment. Publication of the GEF-UNDP Southern Archipelagos Project, [159-189] ISBN 978-959-287-051-2.

[145] Figueredo Martín, T., F. Pina Amargós, JA Angulo Valdés. 2013. Aportes de Bienes y Servicios Ambientales del Parque Nacional Jardines de la Reina (PNJR) a la economía nacional. In "Potenciando la conservación de la biodiversidad mediante la evaluación económica y ambientalmente sostenible de actividades productivas en el Ecosistema Sabana Camagüey, Cuba" collective of authors (Havana) 2013, Publication of the UNDP/GEF Sabana Camagüey Project, ISBN 978-959-300-037-6.

[146] Figueredo Martín et al., 2014a.

carry out an urban reorganization in three of its coastal settlements, and that they should be integrated as complementary tourist products to the tourist destination of Santa Lucía beach. These settlements are Punta de Ganado, Tararaco, and La Boca (Serrano, 1993).

The local delegation of the Ministry of Tourism (MINTUR) and the Provincial Directorate of Physical Planning (DPPF) requested that the Center for Multidisciplinary Studies of Tourism (CEMTUR) and the Faculty of Construction, both from the University of Camagüey, carry out an urban, architectural, and landscape study of these settlements.

The La Boca settlement was intentionally chosen for this study because it has the highest level of urban, architectural, and landscape degradation due to an accumulated lack of maintenance and scarce adherence to the urban development plan in the entire built-up area.

The problem to be solved was how to achieve an adequate urban, architectural, and landscape image that complements suitable urban redevelopment in the coastal settlement of La Boca in Santa Lucía beach? In order to respond, the general objective was defined: design conceptual ideas for the sustainable urban redevelopment of this coastal settlement.

The study was undertaken in three phases: first, a theoretical discussion of concepts and regulations regarding urban, architectural, and landscape planning and redevelopment, as well as studies of international coastal settlements. Second, the settlement was characterized and analyzed from a social, urban, landscape, and environmental perspective, based on the results obtained through interviews, observation, and physical inventories, which will be used to prepare files, profiles, and information related to the urban characteristics of the settlement. Third, proposals and conceptual ideas for urban redevelopment in the settlement were developed.Diagnosis of the current situation of the coastal settlement La Boca de la playa Santa Lucía

La Boca in Santa Lucía beach in Camagüey province was built in 1862. The first construction was a lighthouse to guide ships entering and leaving Nuevitas Bay. At the end of the 19th century, seasonally occupied buildings for summer vacationers began to appear. As the years went by, seasonal use by fishermen and their families led it to become a consolidated settlement (Serrano, 1993).

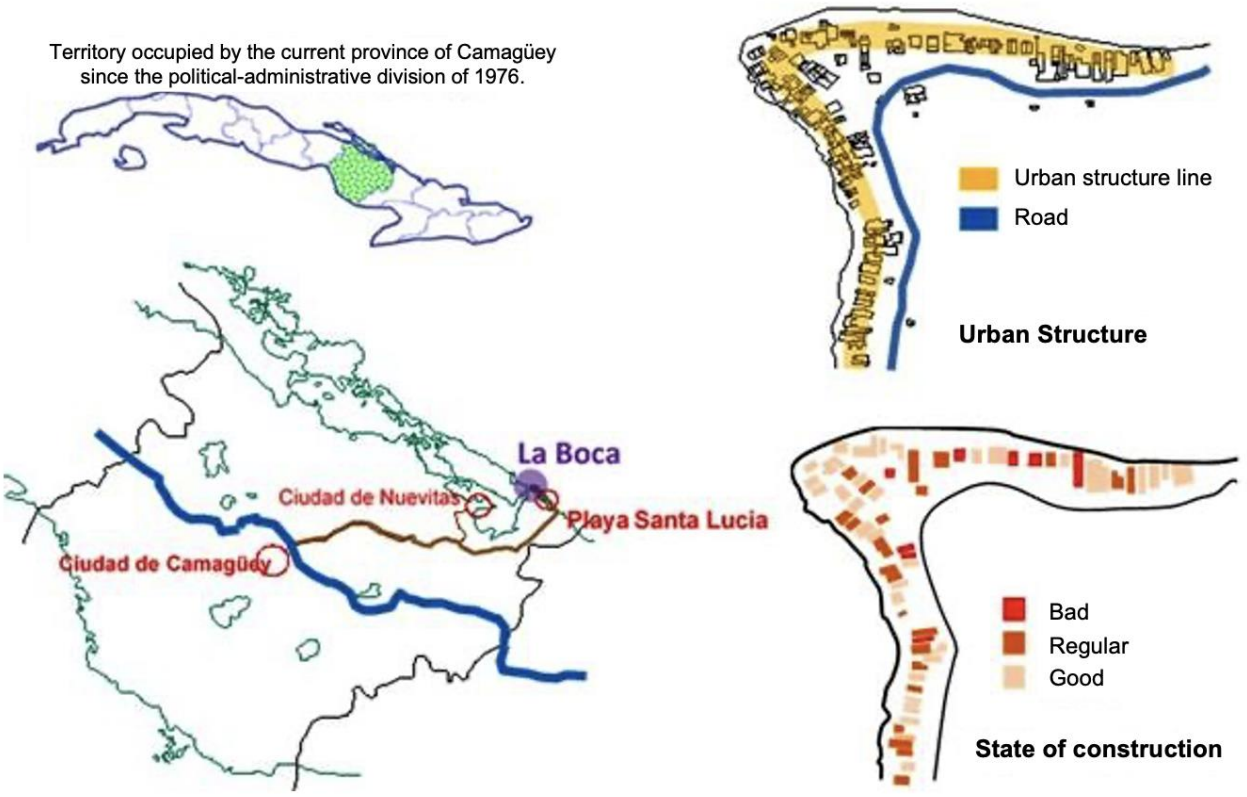

Figure 1: La Boca coastal settlement. Location, urban structure, and physical state of its buildings.
Source: Prepared by the authors based on the survey conducted.

Buildings are deteriorated due mainly to wear and erosion of materials caused by saline intrusion. The most relevant factors in the deterioration of the settlement are manmade causes, natural phenomena, the lack of maintenance, ramshackle construction, and the lack of urban, architectural, and landscape planning for the entire complex.

Vehicular circulation occurs mostly from the embankment that links La Boca to Santa Lucía. Pedestrian circulation is not planned and develops haphazardly.

The technical networks are in fair to poor condition due to the deterioration of wooden posts and corrosion caused by salt penetration. The hydraulic pipes are sometimes poorly located and break due to vehicular traffic. Sanitary disposal is through latrines that discharge waste into the sea and the water table.

As for the architecture, private housing predominates in 80% of the existing properties, followed by socio-commercial buildings used for providing services and lodging to vacationers from state agencies. Individual dwellings predominate, with few semi-detached or row houses.

Most pollution is anthropogenic from construction and vehicular use and flow. There is also flowing pollution from domestic waste that is dumped on the dune and into the water table. Micro dumps arise because there is no designated point or place to deposit waste. The predominant vegetation is coconut, caleta grape, and almond trees, as well as other creeping species such as beach sweet potato and sandspur.

Conceptual ideas for salvaging the urban image and landscape of La Boca settlement in Santa Lucía beach.

Sustainability is one of the fundamental aspects that should be considered within proposed solutions, as a premise for the project and its fundamental components, such as equipment and furniture, and when structuring urban areas.

Considering the detailed diagnosis and guidelines of the Santa Lucia Beach Management Plan (DPPF, 2012), the general urban, architectural, and landscape design criteria can be laid out for salvaging La Boca's urban image on Santa Lucia beach. We summarize these criteria as follows:

1. In areas closer to the dune and the shoreline, constructions should be built on piles with a height of 0.7 to 1 meter, allowing the surrounding environment to flow naturally.
2. The use of front and side portals, sloping roofs of French, Creole, or zinc tiles, the use of wood for enclosing walls and veneers, and the design of double façades for variable typologies will be emphasized.
3. The use of native vegetation such as creek grape, mangrove and almond, coconut trees, and palms will be promoted to enrich the urban image and encourage blending in with the environment.
4. Paths will be created in accordance with the natural flows of the settlement, prohibiting the use of paved construction materials and using only local materials such as stone and vegetation to delimit the roads.
5. The urban complex will be equipped with signage and vehicular and pedestrian lights with photovoltaic sensors and controlled intensity and direction, so that their light beams do not shine towards the sea. The associated networks should be buried whenever the terrain is appropriate. If this is not possible, they should be signposted and blend in with the surroundings.
6. Duly marked trash cans will be installed, as well as a solid waste disposal point. Liquid waste must flow into individual pits or with a collective collector channeled to a common pit or to a decanter tank and oxidation lagoon.

Searching for a suitable solution to the problem, urban design variants have developed and evolved, as designers consider the positive and negative aspects of each. The aim is to promote sustainability as a basic principle for the activities to be carried out.We discuss what follows the most suitable variant, in line with previously established criteria.

Conceptual design variant for salvaging the urban image and landscape of La Boca settlement in Santa Lucía beach.

The conceptual design variant is based on a detailed use of natural elements. Its paths and roads are bordered by natural elements only, such as stones, grass, and soil. The abundant vegetation in addition to the environment and landscaping is also part of road delimitation. Continuity is maintained between the different aspects of the settlement. A series of public spaces are proposed. Over a longer period, the settlement could be provided with walkways over some of the roads and the dune in order to protect the latter. Likewise, urban furniture such as solid waste deposits, benches, and lighting will be considered.

General conclusions:

Salvaging and improving the urban image of coastal settlements gives them certain urban elements which in turn give inhabitants a sense of belonging; the exercise stimulates new investments for environmental recovery and revaluation.

Analyzing the main characteristics of the urban, architectural, and landscape areas helped identify the principal problems that deteriorate the urban image of La Boca in Santa Lucía beach. Historical factors were identified that trace the emergence of the settlement and its subsequent development.[147]

3.10 The Private Sector, an Essential Actor to Build a More Resilient Country

Yordanka Castillo Porras

In 2011, Cuba implemented a new approach to the private sector on the island, buoyed by the update of the Economic and Social Model approved in the Guidelines of the Sixth Congress of the PCC.[148] Since then, the political will to promote expansion of non-state economic actors has increased. One of the general objectives of the National Plan for Economic and Social Development until 2030 (PNDES) is “to achieve greater integration among the country’s economic actors in order to respond appropriately to demands”. Governmental debates and specialized opinions regarding the country’s socioeconomic development conclude that the private sector has gained greater space in the dynamics of the country’s development, with significant and unquestionable results. Economic and social conditions have also led private businesses to shed the traditional image of small family enterprises and take on a greater role as the economic actors needed to achieve an efficient socioeconomic transformation on the island. Although there is no specific data comparing their growth, a report published by ONEI[149] in 2019 shows that 33 percent of

[147] **References 1.** Alberich, M. L. (2003). Estrategias Bioclimáticas en la Arquitectura. Catalunya. **2.** Andino Rubial, A. R. (2007). Turismo de litoral. Protección ambiental. Pinar del Río, Cuba. **3.** Artículos 8 y 9 de la Carta Europea de la ordenación del territorio. Council of Fumna VI CEMAT Torres Molino (1983). Taken from the journal *Estudios Territoriales*, p 14.**4.** Carta Europea de la Ordenación del Territorio. Artículo 8. Revista *Estudios Territoriales*, 53. **5.** Carta Europea de la Ordenación del Territorio. Artículo 9. Revista *Estudios Territoriales*, 71. **6.** DPPF. (2012). Departamento de Planificación Física en el municipio de Nuevitas en la provincia de Camagüey. Nuevitas, Camagüey. **7.** Dr. C. Herrera Pupo, G. (2011). Architectural Design and Planning in fragile ecosystems. **8.** Fariñas, J. P. (2006). Medio Ambiente Urbano, Ciudad de Camagüey, Impactos y Desafíos. Guía para Administraciones Locales (1999). Madrid: published by World Tourism Organization. **10.** Manchado, J. (2001). La Ordenación Territorial en Menorca y la Planificación Turística. In Urbanismo y Ordenación del Territorio (p. 218). Menorca. Padrón, M. (1998). Guía para la elaboración del Plan General de Ordenamiento Territorial y el Urbanismo del municipio. Institute of Physical Planning. Havana.

[148] *Lineamientos del Partido y la Revolución en el Sexto Congreso del Partido Comunista de Cuba (PCC).*

[149] *National Bureau of Statistics*

the labor force is linked to the private sector. Of this 33 percent, 13 percent are self-employed workers (SEW) and 10 percent are linked to the private agricultural and livestock cooperative sector.[150] These figures are high considering that this is a new economic, social, and cultural phenomenon in Cuba.

The most recent private-sector reform, in August 2021, authorized the creation of micro, small, and medium-sized enterprises (MSMEs).[151] Previous reforms authorized private businesses under a SEW license or as non-agricultural cooperatives (NACs) and local development projects (LDPs). Thus, the private sector has more options for continued consolidation under SEW licenses, MSMEs, LDPs, NACs, and for specific sectors such as agriculture, credit and service cooperatives (CSC), agricultural cooperatives (ACs), basic agricultural production units (BAPUs) and private farmers not associated with cooperatives.[152]

Once the legal framework authorizing the creation of MSMEs became effective (September 24, 2021) and up to November 2021, 497 private MSMEs, 12 NACs, 37 LDPs were created.[153] Twenty-eight percent of these actors are linked to food production, 33 percent to other production, 28 percent linked to the provision of services, and the rest are linked to technology services and recycling.[154] In addition, 73 percent of productive land in the agricultural sector is managed by the non-state sector.[155] These figures demonstrate the importance of the private sector[156] in national development. Thus, this growing sector needs to be linked with other sectors, while considering principles of sustainability and resilience. In the National Voluntary Report on the implementation of the 2030 Agenda presented to the United Nations (Agenda 2030 Report), the Cuban government confirmed that the island's private sector contributes to sustained economic growth, social inclusion, and environmental protection.

Private businesses are being created with an ecological-coastal approach such as Yes Ambientes' LDP "Finca Costera",[157] which provides "cultural tourist services with a strong ecological focus that energizes part of the coastal strip of the town of Santa Fe". This includes an environmental management program for reforestation, the care and observation of migratory birds, fish and other animals endemic to the coastal zone, the conservation of the incidence area, and the cleaning of a beach and mangrove area adjacent to the project.

Furthermore, existing, registered businesses, such as Ciclo Papel, Velo Cuba, Finca Marta, Mandaos, among others, contribute to fulfilling Sustainable Development Goals (SDGs) 5, 11, and 15,[158] according to the Agenda 2030 Report. Other hospitality businesses or rental houses located in coastal areas help to clean beaches and manage

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150 *Series Estadísticas Empleo y Salarios 1985- 2019*

151 Limited Liability Companies

152 The agricultural sector had the first non-state management authorized by the Cuban government. The first CSCs were created between 1959 and 1961, the ACs in 1976 and the BAPUs in 1993.

153 These figures are from the latest report by the Ministry of Economy and Planning, valid at the time this article was written. See the website of the Ministry of Economy and Planning for the most recent figures on these actors.

154 Report Produced by ICAN Researchers: ¿Dónde Están Los Primeros 520 Actores De La Economía Cubana?

155 *Voluntary National Report on the implementation of the 2030 Agenda submitted to the United Nations (Agenda 2030 Report).*

156 Informe Nacional Voluntario sobre la implementación de la Agenda 2030 presentado a Naciones Unidas (Agenda 2030 Report)

157 https://www.facebook.com/yesambientes/

158 SDG #5 "Igualdad de Género", SDG # 11 "Ciudades y Desarrollo Sostenible", SDG # 12 "Responsible Production and Consumption".

exotic species, such as the tourist rental houses located in Ciénaga Zapata[159], recognized by experts from the Environment Agency. Ecomadera is another project specialized in creating wood-like plastic from recycled materials, which is then used to build, among other things, walkways to protect the dunes close to tourist hotels.

In addition, small businesses, supported by leaders in economic, environmental, and social responsibility issues, promote events that help the private sector to engage with similar projects. For example, on November 12, 2020, a group of enterprises, encouraged by the "Economy and Consumption" Program of the Antonio Núñez Jiménez Foundation of Nature and Mankind, created the "1st Fair of Products, Services, and Ideas," "an opportunity for management and entrepreneurship models to exchange information; these models, while offering products and services, adhere to principles of social and environmental responsibility". Most of the exhibitors at this fair were food production and service businesses that emerged during the COVID-19 pandemic, exemplifying the adaptability and hands-on transformation of Cuban private businesses.

Also, access to the internet and the use of technology is helping the private sector become more involved in environmental initiatives. Through social media, there have been calls to participate in the cleaning of rivers and beaches. For example, in 2019 a cleanup was undertaken in Quibú River, convened through social networks by the private cafeteria Juanky's Pan, the *Akokán* community project, the Cuban Association of United Nations, the Antonio Núñez Jiménez Foundation, and the Environmental Youth Network of Cuba. This initiative encouraged other governmental organizations such as CITMA,[160] community enterprises, and civil society to join in massively.

However, there is still much work to be done to ensure that existing, emerging, and future businesses create tools to help them develop adaptive, innovative, and resilient strategies and prepare to deal with factors that hinder sustainable business development, such as weather events or economic crises caused by, for example, the COVID-19 pandemic. Finding a balance between economic development, sustainability, and resilience will be a determining factor for efficient integrated development on the island. Achieving this balance is everyone's task, including the growing private sector.

It is essential that the latter access the same benefits and assume the same responsibilities as state actors to help business owners and employees understand the importance of creating, and implementing, resilient and sustainable strategies. We also need to see that communication, implementation and monitoring channels are facilitated, through which local governments, ministries responsible for implementing the *Project Life* Climate Change Response Plan, and other types of stakeholders can jointly contribute with the private sector. If all economic actors on the island and their leaders cooperate in the implementation of adaptive, sustainable and resilient strategies, an efficient economy and country can be built.

[159] https://apnews.com/article/noticias-a13694f66956a6911bf2b961bf837f4b

[160] Ministry of Science, Technology, and Environment

Photo by Noel López Fernández

4. SELECTION OF RELEVANT PROJECTS FOR COASTAL ZONES IN CUBA

4.1 *Mi Costa* Project

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The project is a response to implement measures to ensure that Cuba's coasts adapt to relative sea level rise and associated flooding from extreme weather events. The impacts of these factors are a national security concern for a small island state and pose a threat to coastal settlements and communities.

Cuba's southern coast was selected because of its high vulnerability to climate change, particularly as manifested in coastal flooding and saline intrusion. The project will directly benefit 1,300 km of coastline, 24 communities, and 1,324,114 people through activities and measures that increase resilience to these climate impacts.

Cuba's geographic characteristics and the conservation status of its marine and coastal ecosystems are an optimal opportunity for large-scale ecosystem-based adaptation (EbA), an approach that has been favored by Cuba's State Plan for Climate Change Management, i.e., *Project Life*.

The protection and rehabilitation of ecosystems, capacity building, and strengthening of regulations are the pillars of this project. One pillar aims to recover the functionality of ecosystems in order to provide protection and regulation services; another one will ensure their sustainability and continuity.

The project will improve adaptive capacity through the comprehensive rehabilitation of the coastal terrestrial and marine landscapes, their interconnected ecosystems, and their hydrology. This will be accomplished by rehabilitating ecosystem functions and connections within mangroves and swamp forests, and reducing anthropogenic pressures on coastal-marine ecosystems, which will improve the services provided by integrated coastal ecosystems. The adaptive capacities of coastal governments and communities will also be strengthened by developing their ability to use and understand the benefits of EbA, increasing the flow of information among stakeholders, and strengthening the regulatory framework for territorial management in the coastal zone.

The project will restore 11,427 ha of mangrove forest, 3,088 ha of marsh forest, and 928 ha of marsh grassland, which in turn will improve the health of 9,287 ha of seagrass and 134 km of coral reef crests. Together, these ecosystems will provide protection and regulation services along the selected coastal zone.

The project will establish a new paradigm by including EbA directly into development strategies and actions for integrated coastal zone management in a changing climate. This will help ensure flexible risk management solutions for coastal populations and reduce their flood risks.

4.2 Economic assessment of the mangrove ecosystem

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Ecosystem-based adaptation (EbA) is an approach to working with nature that increases the resilience of vulnerable communities to the impacts of climate change.

In comparing costs and benefits of EbA measures relative to structural measures, monetary evaluations can be useful in highlighting the effectiveness of EbA projects compared to other major engineering projects. This is especially true when weighing development priorities, along with conservation and risk reduction aspects, thus providing decision makers with sound arguments by quantifying costs and benefits of conservation relative to other activities.

In Cuba, inhabitants of the southern provinces of Artemisa and Mayabeque have been affected for years by the indiscriminate logging of their mangroves and swamp forests (prior to the approval of the Forestry Law of 1998), which caused the sea to penetrate inland during different climate events, leading also to the loss of dry land and ecosystem services, mainly of the mangrove forest. This motivated efforts to restore this environment in order to build the resilience of this area and that of nearby communities.

Based on the monetary assessment of 12 of the 22 ecosystem services highlighted by RAMSAR as the most important involving wetlands (i.e., five services: agricultural production, beekeeping, livestock, fisheries, and water purification) and seven regulation and support services (disaster damage reduction, air quality and gas regulation, water regulation, pollution control/waste regulation, erosion regulation, nutrient cycling, and biodiversity)), we performed a cost-benefit analysis to evaluate investment options in monetary terms. Thus, we accounted for the main costs: restoration, conservation projects, maintenance, expendable assets, equipment and fuel, as well as the benefits obtained by these EbA activities in the ecosystem services of the Southern Mangrove of the Artemisa and Mayabeque Provinces.

To provide ecosystem services, the following methods were used: market prices and shadow prices for avoided replacement costs; for regulating and support services, the transfer of value and replacement cost were used.

In the three scenarios studied (effective area, intervention area, and the entire project), the cost-benefit ratio ranged from 6.81 to 14.91; in other words, for every peso invested, a benefit of more than six pesos ensued, demonstrating the profitability of implementing the project under this ecosystem-based adaptation methodology.

The net present value (NPV) was also estimated using two discount rates, one based on the economies of Caribbean countries near Cuba, of 14%, and another environmental rate of 4%, like the one used internationally.

4.3 *Manglar Vivo* Project

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Mangrove ecosystems are among the first and most efficient barriers against storms, storm surges, and hurricanes, protecting coastal areas from erosion and salinization in tropical regions. Mangrove restoration is recognized worldwide as a fundamental tool to prevent these impacts.[161] Given these benefits, the *Manglar Vivo* project was implemented in Artemisa and Mayabeque provinces, led by the Institute of Ecology and Systematics of the Ministry of Science, Technology, and Environment (CITMA), with the support of UNDP and international funding agencies. It applies restoration techniques, education and sensitization activities, and support to sustainable productive activities related to mangroves.[162]

For years, Artemisa and Mayabeque provinces have been affected by the indiscriminate logging of their mangroves, which has impacted their ecosystem services. Ecosystem-based adaptation (EbA) is an alternative approach to increase the resilience of vulnerable communities. Cost-benefit analysis is used to evaluate investment options, where costs and benefits are directly compared in monetary terms. This shows the monetary impact of each in a way that is easy for decision makers to understand.[163]

We have learned many lessons during the six years of the *Manglar Vivo* project. Important contributions include increased health of coastal wetlands, especially the mangrove ecosystem, reduced coastal flooding, and a notable increase of coastal resilience in six municipalities in Artemisa and Mayabeque provinces. Scientific evidence is used for the restoration of mangroves and bordering forests, control of invasive exotic species (IAS), changes in the way agroforestry companies work and their relationship with wetlands, thus strengthening the capacities of the institutions responsible for forest protection. In the case of the Forest Ranger Corps-MININT, this procedure was effective in reducing damage from forest fires and controlling illegal activity within the wetlands, while helping the Corps redesign and implement the naval and land surveillance circuit. An important step towards sustainability was taken with the creation, organization, and training of five groups of volunteers from coastal settlements, including women and community leaders. Effective knowledge management gave us a new view of the coastal wetlands and their communities. Dozens of innovative scientific and technical materials were produced, as well as educational programs for dissemination and awareness-raising on climate change adaptation issues. As part of the project's sustainability, participants calculated the economic valuation of wetland goods and services, and came up with a novel proposal for the cost-benefit valuation of restoration and economic incentives. In addition, with community members of participating settlements, stingless-bee raising was

[161] UICN, 2019. Motion 093- Conservación, restauración y gestión sostenible de los ecosistemas de manglares. [Online] At: https://www.iucncongress2020.org/es/motion/093.

[162] Aguilar González, B. and Vales García, M.A., 2021. MANGLAR VIVO EN CUBA: COSTOS Y BENEFICIOS DE LAS ACCIONES BASADAS EN ECOSISTEMAS. Análisis económico-ecológico en las provincias Sur Artemisa y Mayabeque. *REVIBEC-REVISTA IBEROAMERICANA DE ECONOMÍA ECOLÓGICA*, *34*(1), pp.86-110.

[163] Ibid.

encouraged, with the publication of the first manual of its kind in Cuba, and an analysis was undertaken of the mineral and medicinal potential of the muds associated with healthy mangrove swamps. Lessons learned from the project have been the basis for new project proposals, with a focus on ecosystems and community-based adaptation, as well as coastal and community resilience. One outstanding aspect in the six years of the project was the widescale and innovative scientific production: five manuals, publications in high-impact journals, brochures, books, web series, animations, and audiovisual materials, all of which aimed to benefit the common good. Project results are stored in four Training Classrooms, which are training and integration venues for the people and stakeholders of the coastal zone, as they deal with climate change.

4.4 *Resiliencia Costera* Project

Environment Agency (AMA)[164]

The *Building Coastal Resilience in Cuba through Natural Solutions for Climate Change Adaptation (known as the Resiliencia Costera Project)*project was signed on January 24, 2020. Project activities are in line with the State Plan for Addressing Climate Change in the Republic of Cuba, which recognizes the cross-cutting nature of climate impacts and disaster risks, and their relationship with development planning.

The project's overall objective is to strengthen and integrate disaster risk reduction (DRR) and climate change adaptation (CCA) in the socio-economic development plans of sectors and governments of vulnerable coastal municipalities. The specific objectives are to strengthen capacities for disaster risk reduction and avoid the creation of new vulnerabilities in socio-economic development and post-disaster reconstruction. In addition, the project will increase the resilience of coastal ecosystems and communities to the impacts of CC, with emphasis on sea level rise (SLR) and extreme hydrometeorological events, and adapt local socio-economic development planning to a changing climate, in addition to being gender focused.

To accomplish these objectives, the project will involve nature-based/community-based adaptation (EbA/CbA) solutions, with recognized socioeconomic benefits for the environment and inhabitants. thus increasing climate resilience in key development sectors, supported by improved decision making based on objectives, impact analysis, and capacity building, with gender and social-equity awareness.

The project is based on identifying and evaluating current and future hazards for the municipalities where it is undertaken, updating the territorial Environmental Management Model (EMM), identifying EbA/CbA solution alternatives that would be complemented with gray infrastructure or engineering solutions, all of which will ultimately be included in the Territorial Development Plan.

The project aims to achieve three closely linked results: strengthen capacities for local DRR and its integration into Disaster Risk Reduction Plans; increase resilience of coastal settlements through the implementation of CCA strategies in the main development sectors and in national, local and community governments; incorporate an integrated approach to DRR and CCA in local development planning. This will promote gender mainstreaming in the three outcomes and promote equality between women and men in

[164] This chapter was extracted from the approved document of the *Building coastal resilience in Cuba through natural solutions for climate change adaptation* project.

coastal settlements, while strengthening local management tools.

Project activities will be undertaken at the Sabana-Camagüey archipelago, in north-central Cuba. It covers the fifteen coastal municipalities of Villa Clara, Sancti Spiritus, Ciego de Avila, and Camagüey provinces. Direct activities are planned for four of these municipalities (Municipality Caibarién - Punta Brava Site, Municipality Yaguajay - Vitoria Site, Municipality Chambas - Punta Alegre Site, and Municipality Nuevitas - Santa Rita site) and the remaining 11 municipalities will replicate activities to be defined during the first year.

The project is expected to benefit some 600,925 people throughout this area. Direct beneficiaries are estimated at 194,627 (population, technicians and decision makers in the four municipalities where activities are located) and an estimated 406,298 people in 11 replicating coastal municipalities will receive indirect benefits.

Expected results

The project will obtain three closely interrelated outcomes and generate nine outputs that will help incorporate an integrated approach to DRR and CCA in local development planning. The expected outcomes and outputs are listed below, and a description of related activities is provided.

Result I: Strengthened capacities for local disaster risk reduction and their integration into Disaster Risk Reduction Plans.

Two sub-results are foreseen:

- Strengthened capacities of entities and communities, with heightened gender awareness, for generating and updating DRR information.
- Improved capacity of governments and key sectors for incorporating updated DRR information in sectoral and territorial plans.

Special attention will be given to Risk Reduction Management Centers (RRMCs) and Early Warning Points (EWPs). Local governments will be provided with equipment for climate resilient solutions and their personnel will be trained. By the end of the project, key local actors will have heightened capacities to prioritize actions in sectoral and territorial DRR plans, which incorporate lessons learned from facing extreme hydrometeorological events, and knowledge about current and future risks, reducing existing vulnerabilities and avoiding new ones.

Outcome II: Resilience of coastal settlements is strengthened through the implementation of gender-sensitive climate change adaptation strategies in key development sectors and in national, local, and community governments.

Two sub-results are foreseen:

- Rehabilitated coastal wetland ecosystem services, with an EbA approach, in the activity areas.
- Strengthened capacities of key local governments and sectors for the generation of gender-sensitive municipal CCA plans.

Special emphasis will be placed on strengthening the Centers for Adaptation Learning and Capacity-Building (CCC-GCAs) and their technical coordination with the RRMCs. This will rehabilitate coastal wetlands with an EbA approach and technology transfer through demonstration of natural solutions for CbA at the activity sites.

Outcome III: The integrated approach to disaster risk reduction and climate change adaptation is incorporated into gender-sensitive and socially equitable local development planning.

Two sub-results are foreseen:

- Strengthened the capacities of key actors for the management of tools that help integrate DRR and CCA in gender-sensitive and socially equitable local planning.
- Strengthened capacities for DRR and CCA knowledge and information management.

Strengthening will involve equipment, training, visibility, awareness-raising, and communication, and venues for coordination of actors at different levels. Special emphasis will be placed on strengthening governments, representatives of key sectors, and the media.

At the end of the project, the municipal EMMs will have been updated, and a knowledge management platform will have been implemented to help include an integrated approach to DRR/CCA in local development planning. Local experiences will be socialized and transferred to the rest of the country's vulnerable coastal municipalities, through systematization, exchange, and dissemination of experiences and good practices.

Alliances

Many institutions have been involved in project design and implementation, considering their state and/or social responsibility and their relationship with project results. The following diagram (Figure 1) shows the structure of key institutions involved in the project's different territorial levels.

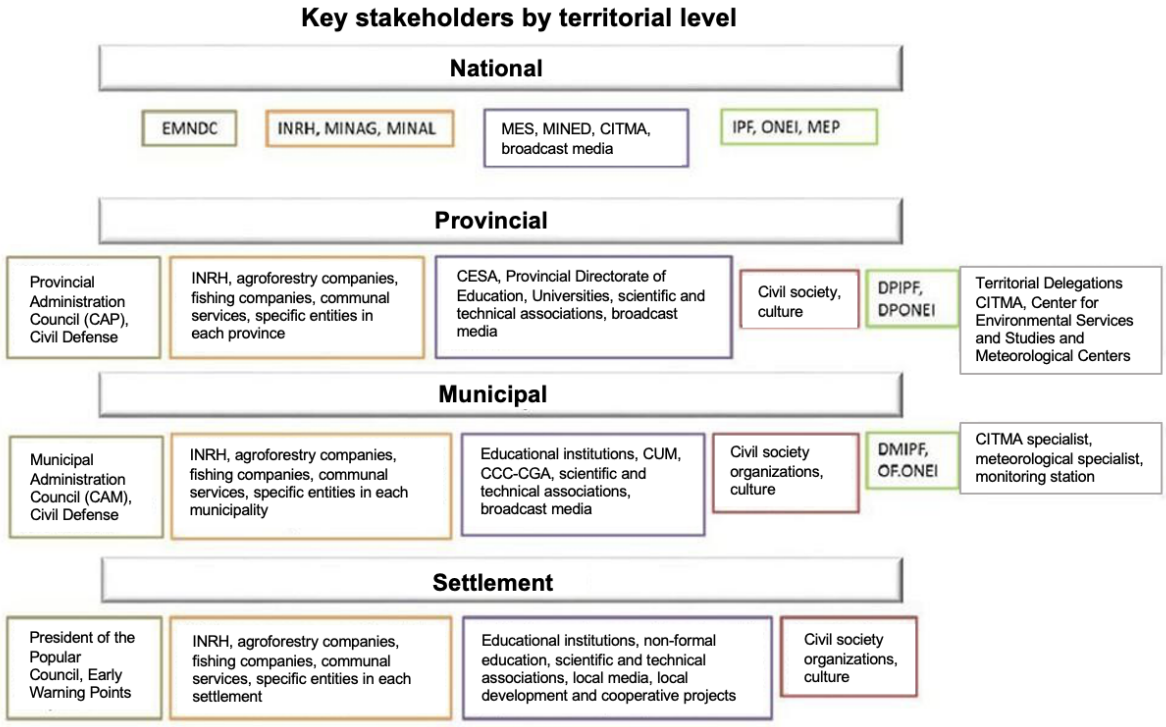

Figure 2: Key institutions with responsibility and/or participation in the project at different levels.

4.5 *SOS Pesca* Project

Ania Mirabal Patterson
Félix Varela Center (CFV)

The project *Sustainability of fisheries in a key area of the Caribbean basin and improvement of the quality of life of fishing communities*, known as *SOS Pesca***,** was implemented in Cuba from June 2011 to July 2016. The participating communities of the project were Playa Florida, Florida municipality, and Guayabal, Amancio municipality, located in the provinces of Camagüey and Las Tunas, respectively.

SOS Pesca was financed by the European Union (EU) and executed by the National Center for Protected Areas (CNAP), with the accompaniment and support of Emerging Countries Development Cooperation (Cooperación para el Desarrollo de los Países Emergentes-COSPE Onlus), the World Wildlife Fund (WWF), and the Environmental Defense Fund (EDF).

The beneficiaries of this project were private and state fishermen and fisherwomen [hereinafter “fishers”] from the communities, technical and scientific personnel from the “Macurije-Santa María” and “Ojo de Agua” Protected Areas (PA), the National Flora and Fauna Enterprise, the Ministry of Science, Technology and Environment (CITMA), the Directorate of Fishing Regulations of the Ministry of the Food Industry (MINAL), the Local Development Center, and participating municipal governments. Specialists from the Marine and Coastal Research Institute (INVEMAR) In Colombia also participated.

SOS Pesca contributed to the resilience of both communities in eastern Cuba. Among the skills to be developed to achieve resilience were *absorption, adaptation, and transformation*. The project emphasized the capacity for transformation. Capacities were strengthened among the different social actors in order to stop and/or reduce the underlying causes of risks and vulnerabilities present in these coastal zones brought by a decrease of marine and terrestrial flora and fauna due to overexploitation, sea level rise, and a lowering of people’s quality of life.

Results ranged from the contribution to the establishment of more robust policies and strategies, new management mechanisms at different levels, citizen participation in the processes, quality of life, to the change in imaginaries, values, social norms, and gender equity.

Cuban and foreign organizations worked jointly for five years and obtained various results and lessons. The actions implemented followed the *research-training-exchange-transformation* logic. The successes of the project can be summarized as follows:

1. The work strategy was participatory and coordinated, which ensured ownership of actions undertaken and their replication.

- Communities that were mobilized based on their interests and needs

became protagonist of their actions. There was a change of mentality regarding environmental and social issues, while communities grew in cohesion and self-esteem.

- Institutions at all levels also transformed their ways of doing things, working in a coordinated and more participatory manner.
- New economic alternatives were implemented in the communities (two oyster farms, a textile workshop in Guayabal and a covered cultivation house in Playa Florida), which contributed to improving the quality of life by providing new and higher income (211 jobs, 81 of them for women).
- Experience was shared with related projects such as *CCamBIO*, implemented by the Antonio Núñez Jiménez Foundation (FANJNH) and financed by the EU, sharing some of the successful strategies implemented.
- Multipliers for MPA management and fisheries administration were trained in Boston (seven from Cuba and three from Mexico).
- Two international seminars were held in Cuba as part of the Convention on the Environment, which forged exchanges and work strategies coordinated at the regional level.

2. The existence of natural values in the project's PAs made them the most important centers to produce environmental goods and services in the region, and the communities involved became the main beneficiaries of these goods and services.

- The creation of the Integrated Coastal Management Regime Zone provides long-term environmental, economic, social, and institutional benefits and impacts. The integrated coastal management plan for this zone was prepared and this experience was shared in Colombia, where participants also learned about co-management.
- The creation, strengthening, and preparation of the Special Operational Plan for the two PAs reinforced systematic biodiversity conservation and monitoring.

3. Scientific results led to management strategies based on the conservation and maintenance of environmental services. These environmental activities and the acquisition of new technologies led to a discreet increase in marine species and the reappearance of some species that did not occur in the region.

- Monitoring protocols were developed, we contributed to the development of the National Action Plan for Rays and Sharks, the Productivity and Susceptibility Analysis was applied to fisheries across Cuba's entire southern region, and we prepared booklets with protection measures for endangered species.
- New environmentally friendly fishing gear was introduced, such as circle hooks, fishing baskets, larger mesh sizes to allow smaller fish to escape, and the mandatory use of escape devices in shrimp catching.

- GPS and echo sounders were installed on fishing company vessels, i.e., technologies that contributed to safer navigation, knowledge of the distribution of fishing activity, and identification of large fish schools.
- Species such as lane snapper, grey mullet, Atlantic croaker, and king mackerel reappeared. In the mangrove swamp, there were abundant juveniles and the return of birds such as flamingos, darters, Zapata rail, and *spoonbills* In addition, more autochthonous species such as the Cuban crocodile were sighted.

4.6 *CCamBIO* Project

Esther Velis Díaz de Villalvilla and Reinaldo Estrada Estrada
Antonio Núñez Jiménez Foundation for Nature and Mankind (FANJNH)

The *Climate Change Impact on Two Fragile Ecosystems in Cuba* (*CCamBIO*) project, July 2013 to September 2017, was a long road with some difficulties that left us with a rich experience and significant achievements.

For the Antonio Núñez Jiménez Foundation (FANJNH) it was a great challenge to carry out a project of this magnitude, the largest ever executed by our institution.

The purpose of this project was to improve understanding of the most appropriate ways to address climate change adaptation in Cuba, particularly in the area of marine-coastal biodiversity conservation, in order to minimize impacts on ecosystem services that support the livelihoods of local communities. This was done through studies and monitoring of selected biodiversity indicators and dissemination of these results and experiences to raise awareness and train local people.

This project responded to a call by the European Union for non-state actors in which FANJNH participated with WWF Netherlands as a partner.

European Union support was constant, not just in financial terms, but also to understand the project's different stages. Likewise, we had the continuous support of MINCEX and MINCULT, our governmental links.

The overall objective was to **contribute to improving biodiversity resilience and the capacity of local communities to adapt to climate change in two ecologically sensitive coastal-marine areas of Cuba, i.e., Caletones in the Zapata Marshlands and Júcaro in Gardens of the Queen.**

The specific objectives were:

1. Develop the capacities of key actors for evaluating, monitoring, and adapting to climate change and its impacts on marine-coastal regions of sensitive ecosystems in Cuba.
2. Evaluate the possible impacts of climate change on biodiversity and its environmental services, as well as its possible consequences for local communities in pilot areas.
3. Establish and implement strategies to improve the resilience and adaptation

of species, ecosystems, and local communities to the potential impacts of climate change in pilot areas and train decision-makers, leaders, and residents of the settlements linked to the former, ensuring adequate age and gender balance.

4. Create and implement a national network for the exchange of experiences and information on assessment, monitoring, and adaptation to the impacts of climate change on biodiversity and its consequences on key economic sectors in Cuba.

Undoubtedly, the greatest achievement in fulfilling objectives and obtaining results was mainly due to how the coordinating group was able to work cohesively and in harmony. The group's members were the Institute of Oceanology (now ICIMAR), the Institute of Tropical Geography, the Institute of Meteorology and the Company for the Protection of Flora and Fauna. We assembled a harmonious team with a high level of professionalism and we therefore express gratitude for the support of the institutions and their directors. We are left with a great experience that encourages us to remain working beyond *CCamBIO* for continuity and sustainability. We feel very committed to sustaining our achievements.

Once this project concluded, we began to discuss ideas on how to continue with the achievements, insofar as the equipment, the weather stations, the buoys will continue to be useful in efforts to reduce the effects of climate change.

This project achieved scientific progress and carried out solid work with the two communities, with participating local institutions, government authorities, and community leaders, creating greater awareness among the inhabitants of the effects of climate change and the need to implement adaptation and mitigation measures.

All institutions and areas were equipped with basic equipment for office and field work (computers, laptops, tablets, GPS, diving equipment, etc.). In particular, state-of-the-art equipment was acquired, such as two underwater automatic stations (buoys), unique in Cuba, that every 30 minutes measure eight parameters of great importance for the study of climate change and biodiversity (temperature, depth, current direction and speed, PH, salinity, turbidity, dissolved oxygen), located in both parks; two automated meteorological stations in both parks that every 10 minutes measure eight parameters (temperature, precipitation, wind speed and direction, humidity, pressure, solar and ultraviolet radiation); two high-precision differential GPS (millimetric), two computer racks for running climate models, an A0 Scanner for old maps and a multiple DVD player that allows us to scale up preparation of informative materials.

A monitoring network on climate change and biodiversity was designed and set up, which includes the two buoys and the two meteorological stations mentioned above, 11 monitoring points for ridges and frontal reefs, where seven parameters or groups of parameters relevant to climate change and biodiversity issues are measured, and four profiles of turtle nesting beaches. Likewise, 15 Climate

Change and Biodiversity Monitoring Protocols were created or modified to include parameters relevant to climate change, including six completely new ones for landscape and temperature elements, based on remote sensing (satellite images).

For the first time climate scenario modeling (1961-2100) was carried out for the entire Caribbean region, with resolutions increased to 25 km (previously 50 km), using the PRECIS regional model in 12 SRES and RCP scenarios. Of these, three RCP scenarios were obtained for the first time, obtaining over 30 TB of information on the evolution of 200 daily meteorological variables, of which 27 of the most relevant have been post-processed for easier use. From this accumulation of data, climate evolution projections for the two project areas have been extracted and analyzed. For the first time, the new scenarios of representation of concentrations (RCP) were implemented in Cuba that substantially improve the old, widely-used scenarios of partial emissions (SRES). These new additions help to reduce the uncertainty associated with the generation of climate change scenarios.

Photo by Noel López Fernández

5. EXPERIENCES OF THE GREATER CARIBBEAN REGION

5.1 The Association of Caribbean States and Climate Resilience in the Insular Caribbean

Jacqueline Laguardia
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Caribbean islands are highly exposed to extreme weather events and climate change. As small island developing states (SIDS), these countries face a variety of challenges in moving towards sustainable development, among which environmental vulnerabilities are exacerbated in a context of economic instability and difficult access to the financial, technological, and professional resources needed to achieve climate resilience.

The Caribbean nations and regional non-independent territories have recognized a valuable alternative in regional cooperation to promote projects aimed at environmental protection and improvement, as well as mitigation and adaptation to the effects of climate change. Some initiatives have been developed in spaces and projects sponsored by the Association of Caribbean States (ACS), a regional institution that facilitates collaboration between Caribbean countries and institutions and other nations, organizations, and multilateral agencies.[165]

The ACS, founded in 1994, is an organization for consultation, cooperation, and concerted action in the areas of trade, transport, sustainable tourism, and disasters in the Greater Caribbean region. It holds a central place in the architecture of regional cooperation with 25 member states[166] and eight associate members.[167] Its objectives are to strengthen cooperation and integration, while preserving the integrity of the Caribbean Sea and promoting sustainable development.

In keeping with the second objective mentioned above, the importance of the Caribbean Sea for the ACS as the common heritage of the territories and peoples of the region was set down in the Preamble of the Convention Establishing the ACS. Article III states that the ACS shall promote "*the preservation of the environment and the conservation of the natural resources of the region, in particular of the Caribbean Sea*".

Since 1998, the ACS has been working on the Caribbean Sea Initiative given the importance of this fragile resource for the economy, social well-being and environmental balance of Caribbean societies and ecosystems. Some of these efforts crystallized in the establishment of the Caribbean Sea Commission to oversee the sustainable use of the Caribbean Sea for the benefit of present and future generations. Its main objective is to promote cooperation and coordination of actions for the protection of the Caribbean Sea, since its sustainability is threatened by multiple factors such as indiscriminate fishing, pollution, and ecosystem imbalances. Manifestations of these phenomena, including

[165] See the ACS's official website: http://www.acs-aec.org

[166] Antigua and Barbuda, the Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Mexico, Jamaica, Nicaragua, Panama, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Venezuela.

[167] Aruba, Curaçao, France (representing French Guiana, St. Barthélemy and St. Maarten), Guadeloupe, the Netherlands (representing Bonaire, Saba, and St. Eustatius), Martinique, Sint Maarten, and the British Virgin Islands.

sargasso tides, coastal erosion, and the expansion of invasive marine species, have exacerbated environmental degradation and caused substantial economic losses. The Commission facilitates communication, consultation and information flow through advisory mechanisms whose recommendations are circulated within the ACS and presented to member state representatives and officials.

The Caribbean Sea is of paramount importance for the ACS and thus its coordinating role for regional integration and cooperation and climate resilience building initiatives in the Caribbean. The Caribbean Sea is a vital asset for the economies of the area, a binding factor for regional identity, and a shared geopolitical space where climate events and the use of common resources can become a threat or an opportunity.

The ACS is developing several projects aimed at the conservation and recovery of the sea and its associated ecosystems. Among them is the project *Impact of climate change on Caribbean sandy coasts: Alternatives for its control*[168]*,* which investigates the erosion of Caribbean beaches due to predatory actions such as the extraction of sand from beaches or the construction of tourist facilities on the dunes. In fact, some deterioration has been found on virgin beaches caused by the rise in sea level and other effects associated with climate change. The project investigates the inflow of sargassum and the presence of exotic species such as lionfish in the Caribbean. One of its objectives is preservation and rehabilitation of Caribbean beaches through a regional monitoring network and professional training, among other activities.

An example of the progress made by the ACS in its work towards the recognition of the need to protect the Caribbean Sea was the approval, in 2016, of Resolution 71/224 *Towards the sustainable development of the Caribbean Sea for present and future generations* by the United Nations General Assembly. The Resolution recognizes the work of the ACS and the Caribbean Sea Commission. At its 21st meeting in July 2021, the Commission focused discussion on the implementation of this Resolution.

The protection of the Caribbean Sea is key to building climate resilience in the insular Caribbean. This requires actions that involve all non-independent countries and territories, since the phenomena that threaten marine and coastal ecosystems do not occur within established political boundaries. Regional cooperation becomes even more important when considering the economic and environmental vulnerabilities of the Caribbean islands that need to join efforts to conserve common environmental resources in a hostile environment that hinders SIDS's efforts to move forward on the path of sustainable development. The work of the ACS is an example of what regional cooperation initiatives can achieve for climate resilience in the insular Caribbean.

5.2 Southeast Reefs Marine Sanctuary, Dominican Republic

Aldo Cróquer, Francisco Núñez, *The Nature Conservancy (TNC)*

Someira Zambrano, *Dominican Reef Network (RAD)*

The Southeast Reefs Marine Sanctuary (Santuario Marino Arrecifes del Sureste-SAMAR) was declared a marine protected area in 2009 under Presidential Decree No. 571-09, whose purpose is to conserve the natural habitat and special environments located on the

[168] See https://ipsnoticias.net/2017/06/el-gran-caribe-capta-fondos-para-proteger-sus-costas-arenosas/

continental shelf of the southeastern portion of the island of Hispaniola. It covers an area of 7,862.59 km^2, along approximately 120 km of coastline and includes coral reef ecosystems, several major urban centers, and two of the country's main tourism centers that host more than four million visitors per year. It is classified under management category IV "Conservation through active management", which corresponds to habitat/species management areas, as established by the IUCN. It is the second largest marine protected area in the country, and stretches from Canal de la Mona (east of Cabo Engaño) to the marine portion south of the mouth of the Higuamo River. It is home to numerous marine species, including the manatee (*Trichechus manatus*), classified as endangered on the IUCN's Red List.

On May 23, 2017, the Ministry of Environment and Natural Resources, the Puntacana Group Foundation, and the La Altagracia Tourism Cluster signed an agreement of understanding, from which the Guiding Management Plan for the Southeast Reefs Marine Sanctuary 2018-2020 was developed. Subsequently, in February 2018, a renewable agreement was signed between the Ministry of Environment and Natural Resources and three groups working in co-management for a period of 10 years, called "Co-management Agreement of the Southeast Reefs Marine Sanctuary" (modified in October 2018). This agreement approved three co-management bodies collectively referred to as "co-managers": (a) South Zone Unit, (b) Central Zone Unit and (c) East Zone Unit.

The SAMAR Co-Management Council includes: (1) the Ministry of Environment and Natural Resources, which presides over the Council, represented by the Vice Minister of Protected Areas and the Provincial Administrator, (2) a corporate representative of co-management in the eastern zone, (3) a corporate representative of co-management in the central zone, (4) a corporate representative of co-management in the southern zone unit, (5) Blue Finance, (6) The Nature Conservancy, (7) a representative of civil society in the southern zone unit, (8) a representative of civil society in the southern zone, (8) a representative of civil society of the eastern zone, and (9) the Dominican Reef Network (RAD) as technical advisor, with voice but without vote.

The co-managers that make up the three units are: Fundación Central Romana, Clúster Turístico La Romana Bayahibe, Asociación de Hoteles Romana-Bayahibe, Fundación Dominicana de Estudios Marinos (FUNDEMAR), Fundación Capcana, Universidad Iberoamericana (UNIBE), Asociacioìn de Propietarios Cap Cana, Scape Ecological Foundation, Fundación Grupo Puntacana, Cluster Turístico La Altagracia, Asociación de Hoteles y Proyectos Turísticos de la Zona Este, Asociación de Proveedores de Servicios Acuáticos de Hoteles de la Provincia La Altagracia, Blue Finance, and The Nature Conservancy.

The area is of great ecological importance because of the convergence of different marine-coastal ecosystems with abundant biodiversity. These include seagrasses, mangroves, sandy coastlines, and coral reefs. These ecosystems, in addition to providing food for hundreds of thousands of people, give the sanctuary unique scenic beauty, making it one of the most visited destinations in the Dominican Republic and the Caribbean. Tourism is an important source of income in the Dominican Republic, and activities directly and indirectly associated with coral ecosystems such as those found in the sanctuary can bring in close to US$1 billion to the national economy. Further, because of their geographic position and a history of warming stress events, the sanctuary's well-

connected coral reefs could have important value as a refuge from the impacts of climate change.

In turn, reefs, grasslands, and mangroves play a key role in the formation and maintenance of sandy beaches of high tourist value, since they favor the accumulation of calcium carbonate sands and/or prevent erosion of these systems.

Preserving the health of the sanctuary's marine-coastal ecosystems is a national priority, and SAMAR offers a unique opportunity to achieve this goal. SAMAR currently has a coral reef monitoring system with a unified protocol that tracks health indicators such as coral cover, macroalgae cover, and abundance of recruits several times a year. The method is based on image analysis of the benthic bottom, following the Global Coral Reef Monitoring Network protocol (adapted). In addition, all co-managers have agreed to contribute to the coral disease and bleaching monitoring action plan developed by the Ministry of Environment, RAD, and TNC to monitor the prevalence and distribution of coral diseases. Standardized databases are in place and several RAD-TNC workshops have been held to train people to collect information and digitize it in the databases. Two of the co-management members, the Dominican Foundation for Marine Studies (FUNDEMAR), and the Punta Cana Group Foundation (FGPC) are leading coral habitat restoration efforts combining sexual (i.e., assisted sexual preproduction) and asexual (microfragmentation and *in situ* coral nurseries) propagation techniques under the technical and experimental support of TNC and coordinated under the efforts of the Dominican Coastal Restoration Consortium (Consorcio Dominicano de Restauración Costera).

All of this highlights the value of the co-management model for conserving the sanctuary's reefs and other marine ecosystems, i.e., where the business sector, local communities, governmental and non-governmental agencies come together to inform decision-makers with the best available science to achieve a common goal: the sustainable use of the marine-coastal resources of a protected area with high economic and ecological value. We hope that as SAMAR and the co-management model takes hold, it will eventually serve as a reference in the Caribbean region as a tool to help us achieve more resilient and healthy ecosystems, communities that can better adapt to the future impacts of climate change, and more sustainable business models in the medium and long term.

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5.3 Meeting the Climate Challenge: Coastal and Marine Resilience in the Caribbean

Caribbean Natural Resources Institute (CANARI)[169]

Caribbean governments have taken important steps toward coastal and marine resilience over the past decade through climate information services and modeling, assessing coastal hazards and vulnerabilities, integrating climate change into policies and plans, and investing in large-scale physical infrastructure for coastal protection (e.g., seawalls and revetments), and addressing water and energy security (e.g., through desalination plants and solar power plants). Regional agencies, including the Caribbean Community

[169] This chapter was extracted and translated with permission of CANARI from: Issue Paper No. 2, *Meeting the climate challenge: coastal and marine resilience in the Caribbean* (2020). [*Special issue*.] Barataria. Caribbean Natural Resources Institute. Retrieved from: https://canari.org/wp-content/uploads/2020/08/CANARI-Coastal-Marine-Resilience-Issue-Paper.pdf

(CARICOM) and the Organization for Eastern Caribbean States (OECS), have also enabled coordinated action and access to finance for climate change adaptation, mitigation, and resilience building. These national and regional efforts are aligned with global commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement, the 2030 Agenda, and its 17 Sustainable Development Goals (SDGs), including Climate Action Goal 13 and the SIDS Accelerated Modalities of Action Pathway[170] (SAMOA).[171]

However, there has been less "on the ground" attention and action focused on the needs of the most vulnerable coastal communities and groups. These groups include small-scale farmers and fishers, owners and members of small and micro-enterprises (SMEs), women, and youth whose livelihoods and well-being depend on coastal and marine resources, and who are already affected by climate change. CANARI has sought to engage and empower these vulnerable communities and groups, and civil society in general, to build resilient coastal and marine ecosystems and livelihoods using a participatory and inclusive approach. This work has included awareness raising and advocacy, assessing vulnerabilities, and enhancing local capacity and action to adapt and develop resilience to climate change.

Problems and proposed solutions for building resilience "on the ground".

Although the importance of building resilience "on the ground" is well recognized, there are several challenges that discourage a local approach. One such challenge is effective engagement of a broad range of stakeholders and sectors to build resilience for an integrated and comprehensive response at all levels. The following sections highlight CANARI's experiences, lessons learned, best practices, and innovations in Caribbean SIDS focused on community and ecosystem-based approaches.

1. Integration of local and traditional knowledge and practices in decision making.

CANARI has been testing innovative participatory information and communication technologies (ICTs) as tools to capture, manage, and share traditional and local knowledge and practices to address climate change. Tools used include participatory three-dimensional models and videos.

These participatory ICTs have been effective in engaging coastal communities, fishers, and other typically underrepresented groups in identifying their own vulnerabilities and key priorities and actions for building resilience. They provided creative and accessible ways to visualize climate change impacts and vulnerabilities, and enabled collective analysis, learning, and sharing of experiences by fishers and other coastal resource users and managers. They also contributed to local resilience through increased awareness and advocacy about the impacts and vulnerabilities of climate change and the need for urgent and collective action "on the ground."

A key lesson learned from the application of participatory ICT is that while local and traditional knowledge and practices are a key resource, **there is a need to integrate local and scientific knowledge for effective evidence-based decision making**. Relying

[170] SIDS - Small Islands Developing States

[171] In English - Accelerated Modalities of Action (SAMOA) Pathway.

solely on one or the other form of knowledge does not provide a holistic picture of climate change impacts and vulnerabilities or appropriate solutions for building resilience in a specific local context. Integrating scientific and local knowledge increases credibility and ensures responsiveness to local needs and priorities. Participatory 3D modeling and other geographic information system (GIS-based) tools are particularly useful to support the integration of local and traditional knowledge, including observed changes, management practices, and scientific knowledge, such as climatic and ecological data. In addition, to ensure adoption and use in decision making, **further innovation and investment in knowledge management and sharing** is needed through products and pathways suitable for coastal and marine resource managers and users, such as mobile applications, social networks, online portals, and other ICT.

2. Empowering local communities and resource users to act.

Governments and the private sector cannot address climate change alone. The participation and leadership of civil society is needed to effectively develop resilience to climate change and other disasters and ensure sustainable use and management of resources. Enhancing the capacity of local community-based organizations, resource user groups, and other CSOs is key to enabling them to play an important role in planning and implementing resilience-building actions. While this is widely recognized, many capacity-building efforts are framed as one-time technical training events that target individuals and do not address the need for strong CSOs that can take climate action. These types of capacity-building efforts also fail to provide support and opportunities to apply new knowledge and develop skills through practical experience, and often use top-down approaches and training materials that do not meet the needs and context of many Caribbean CSOs.

Over the past five years, CANARI has strengthened the technical and organizational capacity of coastal communities, resource users, and CSOs (including over 250 fishers, rural women agricultural producers, and CSO staff) involved in coastal and marine conservation and management to adapt and build resilience in eight countries (Anguilla, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago).

CANARI has used a multi-pronged, capacity-building approach that includes training of trainers, coaching and mentoring, peer-to-peer exchanges, and small grants to support demonstration projects and “learning by doing”. Key aspects of this approach include:

- Technical training on climate change that includes awareness and promotion, vulnerability assessment, as well as planning and implementation using community-based ecosystem solutions. To support the technical training of Caribbean CSOs, the toolkit has been developed for the Implementation of Climate Change Actions. It has the appropriate tools for the Caribbean context and includes examples and case studies from the Caribbean. .
- Provide local communities, resource users, CSOs, and community-based businesses with small grants to create pilot projects for innovative approaches and undertake practical actions to build resilience. Since 2012, CANARI has administered over USD 600,000 in small grants and over USD 5.3 million in large grants to support biodiversity conservation, climate change adaptation and resilience, and sustainable livelihoods, benefiting over 75 CSOs in 18 Caribbean

countries. Along with mentoring in project development, management, and evaluation, these small grants have successfully enhanced the capacity and action of these CSOs (Box 2).

- Establish a regional mentoring network, with 47 trained mentors in 17 countries, to support the organizational strengthening of CSOs, including fishers" organizations. Mentors have provided one-on-one coaching and mentoring for CSO staff and boards of directors on good governance, financial and human resource management, and strategic planning, among other topics. This organizational strengthening has been key to enabling CSOs to function effectively and implement technical work on climate change and resilience building.
- Create platforms for diverse stakeholders, including local communities, resource users, women, and youth, to have a voice in coastal and marine decision making and climate action. At the community and regional level, CANARI's work has promoted multi-stakeholder mechanisms for coordination and decision making, including women, youth, the disabled, and key resource users such as fishers (Boxes 3 and 4).

These capacity building activities have highlighted several key lessons. In particular, the need for a dual focus on technical and organizational capacity building of CSOs and local resource user groups, and businesses to enhance resilience building. Without strong and effectively managed organizations, efforts by CSOs, local resource users, and businesses to act on climate change and build resilience cannot be sustained or scaled up to achieve impact. Five key areas to address in organizational capacity building are ensuring good governance, clear strategic direction, transparent and accountable financial management, financial sustainability through effective fundraising, and human resource management.

Effective capacity building also requires sustained effort and commitment from both the target groups and their partners and sponsors. CSOs, businesses, and local resource user groups must have acceptance and commitment from all their organizations, as well as the human and financial resources to invest in capacity building. Longer-term programmatic support from partners and sponsors rather than the typical one-time activity or project is needed for effective capacity building. This programmatic support should also be flexible and tailored to the needs of CSOs and local resource user groups and companies, recognizing their diversity and based on comprehensive needs assessments and capacity development strategies. So, donors and technical agencies must move from limited, short-term, project-based support to long-term programmatic support and partnerships. Funding streams should facilitate direct access by CSOs, local resource user groups, and businesses to empower them to guide their own development and work in partnership with governments and other actors.

Box 2: Supporting civil society and local businesses through the Caribbean Sea Innovation Fund

In 2019, CANARI established the Caribbean Sea Innovation Fund (CarSIF) as a small-grant mechanism that provides support for coastal and marine management by civil society and community-based businesses, with funding from the EU and the UK's Darwin Initiative. This initiative has supported hands-on activities by fishers' organizations in Anguilla and Montserrat to adapt and promote ecosystem management. In Anguilla, the Anguilla Fishers' Association, in collaboration with the Anguilla National Trust and the fisheries authority, helped restore marine and coastal habitats in the Prickly Pear Marine Protected Area by building lobster houses to create habitat for the Caribbean spiny lobster and produce an artificial reef. They also provided training on safety at sea for fishers, given the more extreme weather events and rougher seas attributable to climate change. In Montserrat, the Montserrat Fishers and Boaters Association conducted weather monitoring with fish aggregating devices (FADs) and fish traps to make them more resilient and environmentally friendly. Ecosystem stewardship was also promoted by organizing a "fishers against marine litter" campaign that included a beach clean-up.

Under CarSIF, CANARI is also providing small grants to an additional nine CSOs and micro grants to nine SMEs to undertake practical actions for coastal and marine conservation, climate resilience, and sustainable livelihoods from 2020 to 2021. Small grants include support to the *Fondation pour la Protection de la Biodiversite Marine* in Haiti to develop beekeeping and mangrove-based honey production as sustainable alternative livelihoods for coastal communities within the 3Bays Marine Protected Area, and to the Caribbean Coastal Area Management Foundation in Jamaica for landscaping and coral restoration in the Portland Bight Protected Area. Micro-grants include support to Petit Martinique Women in Action to promote aquaponics and sustainable agriculture among young rural women in Grenada, Eco South Tours to expand its eco-tour operations in St. Lucia, and the Liamuga Sea Moss Group to strengthen seaweed farming operations and provide a viable alternative livelihood in the fishing communities of St. Kitts and Nevis.

Box 3: The gender team in fishing

At the regional level, the Gender in Fisheries Team has been actively promoting gender equality in small-scale fisheries as part of the adoption of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) and working with women fishers, fish processors, and vendors to improve their representation and leadership in the sector. Members of the Gender in Fisheries Team include the University of the West Indies Centre for Resource Management and Environmental Studies (UWI-CERMES), CANARI, the Caribbean Network of Fisherfolk Organizations (CNFO), the Caribbean Regional Fisheries Mechanism (CRFM) Secretariat, FAO, and the Gulf and Caribbean Fisheries Institute (GCFI). In 2016, the team led a participatory process to advocate for the inclusion of a protocol in the Caribbean Community Common Fisheries Policy that incorporates human rights-based approaches and gender mainstreaming, as well as other aspects of the SSF Guidelines. To advocate for policy changes this participatory process included fisher leaders from the CNFO, whose capacity to influence and communicate policy was strengthened with the support of the team.

Box 3[172]

3. Implementation of ecosystem-based solutions

Ecosystem-based solutions involve the conservation, sustainable management, and restoration of natural ecosystems to help communities, organizations, and economic sectors build resilience to climate change and disasters. Therefore, investing in and maintaining coastal and marine ecosystems provides multiple benefits in terms of building ecological, economic, and social resilience.

Yet, despite these benefits, there remains a heavy reliance on engineered solutions that use solid infrastructure for coastal and flood protection, such as levees and revetments. Ecosystem-based solutions are perceived to be more complex to implement, as they are less applied and less well-known and require more time to operate and achieve impacts.

Coastal and marine spatial planning, the ecosystem approach to fisheries (EAF), and integrated coastal zone and watershed management are examples of methods that support ecosystem-based solutions to climate change in Caribbean SIDS. These approaches consider the ecological, economic, and social context and drivers of vulnerability from “ridge to reef”, or within the broader seascape, to inform planning and actions that address climate change and other disturbances in a holistic manner. They also seek to engage and bring together diverse stakeholders that use, manage, and impact coastal and marine ecosystems for coordinated and collective action.

CANARI has been supporting fishers and governments in implementing the EAF to improve the sustainability and resilience of fisheries and marine resources and related

[172] SSF: Small Scale Fisheries

livelihoods (Box 5). The EAF recognizes that fisheries are socio-ecological systems. It involves an integrated approach to fisheries management to ensure ecological integrity, human well-being, and good governance. This integrated approach focuses on flexibility, balancing multiple objectives and interests, coordination and participation of stakeholders, management of uncertainty, and addressing impacts at appropriate scales.

A key lesson from this EAF work is that the integration of community and ecosystem-based solutions is key to achieving coastal and marine resilience and sustainability. Without the effective engagement of local communities and resource users, ecosystem-based solutions are unlikely to respond to local needs, especially of the most vulnerable. Meaningful stakeholder participation in decision making and the use of local knowledge together with scientific knowledge help to achieve fair and equitable outcomes that balance conservation and development objectives for socioeconomic benefits, especially for vulnerable groups. Improved practical tools and systems to monitor long-term changes and outcomes of ecosystem-based solutions and measure the success of "on-the-ground" actions are also key to better understand what is working and why, and to identify best practices and actions to increase impact.

There is also a need to explore the potential for combining engineered and ecosystem-based solutions as a cost-effective approach that avoids too much risk. For example, both mangrove replanting and revetments can be used for coastal protection. The restored mangrove helps reduce the level of coastal erosion and allows the use of small revetments instead of a large and more expensive seawall. This reduces the high initial investment cost of building and maintaining sound infrastructure, which often requires Caribbean governments to borrow from multilateral banks and other financiers and take on significant debt. Incorporating the value of other ecological and socioeconomic co-benefits also helps build the case for ecosystem-based solutions.

Box 4: Case study. Improving civil society participation in the management of the large marine ecosystems of the Caribbean shelf and northern Brazil.

CANARI facilitated the development of a regional Civil Society Action Program (C-SAP) entitled "People Stewarding the Oceans" in 2018 to strengthen civil society participation in the 10-year Strategic Action Program for the sustainable management of shared marine resources in the Caribbean and Northern Brazilian Shelf Large Marine Ecosystem (CLME+) region, which was endorsed by 25 governments and six overseas territories. The C-SAP was developed by and for civil society, fishers and community enterprises to guide their participation in decision making and their own practical actions for a healthy marine environment in the Caribbean Sea and Northern Brazilian Shelf, and to ensure the benefits and well-being of livelihoods in the region. This program outlined the requirements for technical and organizational capacity building for civil society to play an effective role in partnership with governments and other stakeholders.

The program was developed through a participatory process led by CANARI, which brought together civil society representatives from across the region to collectively analyze the strategies and actions in the politically endorsed "Strategic Action Program" and identify areas where civil society could contribute to its implementation. To date, 51 CSOs operating in 11 countries have endorsed the C-SAP. CANARI also facilitated the establishment of a Small Grants Coordination Mechanism to support the implementation of priority actions in the C-SAP. This mechanism will be incorporated into the governance arrangements for the management of these important marine ecosystems.

Box 5: Applying an Ecosystem Approach to Fisheries on Anguilla and Montserrat

From 2017 to 2020, CANARI worked to incorporate climate change adaptation into fisheries management in Anguilla and Montserrat using EAF, in collaboration with UWI-CERMES and the Anguilla and Montserrat fisheries authorities. This work involved facilitating institutional and vulnerability assessments to understand the impacts of climate change on various aspects of the fisheries sector and preparedness to adapt. The vulnerability assessments included participatory three-dimensional modeling to capture the "ridge to reef" impacts of climate change and inform the work of the EAF. Institutional assessment revealed a lack of relevant data to inform decisions, weak coordination mechanisms, and gaps in the policy and legal framework to support adaptation in the fisheries sector. Resource managers and coastal users, including fisheries authorities and fisher leaders, were trained regarding EAF and then supported in order to integrate climate change adaptation and disaster management into fisheries administration plans and interventions using the EAF. This included updating the Anguilla Small Coastal Pelagic Management Plan and the Montserrat National Fisheries Plan. Fishers' organizations received small grants and mentoring to design and implement practical actions to adapt and build resilience and promote ecosystem stewardship in Anguilla and Montserrat, including help to create artificial reefs and organize a beach clean-up to raise awareness of marine litter. These efforts helped reduce pressure on coastal and marine ecosystems that support coastal fisheries.

4. Climate-proofing businesses and livelihoods

Building resilience of livelihoods and economies is critical to achieving the potential for development and prosperity. It is important to enable SMEs that drive local economies and contribute significantly to household incomes and livelihoods to adapt and build resilience to climate change and disasters. However, SMEs face a number of challenges in developing resilience and taking advantage of market opportunities. These challenges include: limited awareness of climate change, its risks, and appropriate resilience measures at the local level; limited capacity (including skills and tools) for small business

development and management; limited access to appropriate financing and risk-transfer mechanisms; unfavorable business environments; limited market access; and socio-cultural barriers that limit their operations.[173]

In response to these challenges, CANARI has developed and tested a "climate proofing" methodology[174] for community SMEs to build their resilience to climate change and related impacts and add value to a company's operations and products. The methodology considers the enterprise's entire value chain, including activities to develop a product or service, from inputs to processing, marketing, and sales. Using the value chain, climate change impacts and vulnerabilities can be systematically assessed at each step of the chain and potential resilience-building measures for the company can be identified. These measures aim to help the company reduce vulnerability to climate change and add value to its product or service. Added value includes measures that make activities or processes more efficient in terms of time, human resources, or other factors that reduce costs and increase profits. For example, the addition of solar panels reduces vulnerability to power outages, reduces carbon emissions produced by the company, and makes processing more efficient by providing a constant power supply (Box 6).

Strengthening and building resilience among coastal and marine resource-based SMEs is a key pathway to a blue-green economy in Caribbean SIDS, based on inclusive, environmentally sustainable and resilient economic development that delivers the "triple bottom line" of ecological, economic, and social benefits.[175] However, there are three key areas to address in order to effectively strengthen SMEs. First, **SMEs will need to adopt sustainable business practices and models, as well as resilience measures**, which include making their products, services, and value chains environmentally sustainable. Second, there **is a need to significantly increase access to finance and technical assistance** to support the transition of SMEs to sustainable and resilient business models**.** SMEs need targeted microfinance through credit, grants, and low-interest loans from financial institutions, including national and multilateral banks and other financiers. SME incubators should provide technical assistance on sustainable and resilient practices and critical business management functions, such as business planning, financial management, and supplier and consumer relations. Third, **governments must provide an enabling legal and policy framework** to support SMEs and the transition to a sustainable and resilient blue-green economy, including coherent fiscal policies and regimes and a clear strategic direction for investment and growth.

[173] Montmasson-Clair, G., Patel, M., Mudombi, S., Jattansigh, S., Granderson, A., and N. Leotaud. 2019. No todo es verde: adaptación al cambio climático y resiliencia de las pequeñas empresas en países de ingresos bajos y medianos. Documento de antecedentes para la Comisión Global de Adaptación. Rotterdam and Washington DC: Global Commission on Adaptation. https://cdn.gca.org/assets/2019-12/AllIsNotGreen.pdf.

[174] Sandy, K and A. Dardaine-Edwards. 2017. Construyendo resiliencia y agregando valor a las empresas verdes locales: Desarrollo de una metodología de 'protección climática'. Technical Report No. 403. Laventille: CANARI.

[175] CANARI. 2019. Transición hacia economías inclusivas, resilientes y ambientalmente sostenibles en el Caribe Oriental. CANARI Policy Brief No. 25. Port of Spain: CANARI. https://canari.org/wp-content/uploads/2017/08/25-Green-economy-in-the-Eastern-Caribbean.pdf

Box 6: Climate-resilient SMEs based on fisheries and marine resources

CANARI and FAO engaged fishing SMEs and national fisheries authorities in Barbados, Dominica, and St. Kitts and Nevis from 2019 to 2020 to better understand the impacts of climate change on the most disadvantaged and vulnerable in fishing communities and improve their livelihoods and food security. Applying the "climate proofing" methodology, fishers, processors, and local suppliers analyzed their fishing value chains and the impacts of climate change and other impacts and identified measures to build resilience and add value to their fishing operations and products. The main impacts identified were coastal erosion, rough seas, and more intense storms, higher air and sea surface temperatures, droughts affecting water security, and declining fish catches affecting SME operations. "Climate protection" measures included shifting focus to underutilized fish species that are less climate sensitive; acquiring training and equipment for fish drying and salting as value-added products; and improving cold storage and access to water by installing rainwater harvesting systems. This work has contributed to understanding the links between climate change and poverty and identifying responsible practices to reduce poverty and vulnerability to climate change and disasters in the Caribbean small-scale fisheries sector.[176]

[176] References**: 1.** Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS). 2015. Pequeños Estados insulares en desarrollo en cifras. Climate Change 2015 edition. New York: UN-OHRLLS. http://unohrlls.org/sids-in-numbers-climate-change-edition-2015/ **2**.Caribbean Community Climate Change Centre (CCCCC). 2012. Implementando el cambio de transformación 2011-21. Implementación del marco regional de CARICOM para lograr un desarrollo resiliente al cambio climático. Belmopan: CCCCCCC. Walker, B., Holling, C., Carpenter, SR and AP Kinzig. 2004. Resiliencia, adaptabilidad y Transformabilidad en sistemas socioecológicos. Ecología y sociedad 9 (2): **4.** CANARI 2017. Implementando acciones contra el cambio climático: un conjunto de herramientas para las organizaciones de la sociedad civil del Caribe. Laventille: CANARI. https://canari.org/implementing-climate-change-actions-toolkit/.FAO. 2019. Asegurar la pesca sostenible en pequeña escala: compartir buenas prácticas de todo el mundo. FAO Fisheries and Aquaculture Technical Paper No. 644. http://www.fao.org/3/CA3041EN/ca3041en.pdf **6.**CANARI. 2018. People Managing Oceans: Programa de acción de la sociedad civil para la gestión sostenible de los recursos marinos vivos compartidos de los grandes ecosistemas marinos de la plataforma del Caribe y el norte de Brasil (CLME + C-SAP) 2018-2030. Port of Spain: CANARI. http://www.canari.org/wp-content/uploads/2017/08/csapbookletenglishfinal.pdf **7.** CANARI. 2017. Fortalecimiento de la capacidad organizativa eficaz de las organizaciones de la sociedad civil: lecciones del proyecto Climate ACTT project. CANARI Policy Brief No. 24. Laventille: CANARI. https://canari.org/pb24/effective-organisational-capacity-building-of-civil-society-Organizations / **8.** Kapos, V., Wicander, S., Salvaterra, T., Dawkins, K. and C. Hicks. 2019. El papel del entorno natural en la adaptación. Fondo de papel por la Comisión Mundial sobre la adaptación. Rotterdam and Washington DC: Global Commission on Adaptation. https://cdn.gca.org/assets/2019-12/RoleofNaturalEnvironmentinAdaptation_V2.pdf **9.** Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T. and GM Lange. 2019. Integrando verde y gris: Creando infraestructura de próxima generación. Washington DC: World Bank and World Resources Institute. https://openknowledge.worldbank.org/handle/ 10986/31430 **10.** Montmasson-Clair, G., Patel, M., Mudombi, S., Jattansigh, S., Granderson, A., and N. **11.** Leotaud. 2019. No todo es verde: adaptación al cambio climático y resiliencia de las pequeñas empresas en países de ingresos bajos y medianos. Background paper for the Global Commission on Adaptation. Rotterdam and Washington DC: Global Commission on Adaptation. https:// cdn.gca.org/assets/2019-12/AllIsNotGreen.pdf **12**.Sandy, K and A. Dardaine-Edwards. 2017. Construyendo resiliencia y agregando valor a las empresas verdes locales: Desarrollo de una metodología de 'protección climática. Technical Report No. 403. Laventille: CANARI. **13**. CANARI. 2019. Transición hacia economías inclusivas, resilientes y ambientalmente sostenibles en el Caribe Oriental. CANARI Policy Brief No. 25. Port of Spain: CANARI. https://canari.org/wp-content/uploads/2017/08/25-Green-economy-in-the-Eastern- Caribbean.pdf

5.4 *DUNAS* Project

Ana Teresa Colón García, *Para La Naturaleza*

Vulnerability in coastal systems has increased due to the climate crisis. Maritza Barreto, geomorphologist and professor at the University of Puerto Rico, has studied Puerto Rican coasts, documenting the significant impact that coastal erosion has on beaches.

This impact was even more substantial after Hurricanes Irma and María in 2017. For example, the mouth of the Río Grande de Manatí in Barceloneta lost sixty percent of its sediment. Also, other beaches located in the metropolitan area were severely affected by erosion caused as a result of strong storm surges.

For this reason, in 2018, the *Descendants United for Nature, Adaptation, and Sustainability* project, also known as *DUNAS,* was created. This initiative of Puerto Rican professor and archaeologist Isabel Rivera Collazo, professor of environmental archaeology at the University of California, San Diego (UCSD), aims to restore the dunes along Puerto Rico's north coast that were severely impacted by Hurricanes Irma and Maria in 2017 and that continue to be degraded by subsequent weather events.

The *DUNAS* project is a collaboration between For Nature (Para la Naturaleza PLN), Dr. Isabel Rivera-Collazo, UCSD Scripps Institution of Oceanography, Climate Science Alliance (CSA), and Wildlife Conservation Society (WCS). The objective of this project is to restore the coastal dune system of several beaches in the Hacienda La Esperanza Natural Reserve (HLE) in Manatí. This protected area is in northern Puerto Rico and comprises 2,191 acres of land that house more than ten ecosystems, such as estuaries, wetlands, floodplains, coastal forests, and beaches.

Considered a national ecological treasure, the preserve serves as a refuge for many migratory species such as the *West Indian whistling duck* and the *red-breasted merganser*. Several varieties of crabs and turtles such as *hawksbill*, *green and leatherback* turtles also use these dune-front beaches for nesting. Their restoration is therefore vital.

The *DUNAS* project has three main components. First, the restoration of natural ecosystems**,** specifically the dunes. The PLA team, community members, and volunteers have been restoring the sand dunes in the area by implementing biomimicry techniques, i.e., mimicking the processes that occur in nature.

For example, clustered wooden planks or pallets are placed on the sand dunes to mimic mature vegetation. The presence of these boards causes the accumulation of windblown sand and, consequently, the suspended sand begins to create a dune. The pieces of wood used are less likely to be disturbed by people and are easily adjusted as needed. In addition, they are lightweight, protect newly planted vegetation from sudden movement of sand, and are effective in resisting storms.

The second component of this initiative is **the protection of cultural heritage.** Indigenous sites, previously investigated by Dr. Rivera Collazo and her students, are in the area. Along with this restoration, the archaeologist oversees the preservation and documentation of historical narratives critical to the identity of the community. Studies have shown how the dunes, through time, move in response to climate change. As they move, they act as a protective mantle for Puerto Rico's cultural heritage. Vessels and

other exposed pieces of great cultural value have been found in the area. Also, a skeleton and evidence of offerings dating back more than a thousand years were found.

In order to show the public the archaeological materials found but avoiding intervention at the site, a tool kit was created with plastic replicas of these materials. This way visitors, volunteers, and community members can interact with the material up close without removing them from the sand where they are found. This method keeps the archaeological materials in the same place where they were located.

The third key component of *DUNAS* is **the protection of resilient communities.** In this case, the communities are made up by the neighborhoods surrounding the area of interest and the general public. The idea is to provide training and support to engage and educate the community about climate impacts and to test an adaptation strategy for a specific region that will build resilience for the targeted community and, consequently, for Puerto Rico. We work together with individuals to build resilience through new knowledge about this ecosystem and its potential to protect us from increasingly intense natural phenomena.

An example of how we foster resilience is to involve volunteer leaders from the organization and nearby communities to support the process of dune restoration. Once the dunes have been strengthened, reforestation begins. In the biomimicry process there were two phases: the creative phase, in which wooden pallets were painted with different messages alluding to the community, to conservation of the space, and to project goals, and then the phase involving insertion of the wooden pallets.

In-person space tours will soon be starting. The goal is for volunteers to support PLN staff and eventually lead tours with the general public to foster awareness among citizens and tourists visiting the island.

With the sponsorship of CSA and WCS, the guidance and support of Dr. Rivera Collazo and her team, along with the participation of community members and volunteers, we have been able to support the implementation of this project that has great potential for the sustainability of our communities in the short and long term.

With this new knowledge, we intend to instill greater sensitivity towards these coastal ecosystems and a recognition of their great potential as habitat for species. Another goal is to demonstrate their function as a barrier for coastal communities exposed to natural phenomena. This acquaintance with the process will hopefully encourage more conservation activities at this and other locales throughout the Puerto Rican coast and possibly the rest of the Caribbean.

5.5 Coastal Resilience in the State of Louisiana, U.S.A.

Natalie Snider
Environmental Defense Fund (EDF)

Due to the effects of climate change, both on humans and the rich biodiversity of our lands and oceans, we must realize that countries and communities face this growing threat amidst systemic global inequalities: poverty and lack of resources for infrastructure, education, and social programs. Often around the world and in the U.S., people with fewer resources and less capacity are at greater risk of climate impacts. Similarly, those who depend directly on the land and sea for their livelihoods are often the people most

affected by climate impacts. In this context, the Environmental Defense Fund's (EDF) Coastal and Watershed team focuses on the climate action pillar of resilience, i.e., the adaptation of natural resource management systems and community plans, and where necessary, the transformation or relocation of communities and landscapes to address climate change.

Based on our experience in coastal Louisiana and other states, we identified six key elements that we believe are integral to a successful Coastal Resilience Plan:

1. **Define goals and set clear expectations**: Beginning resilience preparation with the articulation of clear and realistic goals helps ensure the effectiveness of the planning process and broad acceptance of the final plan.
2. **Use the best available science**: Science is the fundamental anchor, because it is the best platform for working under urgent and uncertain circumstances, and because it provides the most solid basis to focus the management and policy organization of decision making.
3. **Take collective action**: To be successful, strategic resilience thinking requires multi-sectoral planning and coordination, ideally from the outset.
4. **Account for uncertainty and residual risk**: Risk reduction systems and restored coastal habitats cannot eliminate all flood risk, and some degree of residual risk will be inevitable, thus making adaptive management essential. Recognizing current uncertainties in decision making, particularly with respect to the rate of sea-level rise and flood risks, is key to building a plan that achieves resilience today and going forward.
5. **Focus on impacts on human life**: Climate-driven transitions along the coast will cause fundamental disruptions (community, economic, cultural, psychological), especially where relocation will be possible or required. These transitions will raise multiple questions, including fundamental issues of distributional equity. Because of these significant impacts, decision-making systems, wherever possible, should enable people to participate in planning their own future, and not be subject to distant decision-making.
6. **Identify funding and challenges**: The challenge of obtaining funding is key, since without a budget, plans remain just plans. Given that the current system of government funding (availability and structure) is not sufficient to meet the needs throughout Orleans County, innovation is needed in all funding channels at all levels.

EDF's Coastal Resilience Team knows that resilient ecosystems and communities along coasts and rivers thrive on water and should be safe, equitable, and prosperous places to live, work, and play. Thus, our focus is to galvanize the implementation of natural infrastructure solutions to maintain a resilient coastal ecosystem.

Case Study - The coast of the state of Louisiana, U.S.A.

Coastal Louisiana and New Orleans were devastated by Hurricane Katrina in 2005. The physical and emotional impacts on the people of the region prompted action that is now being replicated in other parts of the U.S. Louisiana has a state government-wide Coastal Master Plan, initiated in 2007, that since then has been updated in 5-6 year cycles. The

iterative and evolving Coastal Master Plan[177] is designed for long-term engagement, strives to incorporate adaptive management principles, and began its development in the context of resource constraints.

EDF's team in Louisiana focuses on supporting the state's efforts, engaging local communities, advocating for a strong grounding in science, and working to obtain funding to implement the Coastal Master Plan, with a $50 billion price tag over 50 years. We do this work in coordination with other NGOs, three of which, including ourselves, are national and international groups (EDF, National Wildlife Federation, and National Audubon), two local groups (*Pontchartrain Conservancy* and the Coalition to Restore Coastal Louisiana). We call ourselves the Coalition to Restore the Mississippi River Delta (*Restore MRD Coalition*).[178] This structure allows the coalition to have the breadth (local and national) and depth (science, economics, law, communications, policy, community engagement) necessary for our work.

Through this coalition, EDF has strived to incorporate each of these elements into our cooperation with the Louisiana Coastal Master Plans and with community participation in the LA SAFE initiative.

1) Define goals and set clear expectations

The Coastal Master Plan has achieved consensus on five broad objectives to be obtained over a 50-year planning horizon: flood protection, natural processes, coastal habitats, cultural heritage, and the working shoreline. The planning framework has developed decision drivers and identified constraints (funding, freshwater, sediment, time, etc.) relevant to these objectives in order to choose possible solutions and evaluate how well the plan meets each of these objectives. The Coastal Master Plan makes it clear that it is impossible to maintain the current shoreline or return to a historic condition. Instead, the goal is to achieve a new, consolidated landscape that can still support viable natural and human communities into the future. Transparency about clear expectations is essential to gain stakeholder buy-in for difficult future decisions.

2) Science-based plans

Science is the absolute foundation; therefore, the Louisiana Coastal Master Plan uses predictive modeling platforms, called Integrated Compartment Models[179] (ICMs), to provide a holistic understanding of the coastal environment and determine the effects on the coast and communities of both individual projects and sets of projects. A decision-support tool[180] helps integrate model results and optimize project selection based on meeting plan objectives, while considering time and resource constraints. The Plan includes a comprehensive assessment of human and ecological systems, including drivers of change, key stressors, and key uncertainties, supported by a conceptual or computer model of the entire system where possible. Natural systems and processes tend to provide the most sustainable options over extended periods and provide collateral

[177] 2012 Coastal Master Plan, https://coastal.la.gov/our-plan/2012-coastal-masterplan/; 2017 Coastal Master Plan, https://coastal.la.gov/our-plan/2017-coastal-master-plan/

[178] http://www.mississippiriverdelta.org

[179] https://ui.adsabs.harvard.edu/abs 2015AGUFMGC53A1192Mabstract#:~:text=The%20Integrated%20Compartment%20Model%20%28ICM%29%20was%20developed%20as,to%20increase%20the%20computational%20efficiency%20of%20the%20model

[180] https://www.rand.org/pubs/technical_reports/TR1266.html#:~:text=Planning%20Tool%20to%20Support%20Louisiana%27s%20Decisionmaking%20on%20Coastal,for%20Kindle%201-3.%20Technical%20Details%20%C2%BB%20...%20

benefits that are so important to communities (such as fisheries, for example). Therefore, plans integrate social and ecological systems where community and ecosystem resilience can be mutually beneficial. Investment in monitoring will further improve the predictive capacity of models and the expertise needed for sound decision making.

3) Take collective action

The resilience of our coastal systems crosses multiple jurisdictional boundaries; therefore, from a structural standpoint, successful resilience planning depends on interagency collaboration and coordination. These jurisdictions range from environmental quality departments to health systems and hospitals, transportation departments, and coastal zone managers. The list goes on. A clear understanding of the trade-offs and a holistic approach to policy decision-making requires strong government leadership for implementation and the active involvement of affected communities to achieve real success. Numerous U.S. states have appointed a Chief Resilience Officer to manage the complex interactions of climate impacts and natural hazards across all branches of government.

In Louisiana, prior to Hurricanes Katrina and Rita in 2005, the tasks of restoration and protection were distributed among different state agencies. After 2005, the state of Louisiana consolidated the expertise of different agencies into the Coastal Restoration and Protection Authority; thus, one agency had clear ownership of coastal resilience. In addition, Louisiana has recently designated a Resilience Coordinator for each agency, in addition to a General Director of Resilience at the behest of the governor. This structure creates a central point of contact to coordinate investments and account for vulnerabilities across the entire socio-ecological system. Having a “resilience czar” dedicated to management and coordination has truly transformed the capacity for integration across departments. Since the centralized unit of resilience coordinators in the directorate has vested authority and a bird’s eye view, it is better positioned to oversee the ongoing process of building and encouraging resilience in terms of adaptive management.

4) Taking into account uncertainty and residual risk

The Louisiana Coastal Master Plan considers key uncertainties in three environmental scenarios to test the robustness of projects vis-à-vis different futures, incorporating parameters such as sea-level rise, precipitation, evapotranspiration, subsidence, storm frequency, and storm intensity. The decision-making planning tool focuses on scientific and technical uncertainties, but also involves socioeconomic quandaries, such as economic growth patterns and levee fragility. The Coastal Master Plan is also legislatively mandated to be updated every six years, using the latest technical advances and physical changes in the coastal landscape. The plan supports and promotes close coordination among all jurisdictional authorities to ensure the most effective plan, utilize adaptive management, and communicate these risk findings to a broad audience. Louisiana provides all master plan data to the public through the Flood Risk and Resilience Viewer.[181] This includes community-level risk data to minimize the risk of property damage and inform stakeholders of ongoing residual risk.

5) Focus on impacts on human life:

The LA SAFE Initiative, an inclusive planning process.

In addressing this coastal displacement crisis, compassion and fairness must be shown

[181] http://cims.coastal.louisiana.gov/masterplan/

to those whose homes, lands, livelihoods, and ways of life may be affected, in the short and long term, by resilience plan projects, sea level rise, and/or flooding.

A key area of work in Louisiana has been community engagement, which in this context means working to assist and empower coastal people and communities to be part of the plans and discussions about their own future. One example of community inclusion in planning that we helped design and implement is the Louisiana Strategic Adaptations for the Environment (LA SAFE) initiative.[182]

The first step of the LA SAFE initiative was to recruit and train volunteers from the community to help facilitate and lead public meetings on local weather-generated risks. This step allowed local people to take leadership roles and help educate their own peers about flood risks within their own communities, and then implement selected solutions with a budget from the Louisiana government. The approach not only helped give citizens a role in their future, but also helped build support and trust around the solutions. The work was aided by online tools that provide the public with ways to access information and get involved, including educational and interactive materials on the website; risk maps; webinars organized to educate interested members of the public about risk and resilience; and a variety of materials translated into other key languages, including French, Vietnamese, and Spanish.

In the end, the LA SAFE process included local leaders, organizations, and impassioned residents who committed to taking action to manage and avoid risks, increase resilience and address coastal challenges based on an informed and up-to-date science-based understanding of the evolving situation.

6) Identify funding and challenges

It is critical to have a predictable long-term funding stream to undertake large-scale coastal resilience efforts and make any resilience plan a reality. Coastal transformation takes time, so a single grant is not enough. A combination of committed government, philanthropic, and private funding is important to ensure momentum in the work.

Communities have developed comprehensive coastal resilience plans that can often provide urgently needed insight at the most strategic locations and ideas on how to spend limited funds. With additional science-based thinking and guidance, resources from a mosaic of sources could potentially be leveraged together more effectively within a broader plan.

In conclusion, building coastal resilience is an iterative and evolving process that requires long-term commitment from government leaders. With each year and each iteration, the process becomes more detailed, public participation more extensive, decision making more transparent, and modeling more sophisticated. This increases our understanding of the system and of management actions that are lacking. EDF helps fill gaps where government stakeholders need information or other support, e.g., requests for field research or advice to the Resilience Lead Office on best practices. Modeled after our involvement in the Louisiana planning process and lessons learned, EDF is providing consulting to other state governments throughout their development and implementation processes.

[182] https://lasafe.la.gov/

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