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Building Climate-Resilient Communities in the Dominican Republic

A BLUEPRINT FOR A COMMUNITY RESILIENCE CENTER IN SANTO DOMINGO

ALCALDÍA DEL DISTRITO NACIONAL

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INSTITUTO TECNOLÓGICO DE SANTO DOMINGO

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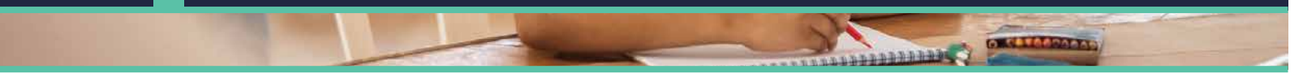
This report was supported and funded by Columbia World Projects under Columbia Global at Columbia University as part of the “Building Climate Resilient Communities in the Dominican Republic” project. Projects are led by Columbia University faculty, researchers, academics and practitioners from across the world, who implement activities designed to achieve a measurable impact on complex local, regional or global challenges. See p.67 for a complete list of contributors

A vision for a Community Resilience Center in Cristo Rey.
Cover image: Vulnerable coastal housing in the Ozama River, Santo Domingo.

Contents



List of Acronyms

ADN	Ayuntamiento del Distrito Nacional
AR6	The Sixth Assessment Report of the United Nations Intergovernmental Panel on Climate Change
BRACE	Building Resilience against Climate Change (Framework)
CDC	Centers for Disease Control and Prevention
CEPAL/ECLAC	Comisión Económica para América Latina y Caribe/Economic Commission for Latin America and the Caribbean
CEPREDENAC	Centro de Coordinación para la Prevención de los Desastres en América Central y República Dominicana
CNE	Comisión Nacional de Emergencias
COE	Centro de Operaciones de Emergencia
CPR	Cardio-pulmonary resuscitation
CWP	Columbia World Projects
DN	Distrito Nacional
DRM	Disaster risk management
DRR	Disaster risk reduction
END	Estrategia Nacional de Desarrollo 2030
GCCHE	Global Consortium on Climate and Health Education
GHG	Greenhouse gas
INTEC	Instituto Tecnológico de Santo Domingo
IPCC	Intergovernmental Panel on Climate Change
MEPyD	Ministerio de Economía, Planificación y Desarrollo
NGO	Nongovernmental organization
PAHO	Pan-American Health Organization
PNPSP	Plan Nacional Plurianual del Sector Público
RC	Resilience center
SDG	Sustainable Development Goals
SIDS	Small Island Developing State
UNFCCC	United Nations Framework Convention on Climate Change
UNIBE	Universidad Iberoamericana
WHO	World Health Organization

Cristo Rey, Santo Domingo.

Foreword

This climate-resilience project in the Dominican Republic is particularly dear to my heart as it represents the essential vision of Columbia World Projects and Columbia University's and one of Columbia University's core commitments: to bridge scholarly knowledge and real-world action, with the ambition of having the greatest possible impact on the biggest challenges of our time.

Climate change and its consequences is arguably *the* most pressing issue of our time, and likely to remain so for generations to come. As with other significant challenges the world faces, the effects of climate change are most acutely felt by the most vulnerable. Likewise, it is these same communities and local actors that are on the front lines of climate change, both serving as first responders during extreme events and leading the efforts to respond, build back, and adapt.

The design of the resilience hub described in this report is an innovative model for enhancing community resilience in the face of anticipated climate and other crises to be faced by the Dominican Republic. I truly believe that through partnerships between local governments, academic institutions, community-based organizations, and the development of localized solutions, grounded in community support, we can make strides in ensuring vulnerable communities now and in the future are not only able to mitigate the effects of climate change but are leaders in shaping a better, more resilient future.

Dr. Wafaa El-Sadr
Executive Vice President, Columbia Global
University Professor of Epidemiology and Medicine
Dr. Mathilde Krim-amfAR Chair of Global Health
Director, ICAP at Columbia University
Lead, NYC Pandemic Response Institute

Executive Summary

Climate change is one of the most pressing scientific and policy challenges of our time. Recent climate disasters have highlighted the need to improve the resiliency and sustainability of communities globally. The Dominican Republic (DR), a country particularly vulnerable to natural hazards, has been consistently ranked among the countries with the highest natural disaster risk in the western hemisphere. As the Dominican Republic experiences increasing frequency and severity of such threats, with disastrous human and economic consequences, there is an urgent need for novel and practical solutions to achieve climate resiliency.

The Building Climate-Resilient Communities in the Dominican Republic project was conceived as part of the Columbia World Projects 2019 Forum on Disaster Preparedness, Resilience, and Response. The idea of designing and prototyping resilience centers to build communities' capacities to prepare for and respond to natural disasters emerged as a promising concept. The opportunity to design such a resilience center in Santo Domingo, Dominican Republic, was supported by the Ayuntamiento del Distrito Nacional (ADN), or the Mayor's Office of Santo Domingo, and two Dominican-based universities—the Instituto Tecnológico de Santo Domingo (INTEC) and Universidad Iberoamericana (UNIBE). After a period of collaborative project development, Columbia World Projects (CWP) made the commitment to support the development of a "blueprint" for a model resilience center in Cristo Rey, a dense, mixed-use, semi-industrial neighborhood in Santo Domingo where there has been strong interest by the community and the municipality to support such an effort.

The proposed site for the resilience center in Cristo Rey is a municipality-owned building that was already designated to accommodate a satellite ADN office and to establish a capacity building center for the community that is focused on youth economic development.

What are community resilience centers? Resilience centers are physical community spaces developed with the goal of increasing communities' capacities to prepare for and respond to natural and other disasters. Resilience centers are places that **(1)** empower communities through ongoing education, training, and health and social services; **(2)** provide coordinated emergency response in the event of disaster or disruption; and **(3)** enable effective recovery with information dissemination and research during postdisaster recovery.

This report provides background on the project, partners, and characteristics of the resilience center that was designed for implementation in Cristo Rey, Santo Domingo, Dominican Republic. The report includes the description of the consultative design process and consolidates methodologies, findings, and recommendations from the four complementary assessments undertaken (see p.4). Based on this consultative process and the assessment recommendations, a detailed design for the resilience center—including its physical infrastructure, programs, and management—is presented.

Assessments

Different factors need to be considered in designing sustainable resilience solutions—the physical infrastructure, the policy environment, and social and health factors and needs. Therefore, four complementary assessments were undertaken to inform the design of the resilience center. Each assessment was led by a different project partner or team, with different approaches. Common methodologies included literature reviews, interviews, site visits, surveys, mapping, and data collection and analysis. Additionally, the project team undertook formative and ongoing work to engage key stakeholders at national, municipal, and community levels, via regular meetings, interviews, and communications. These inputs have informed the methodologies of each assessment and the design of the resilience center.

The policy assessment mapped existing institutional structures, laws, policies, plans, and strategies related to resilience, climate change adaptation, disaster risk management, and urban planning in the Dominican Republic using a qualitative approach (including literature review, key informant interviews, and stakeholder meetings). Findings revealed that, in legal and institutional terms, the Dominican Republic has made significant progress in developing its institutional capacities to increase resilience, strengthening disaster risk management, and increasing knowledge of the effects of climate change over the last two decades. Despite these advances, the country faces challenges to incorporate these advances into the development agenda, strengthen links between national institutions and local governments, actively involve the private sector, and access accurate data about the vulnerabilities of each territory. These are crucial to increase resilience among the most vulnerable communities. A number of recommendations illustrate opportunities within ADN to further advance and strengthen the implementation and sustainability of climate-resilience initiatives within the National District and within local communities, such as Cristo Rey.

The physical and digital infrastructure assessment included a review of historical data, an on-site assessment of the existing ADN building in Cristo Rey, and an analysis of the energy requirements of the building. The assessment concluded that the building is in a suitable location to serve as a resilience center and is well connected with the community and that, with appropriate retrofitting, it has the potential to provide emergency response services before, during, and after an extreme natural event. The assessment data were used to develop a set of infrastructure recommendations required for the building to function as an effective resilience center.

The community assessment used complementary, participatory methodologies to gather community input. The assessment was conducted by faculty and students of architecture, urban sociology, and design at UNIBE and used site analysis and mapping, community interviews, a community vulnerability survey, and community consultation workshops. A number of findings and recommendations from the community assessment underscored the critical role of community participation and engagement in resilience center planning and implementation, the importance of collaborating with and strengthening existing local groups involved in risk management, and the desire for improved community awareness about climate change and actionable mitigation.

The health assessment included a rapid assessment to understand what current health and health system resources, assets, and vulnerabilities exist in Cristo Rey. Findings reiterated how climate change presents both acute and slow-onset health impacts. There is health infrastructure in place in Cristo Rey; however, more coordination and capacity building is required, as well as more data to analyze specific vulnerabilities and needs of the community related to health and resilience. Recommendations included that resilience center programs, such as those related to physical and mental health, be organized into three complementary operating levels: everyday resilience-building activities, programs and services during disasters, and post-disaster and recovery programs, with complementary staffing and partnership and community engagement strategies to support the three programmatic levels.

Design of Blueprint for Resilience Center

The proposed design for the resilience center has three primary components:

- **Physical and energy retrofitting and upgrades to the existing ADN building**
- **Design and implementation of proposed activities and programming**
- **Integration of the management, operations, and evaluation strategies**

The following **physical and energy retrofitting and upgrades** are proposed based on INTEC's assessment and recommendations of the existing ADN building:

1. Upgrade/replace the center's roof so that it can withstand the wind forces during hurricanes and other extreme weather events and support the weight of the proposed photovoltaic system.
2. Replace the windows with those that can resist hurricane winds and limit water entry.
3. Install a renewable, photovoltaic energy system that maintains power for three days.
4. Establish a weather station to collect data on weather and geophysical events.
5. Upgrade the digital infrastructure, including installing a satellite information system.

A staged plan for building upgrades is proposed so as not to disrupt continued services and community access. See Appendix III. p. 77.

Based on the community and health assessments, **the design of the health and social programs** at the center includes the elements summarized in Table 1 below.

Table 1: Framework for Resilience Center Design

EVERYDAY RESILIENCE-BUILDING ACTIVITIES	ACTIVITIES DURING DISASTERS AND DISRUPTIONS	POSTDISASTER AND RECOVERY ACTIVITIES
Improve baseline knowledge and skills, social cohesion, and disaster preparedness.	**Serve as a central point of access to information and basic services.**	**Support vulnerable families and help the community recover and rebuild.**
■ Safe, open community space and hub ■ Trainings to improve baseline health knowledge, skills, and disaster preparedness ■ Safeguard mental health via community approaches ■ Hub for health and social services resources ■ Support for community research	■ Centralized information hub for the community ■ Internet and phone services ■ Disseminate key information from local authorities ■ Basic services—first aid, food, hygiene supplies, clean water, shelter capacity, restrooms, showers ■ Space for Centro de Operaciones de Emergencias (COE) satellite operations in the community ■ Support for first responders/emergency workers ■ Trained, volunteer community crisis response team	■ Continuation of basic services provided during the disaster (first aid, clean food distribution, clean water, restrooms, etc.) ■ Hub for the community to receive information and referrals to needed services and supplies (resources for rebuilding, support to apply for aid, etc.) ■ Community space for local and community organizations to convene, support to reduce duplication of effort ■ Conduct postdisaster analysis with the community and make recommendations

Management, Operations and Scale

The proposed management structure design reflects the collaborative nature of the center's development. The resilience center can use a hybrid management model, with the center staff colocated within the ADN building, alongside other existing partners, and working in close coordination with the ADN units focused on environmental and risk management. The resilience center staff will be managed by a Dominican nongovernmental or academic institution with expertise in community resilience. As the programming is established, the center could explore continued colocation or the potential of long-term integration into the ADN structure and team. Depending on funding, the center could initially have three full-time staff, an advisory board, and an inclusive and diverse community advisory committee.

A monitoring, evaluation, and learning system will generate output, outcome, and impact data that can be used locally to guide program activities and, eventually, to inform replication and scale of the approach. CWP, UNIBE, INTEC, and other partners are well placed to design and implement such a system, which would include building the capacity of local community leaders and partners.

Community resilience centers, including the one designed for Cristo Rey, offer a promising, decentralized model of urban disaster preparedness and response. Supporting local-level resilience and response can help to achieve national goals on climate resilience in the Dominican Republic and the region.

The community of Cristo Rey is a dense, mixed-use, semi-industrial neighborhood in Santo Domingo.

Design of a Blueprint for a Community Resilience Center in Santo Domingo

This consolidated report summarizes the consultative design process undertaken by the project team and, based on the results of this process, offers a detailed design for a community resilience center in Cristo Rey, a Santo Domingo neighborhood vulnerable to natural and other crises. Based on availability of funding and other factors, the vision is that ADN will use this design to integrate the resilience center into their community center in Cristo Rey.

Project Overview

The Building Climate-Resilient Communities in the Dominican Republic project was conceived as part of the Columbia World Projects (CWP) Forum on Disaster Preparedness, Resilience, and Response, held in June 2019 at Columbia University in New York. The Forum brought together experts from inside and outside Columbia University to further their understanding of natural disasters and other public health emergencies and identify promising projects that would be appropriate for CWP to support to advance solutions to this challenge. After a period of collaborative project development, CWP made a commitment to support the development of a "blueprint" for a model community resilience center in Cristo Rey, a dense, mixed-use, semi-industrial neighborhood in Santo Domingo where there has been strong interest by the community and the municipality to support community development efforts. The intended use of the blueprint is for use by the Ayuntamiento del Distrito Nacional (ADN) de Santo Domingo, the Mayor's Office of Santo Domingo, to use the blueprint in the development of a resilience center in Cristo Rey, as well as for use by other municipalities and partners in the Dominican Republic (DR) and the region to establish such centers.

Partners

The project brings together experts in disaster preparedness and resilience, public health, urban design, and engineering at Columbia University and two Dominican universities—Instituto Tecnológico de Santo Domingo (INTEC) and Universidad Iberoamericana (UNIBE)—in close partnership with the ADN as well as leaders across the Dominican Republic and United States who are supporting collaborative efforts to strengthen capacities to better prepare for and respond to disasters and crises in these communities.

Project team and collaborators

Columbia World Projects is a university-wide initiative established in 2017 to bridge scholarly knowledge and real-world action. With the goal of achieving the greatest possible impact on pressing challenges of our time, CWP mobilizes Columbia University's scholars, researchers, practitioners, and students to identify and implement interdisciplinary solutions to complex societal challenges in partnership with targeted change agents, such as policymakers, government agencies, nongovernmental organizations (NGOs), and corporations. CWP has served as the facilitating partner for this project, supporting the collaborative design, development, and implementation of key activities.

Columbia University Mailman School of Public Health faculty from the Global Consortium on Climate and Health Education, based at Columbia University's Mailman School of Public Health, led the health- and climate-focused assessment and program design for the project. The Consortium is focused on uniting health professional training institutions, health societies, and regional health organizations to create a global climate-ready health sector, prepared to mobilize and lead health promotion and response in the era of climate change while restoring the health of the planet. The Consortium collaborated with partners in the Dominican Republic in the health and emergency management sectors to propose health and climate programs (education, training, and preparedness resources) for the resilience center.

Columbia University Graduate School of Architecture, Planning and Preservation (GSAPP) faculty led the initial conceptualization, design, and partnership engagement of the CWP project. GSAPP strives to redefine the roles of architecture and urbanism within a research university by creating opportunities for interdisciplinary collaboration, and, as such, faculty leaders led the implementation of the blueprint design and development, working in close collaboration with the project partners. In addition, GSAPP faculty led a 2023 spring semester seminar titled Caribbean Resilience: Prototyping a Hub in the Dominican Republic, in which graduate students, faculty, and guest speakers further explored the design, scope, funding, and reach of resilience centers.

The Ayuntamiento del Distrito Nacional de Santo Domingo (the Office of the Mayor of Santo Domingo) is the key partner to the resilience center. ADN selected the site for the project and manages and operates the building where the center will be located. With the endorsement of the mayor, ADN staff have worked in close collaboration with the team from the initial inception of the project through the design and eventual operations, providing critical inputs to the assessment, design, and operational phases.

Instituto Tecnológico de Santo Domingo is a private, nonprofit, public service, Dominican higher education institution founded in 1972 by a group of academics committed to the social transformation of the country and the continuous promotion of the quality of life and education of its citizens. INTEC is considered a premier institute of technology in the country, characterized by innovation in the areas of engineering, business, health and environmental sciences, social sciences, and humanities. Faculty from INTEC led the physical, digital, and energy infrastructure assessments for the resilience center and developed the design for the physical and energy retrofitting and upgrades to the existing ADN building.

Universidad Iberoamericana is one of the largest universities in the Dominican Republic with 3,000 students and a range of graduate and undergraduate degree programs. The institution has a long history of community-based programming and implementation research. Faculty, staff, and students from UNIBE led the social infrastructure assessments for the resilience center, engaging the community and stakeholders in the development of the overall vision for the center, as well as the proposed design for the community partnership, and social and resilience programming.

Objectives

The project aimed to strengthen the capacity of the Dominican Republic to confront natural and other disasters. Specifically, the objective was to undertake a consultative process with the community and other key stakeholders to inform the design of a blueprint for a community resilience center in Cristo Rey, a neighborhood in Santo Domingo. The center would serve to reduce the vulnerability of the surrounding communities and improve their capacity to mitigate and respond to severe natural events of all types. The vision is that ADN will use this design to implement the resilience center in the community of Cristo Rey, and lessons from this center will inform the adoption of additional such centers across the country.

—"Resiliency in the face of ever-increasing natural disasters is of particular importance to developing contexts and the vulnerable communities we are called to serve." —

Dr. Aída Mencía-Ripley, Vice-Chancellor for Research and Innovation, UNIBE

Guiding Principles

A number of *guiding principles* informed the consultative process:

- The importance of supporting and funding local resilience and adaptation initiatives
- The critical role that community members—often the first responders when a natural disaster strikes—play in the planning, implementation, effectiveness, and sustainability of resilience building
- The critical role of data and information in resilience so that communities can understand, prepare for, respond to, and recover from disasters
- The importance of leveraging, coordinating, and building on existing resources, organizations, and individuals committed to strengthening resilience

Cristo Rey's communities are characterized by overcrowded housing and informal alleys.

Context

Natural Disasters and Climate Change

Climate change is one of the preeminent scientific and policy challenges of our time, as noted in Figure 1, by an increase in the number of natural disasters globally. These realities have made community resilience and sustainability initiatives imperative throughout the world. Ongoing burning of fossil fuels and deforestation continue to increase atmospheric concentrations of greenhouse gasses (GHGs), alter the planetary radiative balance, and disrupt the climate system. Recent natural disasters have highlighted the need to improve the resiliency and sustainability of communities throughout the world.

Figure 1: Annual number of natural disaster events worldwide[1]

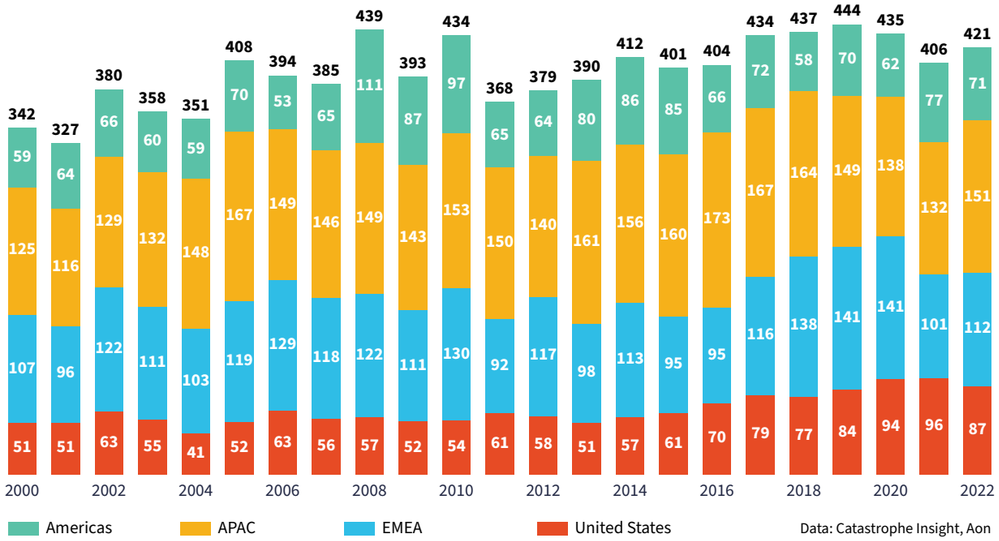


Figure 2: Total disaster events by type: 1980–1999 vs. 2000–2019[2]

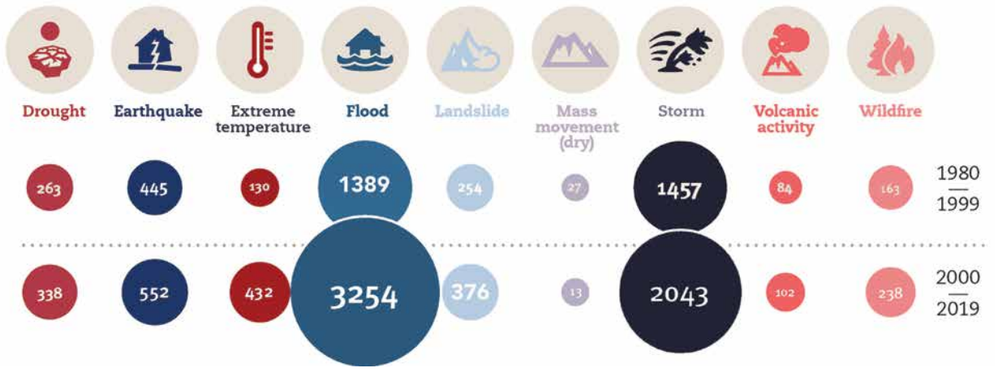
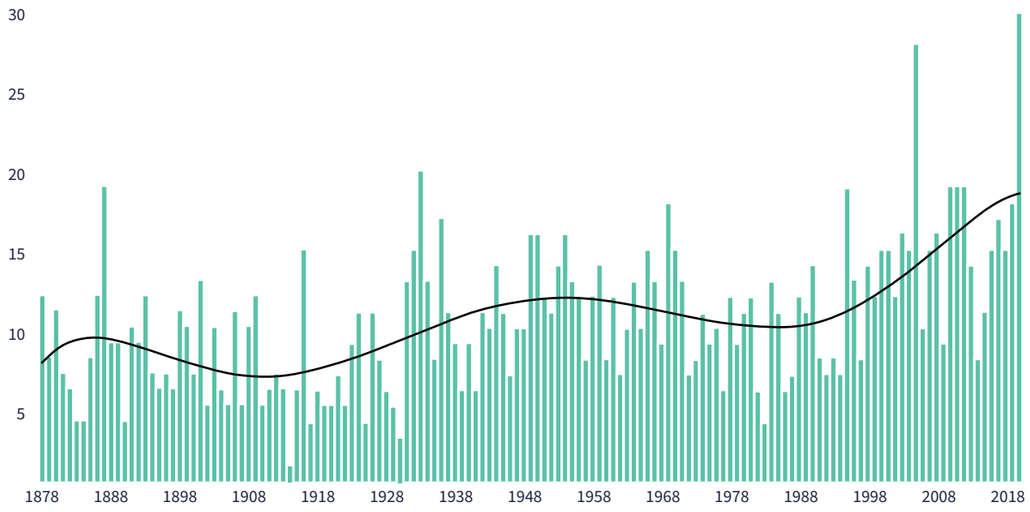


Figure 3: Yearly number of tropical storms and hurricanes in the Caribbean and Atlantic region (1878–2020)[3]



The increase in the occurrence of extreme natural events of all types (Figure 2) is correlated with the steady increase in mean global temperature and climate change. For example, more than 30 storms were registered during the 2020 hurricane season in the Caribbean, Gulf of Mexico, and North Atlantic regions (Figure 3), with economic losses close to USD$42 billion and more than 200 casualties.

Climate Change and Health

The adverse effects of climate change are now apparent and present urgent and complex challenges to human health and health systems globally. Heat waves, rainstorms, and flooding are becoming more deadly, disease outbreaks (dengue, malaria, cholera, etc.) last longer and are seen in new regions, wildfires release stored carbon and reduce air quality, and food and water security are threatened by drought and extreme weather. On an individual and community level, changing climatic patterns threaten the tenets of a stable and secure livelihood, resulting in deteriorating mental health, forced migration, and civil instability.

Rapid environmental change is also worsening existing health inequities and access to health care, undermining economic well-being, and worsening social determinants of health while compounding preexisting ill health and creating serious population-wide health threats. Populations and communities are not affected equally, highlighting the need to focus on environmental justice.

Natural Disasters and Climate Change in Dominican Republic

The DR is a Small Island Developing State (SIDS)[4] that shares the island of Hispaniola with Haiti, the second-largest island in the Caribbean after Cuba. The country is bordered to the north by the Atlantic Ocean, to the south by the Caribbean Sea, to the east by the Mona Passage, and to the west by the Republic of Haiti (Figure 4). It occupies an area of 48,156.94 km2, which represents about two-thirds of the island, with approximately 1,575 linear kilometers of coastline.[5] The Office for National Statistics estimates a population of 10 million people, of which 75 percent reside in urban centers.[6]

Figure 4: Dominican Republic and the Insular Caribbean[7]

Rapid growth and urbanization has made the Dominican Republic particularly vulnerable to natural hazards (Photos 1 and 2) and the country has been consistently ranked among the countries with the highest natural disaster risk in the western hemisphere.[8] Further, risks are due to its geographic location and the geologic conditions of Hispaniola, which is located in the denominated "Hurricane Alley," a tropical zone in the Atlantic Ocean with favorable climatic conditions for the development of storms (Figure 5). Between November 2016 and April 2017, several severe storms affected the Dominican Republic, including hurricanes Irma and Maria (2017), with economic losses estimated close to RD$49,837 million (USD$1.04 billion), which represented 7.98 percent of the total government budget for 2017 and 1.5 percent of the gross domestic product for 2016.[9] Hurricane Maria also caused significant losses to nearby Puerto Rico, with a death toll estimated at 3,000 and economic losses close to USD$91 billion. The damages to Puerto Rico were catastrophic, with some communities without power for several months.

Photos 1 and 2: Communities in the Dominican Republic vulnerable to natural disasters

Figure 5: Trajectory of recorded hurricanes in the Caribbean[10]

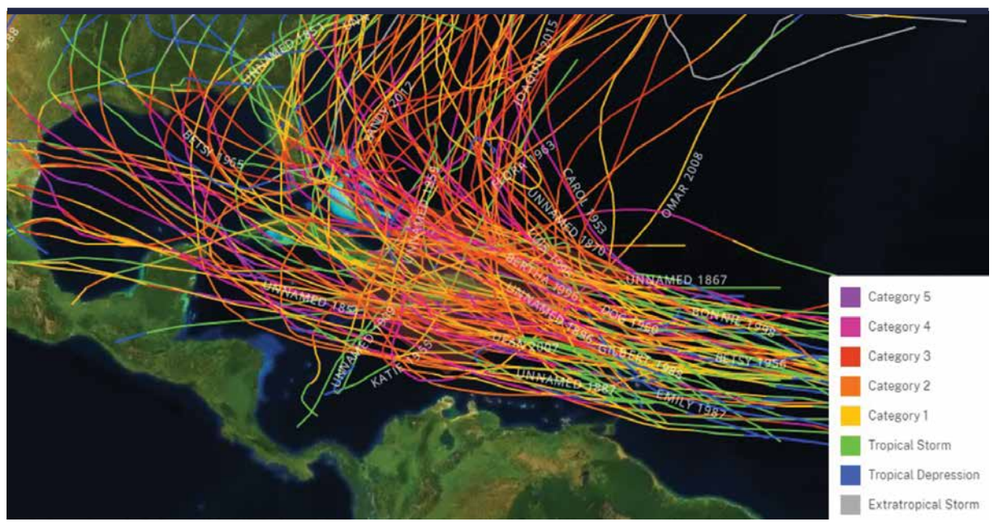
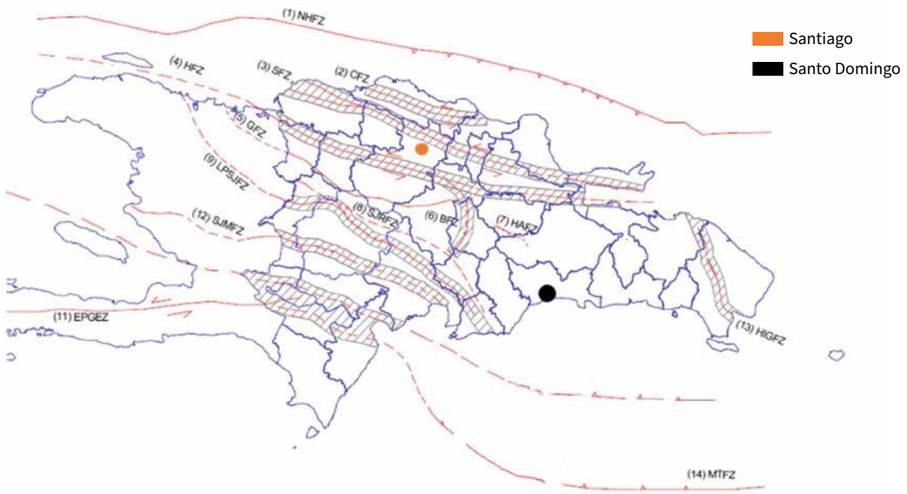


Figure 6: Seismic faults in Hispaniola[11]



Photos 3 and 4: Damage from the 2010 Haiti earthquake[12]

Another major source of natural hazards in Hispaniola is the potential for earthquakes, generated in the 10 active seismic faults on the island (Figure 6). The potential of Hispaniola's seismic faults to cause major damage was demonstrated after the 2010 earthquake in Haiti, considered one of the most devastating natural disasters of the last 100 years (Photos 3 and 4). This earthquake was caused by a rupture of the Enriquillo-Plantain Garden fault in the southwestern region of the island, resulting in an estimated 300,000 casualties and economic losses nearing USD$14 billion. Civil infrastructure suffered major damage, with more than 300,000 collapsed buildings and more than 2 million people displaced. In January 2020, Puerto Rico was struck by a 6.4-magnitude earthquake that caused damage valued at USD$800 million.

Weather-related events and extreme weather have also increased risk and vulnerability in the Dominican Republic. For example, in the past year there have been extreme rain and flooding events, drought, and fires across the country. In November 2022, eight people died from one of the largest torrential rain and flooding events unrelated to a hurricane or storm. Santo Domingo experienced 230 millimeters/m^2 (nine inches) of rain in three hours, twice the estimate of the entire month. In March 2023 alone, the Dominican Republic lost more than 6,000 hectares of forest due to fires. Although there is some speculation that these fires were caused by human activity and negligence, the intense drought and strong winds made the country's protected forests primed for wildfires. The experiences of the Dominican Republic, Haiti, and other countries in the Caribbean highlight the need to reduce the risk of, and improve the resiliency against, natural disasters.

The Distrito Nacional

The *Distrito Nacional* (DN; National District) is a special subdivision of the country for the capital, Santo Domingo. It is the center for *Greater Santo Domingo*, the country's largest metropolitan area and home to almost 3 million people (Figure 7). It is the seat of the national government and the most economically productive region of the country. As a region, it is responsible for the highest emissions of greenhouse gasses nationally. Located on the southern coast, and in the watershed area of two rivers, it is uniquely vulnerable to the effects of climate change, including hurricanes, sea level rise, river flooding, and heat waves. The sea level has risen 1.8 mm/year for the last 60 years. Fortunately, the area of the city directly on the coast has not experienced significant flooding thus far, most likely because it is located an average of six meters above sea level.[13]

Though uniquely vulnerable, Santo Domingo also has an enormous capacity for resilience and adaptation. It is home to the highest concentration of universities, hospitals, and commerce in the Dominican Republic. Santo Domingo possesses a high number of resources to respond to the effects of climate change and has a diverse profile of industries on which to rely.

Figure 7: City population and density in the Dominican Republic[14]

Community Resilience Centers: A Model for Decentralized Urban Disaster Response

While the Dominican Republic is vulnerable to various threats, the current physical infrastructure that provides basic services such as water, electricity, and telecommunications (phone, internet) to urban residents is outdated and strained. Large, centralized facilities that deliver most of these services around the country are particularly vulnerable to natural events, and an outage at even a single facility in the wake of a natural event can have severe consequences.

Community members and community-based organizations are often the first responders during and after natural disasters. Moving to a smaller-scale, more decentralized urban disaster response system[15] can help to address these problems, increasing the resilience of basic infrastructure to natural disasters and helping individuals and communities to better manage the effects of severe natural events.

However, a community's resilience is based not only on the state of its physical infrastructure. A sustainable strategy to resilience must also engage the people and institutions that provide long-term support for social well-being (e.g. healthcare, housing, education and safety). Furthermore, all of this must be anchored in enabling policies at the local and national level that prioritize climate resilience and unlock needed resources. These three different kinds of infrastructure—physical, social, and policy—need to all be considered in building resilient solutions.

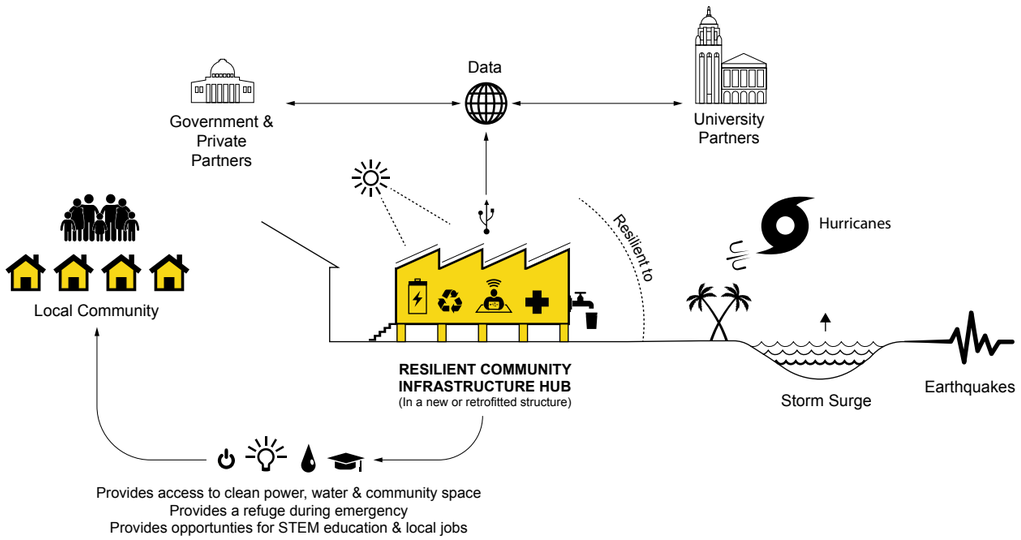
Thus, community resilience centers offer a promising, decentralized model of urban disaster preparedness and response. Such resilience centers are physical community spaces developed with the goal of increasing resilience. Community-based resilience centers can provide opportunities to build the community's capacity to prepare for and respond to disasters and crises, recognizing that

they are often the first responders. Resilience center components and programs are meant to evolve over time to align with and respond to changing climates, contexts, and hyperlocal needs and assets.

Resilience centers can play important roles before, during, and after natural and other disasters (Figure 8), including:[16]

- Supporting community physical and mental well-being
- Increasing the resilience of urban infrastructure
- Serving as a reliable source of utilities
- Providing essential health information and services
- Supporting distribution of resources
- Amplifying communication of health and social risks and solutions
- Accelerating equitable community development and social inclusion
- Prioritizing most vulnerable populations, including women, children, youth, individuals with disabilities, and the elderly
- Collaborating with and supporting existing entities with the community
- Providing data to inform future disaster preparedness and response
- Providing job opportunities and training to local residents
- Playing a part in reducing greenhouse gas emissions and other climate-friendly solutions

Figure 8: Model of a collaborative, multi-functional resilience center



Site Selection

The community of Cristo Rey, a neighborhood in the city of Santo Domingo, was identified by the municipal government as an ideal location for a community resilience center, both in terms of need and to serve as a model for other similar communities across the country and region.

Cristo Rey is a lower-middle-class neighborhood that is susceptible to natural and other disasters and that faces multiple challenges to overcome severe events. Cristo Rey is characterized by residential, commercial, and industrial facilities that remain vulnerable to flooding, insufficient stormwater drainage systems, limited waste management and sewage infrastructure, and intermittent access to electrical power. It is a densely populated area and a mixed-use neighborhood, with a combination of industrial and commercial businesses, formal and informal residential housing, and a wide range of health, education, community, commerce, and recreational supports.

The identified site for the resilience center is one where ADN is already renovating an existing building to accommodate a satellite ADN office and to establish a capacity building center for the community, focused on youth economic development. The existing 1,700-square-meter building was formerly the offices of Talleres CIMA, an industrial company that manufactured aluminum windows (Photo 5). The building is more than 70 years old and has survived the effects of multiple major storms, including two category 5 hurricanes. ADN identified the building in 2012 and, through consultations with the surrounding community, is in the process of retrofitting the space to accommodate an ADN office and a community support building center (Figure 9). The building has been gutted, and the ADN contractor expects to have some of the renovations completed in 2023.

— "The number one priority in our administration is the safety and well-being of those who reside in and visit Santo Domingo. This synergy with Columbia, INTEC, and UNIBE grants us the power of touching many lives in a transcendent manner in embattled communities in the north side of our city. We are all together for Santo Domingo, tackling right through the challenges of climate change by making a more resilient city." —
Mayor Carolina Mejía de Garrigó

Photo 5: Former business at building site, Santo Domingo 1950

Figure 9: Exterior view of the building that will host the resilience center

Local governance and community leadership: The lowest level of governance in Santo Domingo and other major cities across the Dominican Republic is the *Juntas de Vecinos*. These are the most numerous and diverse social and community expressions and represent various interest groups—from cultural, environmental, and professional groups and economic interests to sports, recreation, and religion. These civil society entities are aligned with geographic boundaries and made up of residents who are elected to form a committee tasked with "the development of the community, defend the interests and ensure the rights of the neighbors, and collaborate with the authorities of the State and the municipalities."[17]

The *juntas* typically work in close coordination with the municipal government and have a voice in the participatory municipal budgeting and planning processes. In the case of Cristo Rey, the decentralized leadership of the *juntas* often meets with the ADN director of community development to plan, identify, and prioritize community needs and to disseminate key communications and opportunities to the neighborhood. The municipalities are charged with the institutional strengthening of these

community organizations so that there is active participation, equity, and application of mechanisms that make them act as truly social democratic entities.

Cristo Rey has a strong network of professional, cultural, and religious organizations, in addition to the *Juntas de Vecinos*, that plays a vital role in identifying community priorities and needs, coordinating services, and working with the community in times of disaster and crisis.

Cristo Rey demographics: The population of Cristo Rey is generally young, with less than 6 percent of residents over the age of 65 and nearly 30 percent of the population between the ages of 0 and 14. Table 2 shows the sociodemographic characteristics of the population of Cristo Rey. While elderly populations are vulnerable to the health impacts of climate change due to higher rates of comorbid conditions, frailty, and impaired mobility, younger populations, especially those under the age of five, are vulnerable to impacts resulting from air pollution, heat exposure, malnutrition, and water-, vector-, and food-borne diseases. Notably, there is a large number of disabled persons living in Cristo Rey. Depending upon the type of disability, these individuals likely represent a highly vulnerable demographic. The high literacy rate is protective and informs potential avenues of public health messaging and education. However, low levels of educational attainment and relatively high rates of poverty place many members of the community at higher risk of health impacts of natural crises as resources, including sufficient food, safe environments, housing, and access to health care may be limited.

Table 2: Overview of age structure, literacy rates, education, and poverty rates in Cristo Rey as compared to the Dominican Republic at large and the National District[18]

DEMOGRAPHIC VARIABLE		NATIONAL DISTRICT	CRISTO REY
Residents born outside the zone		32.9%	32.1%
Age	0–14 years	22.9%	28.3%
	15–54 years	68.8%	65.8%
	>65 years	8.3%	5.9%
Disabled		14%	13%
Illiteracy		7.4%	8.9%
Education	Finished primary school	24.8%	32.2%
	Finished secondary school	34.7%	42%
	University education (any)	37.7%	22.5%
	Adolescents with university education		16.4%
Economic status	Poverty prevalence	26.7%	34%
	Extreme poverty prevalence	4.7%	4.4%
Overcrowding in the home		19.4%	30%

Employment and economic status: Employment and labor sectors are highly relevant factors that affect an individual and a community's climate and health resilience or vulnerability. Employment and economic status can amplify or mitigate the effects of disasters on individuals, including heat exposures, exposure to degraded air quality, vector-borne disease, and more. Employed individuals likely benefit from greater levels of socioeconomic and financial security, resulting in access to resources. As shown in Table 3, employment rates within Cristo Rey are comparable to the National District overall, at approximately 43 percent. Among those employed, roughly 20 percent are involved in an informal sector. Notably, there are higher rates of employment among men ages 18–29 compared to age-matched women. Youth unemployment in Cristo Rey is similar to the national average.

Table 3: Employment rates and workplaces among residents of Cristo Rey[19]

CHARACTERISTIC	NATIONAL DISTRICT	CRISTO REY
Employment rate	**43.7%**	**43.3%**
Unemployment rate	**5.8%**	-
Salaried job	-	**71.5%**
Informal sector	-	**19.5%**
Employment rate ages 18–29	-	**50.8%**
Employment rate ages 18–29 men	-	**61.7%**
Employment rate ages 18–29 women	-	**39.6%**
Unemployment youth	-	**18.2%**

Housing: Safe primary housing is fundamental to buffer the health impacts of climate change resulting from extreme weather, floods, air pollution, and extreme heat. Key indicators of housing quality are listed in Table 4. Within the community of Cristo Rey, over 50 percent of homes are likely to be affected by natural disasters, including hurricanes and flooding, with over 10 percent expected to be severely affected. Nearly 50 percent of homes are located near a canal or other inland freshwater channel, which poses flooding risks and resulting health impacts including water- and vector-borne diseases. Just over 55 percent have running water in the home, although availability of sanitation is higher with more than 95 percent of homes having a toilet. Lack of access to running water poses risks during and after extreme weather events as well as impairs residents' ability to hydrate and cool themselves during heat events. Regarding access to communication, it is currently unknown the percentage of homes with cellular or internet access within the community of Cristo Rey.

Table 4: Key indicators of housing quality in Cristo Rey, as compared to the National District and the Dominican Republic at large[20]

CHARACTERISTIC OF HOMES	NATIONAL DISTRICT	CRISTO REY
Running water in the house	**63.5%**	**56.2%**
Likely to be affected by natural disasters	-	**51.6%**
Likely to be severely affected by natural disasters	-	**10.8%**
With indoor toilet	**94.9%**	**95.8%**
With concrete roof	**71%**	**58.8%**
With zinc roof	**28%**	**39.9%**
Near a river or stream bank	-	**5.8%**
Near a canal	-	**48.4%**
With cellular access	**87.8%**	-
With internet access	**33.3%**	-

More detailed demographic, social, and health information about Cristo Rey is included in both the community and health assessment sections of this report and in appendix II.

Vulnerable housing at the Isabela River's edge.

Assessment Methods, Findings, and Recommendations

Overall Assessment Methodology

Different kind of infrastructure—physical, social, health, and policy—all need to be considered in the design of sustainable resilience solutions. Therefore, four complementary assessments were undertaken, with each led by a different project partner or team, with different approaches (described below), and common methodologies included literature reviews, interviews, site visits, surveys, mapping, and data collection and analysis.

Stakeholder and community engagement was undertaken with key partners at national, municipal, and community levels via regular meetings, interviews, and communications. These included community leaders and leadership structures in Cristo Rey, local and national government agencies, civil society organizations, and local organizations working in health and social development. The inputs and results have informed the direction, design, and methodologies of each specific assessment undertaken and the design of the center.

Summaries of the four assessments—policy, physical infrastructure, social, and health—and their findings and recommendations are presented below.

Centering Community

Community residents are recognized as the ones who know best what the needs, resources, opportunities, and challenges are within their own settings. The resilience center assessment and design process has prioritized the engagement and integration of community members, leaders, and organizations—each of whom will also be critical to the future implementation of the center. This effort included conduct of participatory workshops, community-led mapping and data collection, and regular communication via the Junta de Vecinos, among other community-centering approaches.

Community members in Cristo Rey at visioning workshop

Policy Assessment

Methodology

The policy assessment mapped existing institutional structures, laws, policies, plans, and strategies related to resilience, climate change adaptation, disaster risk management (DRM), and urban planning in the Dominican Republic using a qualitative approach. The literature review included 30 relevant documents (policies, proposals, reports, studies, agreements) at a global, national, and subnational scale, and 11 semistructured key informant interviews were conducted (four with national ministry agencies, three with local government officials, three with independent experts on climate change and disaster risk management, and one with a project manager). The policy assessment also included organizing 10 meetings with stakeholders at government agencies and potential beneficiaries. Assessment findings informed specific recommendations for the design of the resilience center in Cristo Rey.

Findings

In legal and institutional terms, the Dominican Republic has made significant progress in developing its institutional capacities to increase resilience, strengthen disaster risk management, and increase knowledge of the effects of climate change over the last two decades. Figure 10 summarizes the local, national, and global climate-related policies that the Dominican Republic has signed onto and/or enacted as well as the timeline for each respective policy. Despite these advances, the country faces challenges to incorporate them into the development agenda, strengthen links between national institutions and local governments, actively involve the private sector, and access accurate data about the vulnerabilities of each territory. These are crucial to increase resilience among most vulnerable communities.

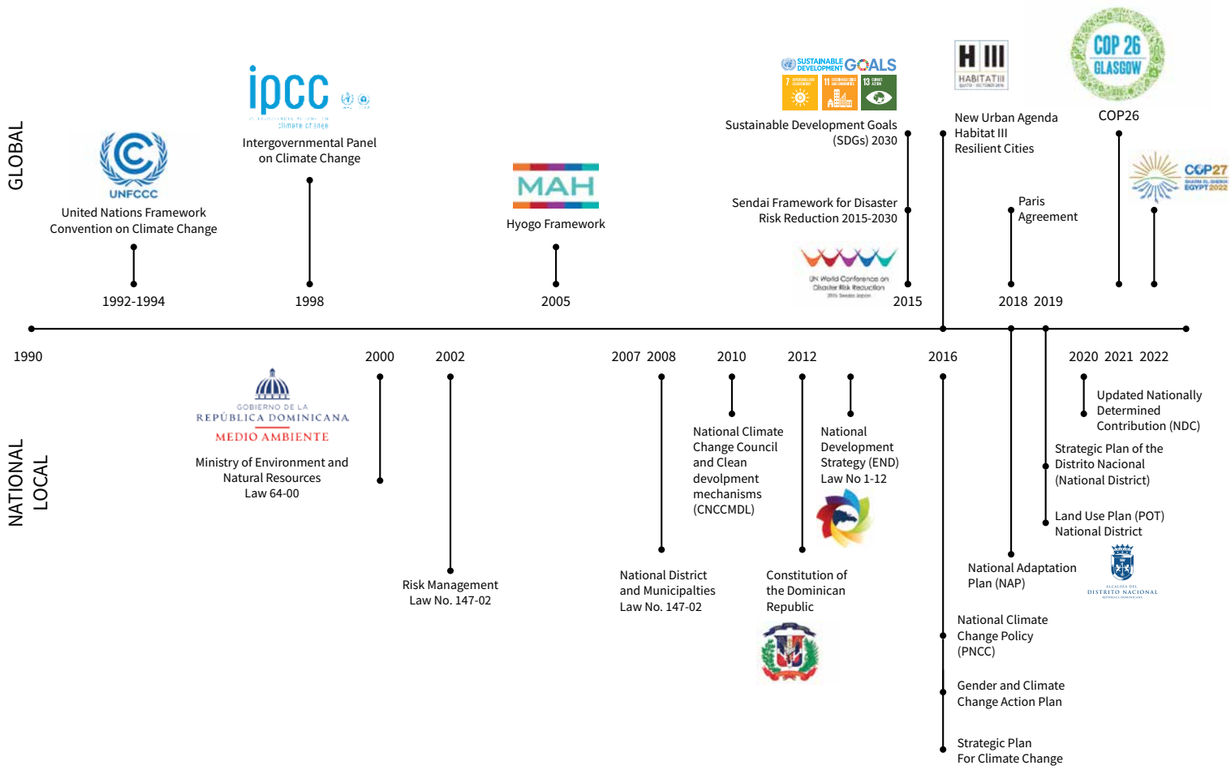
At the international and regional levels, the Dominican Republic has been a member of the United Nations Framework Convention on Climate Change (UNFCCC) since 1998 and a signatory to the Kyoto Protocol (2002) and the Paris Agreement (2017). In 2015, the Dominican Republic submitted a Nationally Determined Contribution to the Convention and an update in 2020, in which it increased its voluntary commitments both in terms of GHG emissions reductions and measures to increase resilience to the adverse effects of climate change in the most affected sectors.[21]

As part of its development agenda, the Dominican Republic adopted the Sustainable Development Goals (SDGs) in 2015. Among the most relevant for this project are Affordable and Clean Energy (SDG7); Sustainable Cities (SDG11), which seeks to make cities more inclusive, safe, resilient, and sustainable; and Climate Action (SDG13), which seeks to address the needs of developing countries in terms of adaptation to climate change and investment in low-carbon development.

The Dominican Republic actively participates in international and regional UN initiatives,

— *"The time to see ourselves as climate victims is over. Although we are, the time to take the helm of the ship has begun. It must be clear to our peoples and to the world that we are serious and that, even in the most difficult circumstances, we are not going to stop. We will overcome the difficulties. This is the message that Latin America and the Caribbean are taking to COP27 in Egypt."*[22] —
Dr. Max Puig, Minister of the Environment, Executive Vice President of the Country's National Council for Climate Change and Clean Development Mechanism

Figure 10: Climate change and resilience policy infrastructure for the Dominican Republic



assuming commitments as signatory of the main agreements on risk management. This includes the Hyogo Framework for Action (2005) and, subsequently, the Sendai Framework (2015), whose approach seeks disaster risk reduction (DRR) and recognizes the role of local governments and other actors to achieve these objectives. The country also belongs to the Coordination Center for Disaster Prevention in Central America and the Dominican Republic (Centro de Coordinación para la Prevención de los Desastres en América Central y República Dominicana), through which it has been able to obtain technical assistance and exchange experiences in the region.

At the national and subnational levels, the country has implemented several state reform processes, including the Constitution of the Republic (2010) as the general framework of fundamental rights of the country. The Constitution recognizes the conservation of the ecological balance and the protection of the environment and establishes the need for adaptation to climate change in land use planning. In the last decade, the country has made progress, both in risk management and in planning for adaptation to climate change, and processes have been initiated for its mainstreaming in development policies.

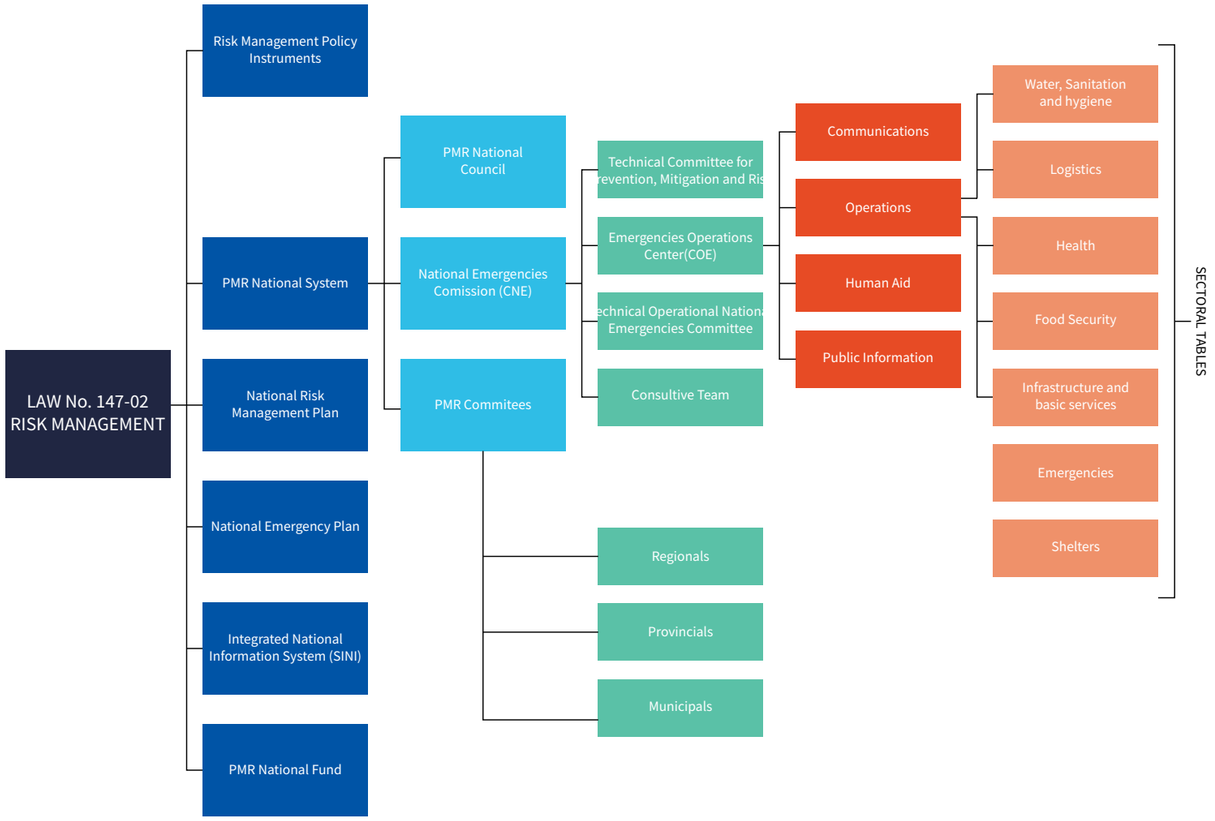
The National Development Strategy 2030 (Estrategia Nacional de Desarrollo 2030, END) is the main instrument of the National Planning and Public Investment System. It promotes environmental sustainability, risk management, and adaptation to climate change, as well as sustainable consumption. To complement the END, in 2018 the National Climate Change Policy (Política Nacional de Cambio Climático) was developed. It proposes fiscal initiatives to address climate change and the incorporation of adaptation into both the long-term strategy and the National Multiannual Public Sector Plan (Plan Nacional Plurianual del Sector Público, PNPSP), the country's medium-term planning instrument, and its articulation with the other cross-cutting policies (environmental sustainability, risk management, territorial cohesion, and gender equity).

Territorial planning is approached as a shared responsibility between national and local governments. The Ministry of Economy, Planning and Development (Ministerio de Economia Planificacion y Desarrollo, MEPyD) governs Territorial Planning and Land Use management, from the Vice-Ministry of Territorial Planning and Regional Development, a recent incorporation that includes the Directorate of Territorial Planning and Development and the Directorate of Risk and Climate Change. The Vice-Ministry focuses on incorporating disaster risk reduction criteria and cross-cutting linkages with climate change in all planning processes.

Following Hurricane Georges, the Risk Management Law established the Centro de Operaciones de Emergencias (COE), as part of the Prevention, Mitigation and Response (PMR) National System. Figure 11 illustrates the established structures, authorities, entities, and respective sectors encompassed through the system. By mandate it focuses on preparedness and response to disasters and crises at the country level and plays a key role in the case of an event. For preparedness, they convene a 26-member committee with representatives from ministries and other key agencies such as national security, first responders, and basic services, including ADN, which has a seat on the national committee, as well as key international entities (e.g. US Embassy, Plan International, World Vision, and the Food and Agriculture Organization of the United Nations). They operate continually and are the only national, centralized preparedness and response unit in the Caribbean. For response planning and execution, they manage six standing teams: logistics, temporary shelter, health, emergency, infrastructure, and water and sanitation, which are all responsible for operational and

— *"We believe communities are the first responders, with the right tools and knowledge they can save lives before help arrives. The Alerta COE app is one of these tools that allows alerts to be disseminated quickly and in real time at the hands of the population. Citizens are able to have direct contact with the COE, thus enabling them to become collaborators in reporting potential risks or threats."* — ***Ing. José Luis Germán, Subdirector of COE and Risk Management Specialist***

Figure 11: Risk Management Policy Instruments, Law No. 147-02



data management, communicating with and engaging key stakeholders in the topic area, and coordinating in the event of an emergency in the given area to respond with coordinated efforts and resources for effective response.

COE serves as a link between local governments and national ministries and agencies as they coordinate the PMR committees at national, regional, and local levels. These committees represent COE in each municipality (e.g., municipal police in ADN), and identify and engage community leaders via the Junta de Vecinos or other relevant locally based organizations to prepare, communicate, and coordinate response. In 2016, COE, US Agency for International Development (USAID), INTEC, and Fundación REDDOM developed "Alerta COE," a two-way communication and data-gathering application that provides users with climate notices, warnings, and other advisories while also allowing the COE to receive notifications directly from users to help the center act fast if emergencies arise.

At the local level, despite municipalities' mandates for planning, they often do not have sufficient human or economic resources to meet demands for infrastructure and services. Although local governments do not specifically have units in charge of risk management or climate change, these approaches have been incorporated as cross-cutting themes in planning instruments and in PMR committees, which rely on existing institutions.

Within the National District, the PMR Committee is led by ADN, currently through its municipal police and fire department, coordinating local preparedness and response with active members from Civil Defense, Red Cross, National Weather Office, and other government agencies (e.g., water, health, power, infrastructure, assistance for vulnerable groups). The fire department, a dependency of ADN, hosts the PMR in their general station, facilitating resources such as a monitoring center with a GPS system, 22 fire trucks, six retrofitted water cistern trucks, and close to 500 firemen and volunteers. Throughout the DN they have another 15 neighborhood stations. The PMR-DN team maintains direct communication with community networks (e.g., community-based networks trained in risk reduction, disaster preparedness, and postdisaster recovery, which operate in coordination with the PMR committees in their jurisdiction and, in some cases, like in Cristo Rey, work in close coordination with the Juntas de Vecinos) during an emergency via WhatsApp groups and on-site volunteers.

Even though municipalities play an active role in disaster risk management and receive the effects of climate change in their territories, due to the cross-cutting nature of these issues, and the agenda of existing units, climate change and disaster risk management are not visibly addressed by existing units or in a comprehensive manner.

Policy Recommendations

Building community resilience is one of the major challenges for Santo Domingo, faced with more frequent and extreme weather events. The following recommendations illustrate opportunities within ADN to further advance and strengthen the implementation and sustainability of climate-resilience initiatives within the National District as well as within local communities such as Cristo Rey:

Coordination and capacity building—national and municipal levels: The resilience center in Cristo Rey provides an opportunity to integrate ADN's preparedness and response efforts with its planning and management areas as a climate change and disaster risk management unit, working with the community to better understand their vulnerability and plan to build resilience.

- Create a designated unit within and (e.g., proposed *Climate Change and Risk Management Unit*) to coordinate efforts related to climate resilience building across ADN and related national, municipal, and local entities. The Unit would be charged with advancing the climate change and adaptation agenda of the municipality, supporting implementation of direct actions, and building capacity across the municipal and local entities to initiate and sustain resilience-focused efforts.

- Integrate local plans and legal frameworks to the national agenda to address climate change and identify funding opportunities, available through the global mechanisms to support local actions.

- Designate a focal point within ADN for government agencies to advance in the climate-resilience agenda of the region.

- Provide resources (i.e., data collection, access to information) to the PMR-DN to improve their coordination with the community, increasing their capacity to respond effectively.

Sustainability of resilience-building efforts in Cristo Rey and other localities:

- Develop vulnerability assessments for Cristo Rey and other local communities across the municipality in partnership with Community Based Organizations (CBOs) and NGOs and MEPyD.

- Coordinate with government agencies, academic institutions to facilitate training for community members and organizations, ADN staff, and community organizations on climate change, resilience, DRM, and DRR.

- Establish a binding agreement between ADN and the Cristo Rey's Union of

Junta de Vecinos to define ADN's role and commitment to the community to support resilience-building efforts in Cristo Rey, including the resilience center implementation and sustainability.

- Further development of possible management structures to plan, operate, and monitor the resilience center and its operations, to respond to ADN's and the community's capacities for the mid- and long-term sustainability and its replicability in other neighborhoods.

- Document, evaluate, and disseminate lessons learned from the Cristo Rey center and facilitate replication of the model in other areas of the country.

Physical/Digital Infrastructure Assessment

Methodology

The design of the resilience center needs to withstand the effects of extreme natural events without suffering major damage or disruptions that could affect the center's ability to accomplish its intended design goals. To evaluate the current state of the physical and digital infrastructure, INTEC reviewed historical data and conducted an on-site assessment of the existing ADN building in Cristo Rey. The assessment included an analysis of the roof capacity, earthquake resistance, and the energy requirements of the building during extreme events, among others. The wind load was calculated using a design wind speed of 180 mph, corresponding to the design wind speed in high-exposure regions on the southern coast of the Dominican Republic. A design roof load of 50 kg/m2 was selected based on the panel's weight obtained from the panel's specification. Earthquake load was considered using a response spectrum analysis based on the design spectrum of the Dominican Republic as defined in the local building code R-001.

Findings

INTEC concluded that the building is in a suitable location to serve as a resilience center, it is well connected with the community, and, with an appropriate retrofit, it has the potential to provide emergency response services before, during, and after an extreme natural event. In particular the building is located at a high elevation point with two-way slopes at each side, reducing the possibility of flooding during a storm, likely the most important natural hazard in the region. Based on historical data, the location has a low flood risk. Overall, the structure is in good condition with select components needing upgrades to accommodate the proposed energy infrastructure.

Infrastructure Assessment

The building structure consists of two main structural systems: a reinforced concrete frame system supporting a reinforced concrete slab for the central portion, and a masonry wall system supporting a steel truss system on the two sides.

Steel truss roof structure: The steel truss roof structure was built more than 50 years ago. In this period of time, the structural steel corrodes, reducing the effective area of the members to resist loading. Moreover, the truss was designed using outdated building codes that do not account appropriately for the wind loads induced by severe storms. In addition the truss needs to be able to support the weight of a renewable energy system (to be discussed in the following sections). The capacity of the existing roof structure could not be evaluated given the lack of access to the original structural drawings used for the construction.

Reinforced concrete slab: At the time of the assessment, the concrete slab's rebar on the central part of the building is exposed and likely corroded or damaged. The rebar requires further evaluation and cleaning.

Windows: The building structure is designed to be naturally ventilated—that is, it is assumed that air conditioning would not be available 24 hours in the building; this is not uncommon in the Dominican Republic where the majority of public schools and buildings do not have air conditioning, or air conditioning does not operate 24 hours. For this reason the building has several openings and windows panels.

There are several large window openings that may limit the operation of the center if they fail during a storm, with potential to cause flooding in the center.

Digital Infrastructure

The resilience center needs to have the capability to operate without interruption during a severe event. This includes the digital infrastructure needed to collect and transmit data, as well as to remain informed about the state of severe natural events happening in the surroundings. Although the center has access to regular public and private utilities, the continuous operations of the center during an emergency would not be guaranteed if the center solely relies on such services; from experience with past severe events in the region, usually electricity and communications (phone and internet) are interrupted from days to weeks, depending on the severity of the event.

Data collection and management: The general building and region assessment revealed a significant lack of local data and information related to weather and geophysical events in the area. This is an important challenge in the development of strategies aimed at preparing communities to be resilient against severe natural events, particularly in the Dominican Republic, where the exposure to severe natural hazards is significant. In particular, decisions related to resource allocation and preparedness plans are often based on the available local data, such as rainfall and wind speeds.

Energy Infrastructure

In order to fulfill its goals, the center needs to have access to a continuous source of power. The building belongs to the electricity distribution circuit CUAR 102 of the Dominican electric company EDESUR S.A. Dominicana (La Empresa Distribuidora de Electricidad del Sur). With this information, a complete history of outages and blackouts in the area was obtained, including their causes and the outages' time period.[23] In addition, the impact of connecting potential solutions to the grid (such as a hybrid photovoltaic system) was studied.

Figure 12 shows the historic annual outage hours for the circuit. While the number of power interruption hours has decreased over recent years, it is in part due to an increase in the number of power plants in the country.

Figure 12: Total annual energy interruption hours for the period 2012–2022[24]

	TOTAL NUMBER OF HOURS	AVERAGE NUMBER OF HOURS	MAXIMUM OUTAGE TIME FOR A SINGLE OUTAGE	MINIMUM OUTAGE TIME FOR A SINGLE OUTAGE
2012	267:27:00	1:31:42	12:06:00	0:01:00
2013	126:57:00	0:49:09	12:01:00	0:01:00
2014	75:04:00	0:42:06	12:03:00	0:01:00
2015	132:42:00	0:49:27	12:04:00	0:01:00
2016	91:44:00	1:05:31	12:11:00	0:01:00
2017	64:59:00	0:32:29	6:20:00	0:00:00
2018	77:13:00	0:47:46	6:42:00	0:01:00
2019	36:40:00	0:33:20	6:02:00	0:01:00
2020	44:36:00	0:50:29	8:16:00	0:01:00
2021	15:04:00	0:27:24	4:02:00	0:01:00
2022	1:29:00	0:08:54	0:31:00	0:01:00

Green Infrastructure

Greater Santo Domingo's (GSD) inadequate stormwater and sewage systems, and its current deficit of natural permeable areas, leave the population extremely vulnerable to severe rain events and flooding. The storm sewer system, managed by the municipal governments, consists of underground collectors that carry the water to streams, rivers, and the sea or reservoirs, filtering wells and natural caverns. The household sewage systems, managed by the Aqueduct and Sewerage Corporation (CAASD), is currently serving 27 percent of the GSD population, and only 5 percent of the sewage is directed to sewage treatment plants. Despite a sewage system expansion program by the CAASD, little progress has been made in the past decade. Significant investment is needed in wastewater infrastructure and green infrastructure strategies, such as planting trees, preserving and expanding natural areas, and creating green roofs to reduce runoff and increase sewer system capacity. These solutions would provide benefits like improved air quality, stormwater management, energy conservation, shade, noise reduction, and aesthetic value.

Urban communities like Cristo Rey continue to experience elevated temperatures associated with climate change, which are exacerbated by the "urban heat island effect." Replacing vegetated areas with areas for nonreflective, impervious surfaces, such as roads, parking areas, and rooftops, worsens this issue.

Physical and Digital Infrastructure Recommendations

The existing building would require the following physical and energy retrofitting and upgrades to function as a resilience center for the Cristo Rey community:

- A new roof structure with reinforced foundations to safely resist the weight of the photovoltaic system and wind forces.
- Hurricane wind–resistant windows and exterior components.
- Given the lack of reliability on the Dominican Republic power grid, particularly during severe events, it is necessary to have an external source of power that can supply the center during emergencies.
- A weather station with sensors to measure rainfall, wind, and ground motions.
- A stormwater collection and management system.
- Permeable, green public spaces.
- Interior fittings that can easily reconfigure the center during emergencies.
- Additional access and egress points for multiuse space and shelter areas.

UNIBE students traveling for community assessment

Community Assessment

Methodology

The methodology used for the community assessment included: data collection (desk reviews, mapping, and collection of available data), community participation and engagement (interviews, workshops), and analysis. The process was led by UNIBE's department of architecture and urban design, in partnership with experts and consultants in sociology, participatory research, community engagement, and environmental and sustainable development.

- ***Data collection, site analysis, and mapping:*** Students in a UNIBE urban sociology students were trained and mentored to conduct, map, and analyze community-level data. They gathered information on Cristo Rey from public and private sources, looking at physical networks, infrastructure, urban regulations, housing vulnerability, and social indicators. This contextual information was used to generate neighborhood maps, showing infrastructure, walkability, public transportation, green systems, public spaces, housing, businesses, and road networks, among other features. The study area was defined as a 10-minute walking radius from the site of the Cristo Rey resilience center, which is the desired walking distance for residents to conduct their daily activities.
- ***Community resilience interviews:*** This portion of the assessment was led by a social worker, who developed a set of questions to determine the resilience capacity of the community, organized into five thematic areas: governance, risk assessment, knowledge and education, vulnerability reduction, and disaster preparedness and response. The social worker, with the help of local leaders, identified willing community members residing within the six-block study area in Cristo Rey. The UNIBE students conducted and transcribed 34 interviews, and the social worker analyzed the results and summarized the findings. The findings include valuable information on community leadership, knowledge on citizen rights and duties, inclusion of women and vulnerable groups, knowledge and knowledge transfer, risk perception, and local capacities to face emergency situations.
- ***Community vulnerability survey:*** The methodology for the community vulnerability assessment had been previously developed by ArcoIris, a nongovernmental organization in the Dominican Republic, in coordination with the National Institute of Housing and Foro Ciudadano, a nonprofit organization focused on promoting participatory democracy, transparency, and social and gender equity. Homeowners within Greater Santo Domingo are able to complete this survey using a mobile device, in order to assess the vulnerability of their homes and potentially qualify for housing improvement government programs.[25] ArcoIris trained UNIBE students in this survey methodology and implementation. The community vulnerability survey was carried out with the assistance of ArcoIris, using their methodology, tools, and georeferencing platform. A total of 174 homes were surveyed to determine their level of socioeconomic and material vulnerability. The results from this survey were used to generate geographic information system maps and narratives on social indicators, housing, community life, and vulnerabilities.

UNIBE students conducting community assessment

- ***Community consultation workshop:*** UNIBE engaged an expert facilitator to design and lead a community consultation workshop, drawing on the results obtained during the analyses and surveys described above (Photos 6, 7, 8). The 30 workshop participants included children and their families, the Junta de Vecinos presidents, and local leaders. The workshop used creative, participatory methods to discuss resilience, generate a process of collective expression using brainstorming and group iteration techniques to bring out community desires for the resilience center, and engage children and adolescents through educational entertainment and artist activities.

Findings

Findings from the site analysis and mapping exercise: Cristo Rey is a mixed-use neighborhood with a strong presence of industries, logistical areas with warehouses and product distribution centers, and large commercial areas. However, in this central neighborhood of Santo Domingo, a large number of multifamily and mixed-use housing (housing and commerce) share space with these industries. Stores are located mainly along the main avenues. Many dwellings do not have direct access from the street but instead are linked to the formal road network through alleys. Many areas have residential buildings that face the street, with informal alleys and overcrowded housing in the interior of the block. It is common for residential buildings, especially those facing the street, to have commercial use on the first level and housing on the upper levels.

The height of the buildings in Cristo Rey is similar to other mixed-use neighborhoods in the Dominican Republic, with a predominance of houses between two and five levels. This corresponds to the typical tradition of first building a single-family house and progressively adding levels for rent (as a form of income) or to house family members. In most cases, these buildings are self-constructed.

The analysis of full and empty lots in Cristo Rey confirmed what the statistical data show: it is a neighborhood with a very high density and compactness. There are no large empty lots or vacant plots.

Findings from the community resilience interviews: Individual interviews were conducted with 34 Cristo Rey residents. Findings illustrate that Cristo Rey possesses strong community leadership. However, some interview respondents suggested that this leadership is highly politicized and that disaster risk management aid is often not channeled through institutional channels

Photos 6, 7, and 8: Community consultation workshop

but through political leaders. Community members identified three main concerns regarding possible threats: floods, earthquakes, and fires. Since it is an industrial zone, there are permanent threats, such as the presence of chemical waste, fires, and air and noise pollution. The experience of flooding is very common among community members who live in areas adjacent to canyons.

Community members perceive Cristo Rey as resilient and supportive in the face of hazards. In their experience, it is the community that mobilizes to come to the rescue when floods and other disasters occur, helping itself before other actors intervene. When asked to identify with whom the responsibility for relief lies, the vast majority answered that it is the community first and then identified government actors. Very few cited external institutions and organizations.

Some respondents mentioned that women are very active and participate in community meetings, but they are not usually the decision makers. None of the interviewees could recall any female leaders in the community nor leaders from other vulnerable and underrepresented groups. Responses showed that there are opportunities to work with male and female leaders on risk management issues, especially on street and garbage improvement and storm drainage solutions. The creation of an early warning system also emerged as a desire of some community members. All agreed that the people who intervene in times of emergency also need more training.

Findings from the community vulnerability survey, conducted with ArcoIris:

- ***Waste management:*** It is very common to see waste accumulated in the streets of Cristo Rey, including food scraps and plastics. There is a need for more refuse containers so residents do not have to travel long distances to dispose of garbage. Solid waste left in the streets is also responsible for other problems, such as flooding during heavy rains when the waste obstructs the sewage system. There is also noise pollution due to the high vehicular traffic flow and loud music in the neighborhood and air pollution from local industries.

Photo 9: Children's ideas of the resilience center

- ***Lack of planning:*** The lack of urban planning in the neighborhood has resulted in a system of unplanned alleyways between and in the back of buildings. Residents have organized themselves to keep the alleys that connect to the block interiors closed and clean.

- ***Poor condition of public spaces:*** Many streets have irregular sidewalks, fillers, and holes that make the street difficult to walk on, especially so for people with physical disabilities.

- ***Lack of recreational spaces:*** In Cristo Rey there are only two parks, Cristo Libre and Cruz Jiminian. Within the proposed resilience center catchment area, there are only two recreational spaces, Cruz Jiminian Park and the nearby Los Cachorros Club, a sports and cultural club that is one of the main community gathering places.

- ***Vulnerable buildings:*** Although the predominant material used in house construction is concrete, construction methods and building on flood-prone soils or with slopes greater than 20 percent make them vulnerable to flooding, fire, wind, and other damage.

- ***Poor accessibility:*** The neighborhood of Cristo Rey has wide, exterior streets, but the interior network consists of narrow alleys. These alleys give access to most of the houses, which means that most of the inhabitants of the neighborhood do not have direct access to the streets or to emergency services. This points to a high vulnerability, especially for people with reduced mobility, because in the event of an emergency or disaster, it would be very difficult to access them or leave their homes.

Findings from the community consultation workshop: The community consultation workshop (Photo 9) attracted a diverse group of 30 participants, ranging from 3 to 91 years old. The workshop helped create synergy, which allowed participants to understand resilience and facilitated local-level organization and empowerment to achieve a common goal.

Community participants were asked about the uses and activities they wanted to occur at the resilience center, summarized in Table 5 below.

Table 5:

	PRIORITIZED ACTIVITIES AND SERVICES CHARACTERISTIC	DE-PRIORITIZED ACTIVITIES AND SERVICES
Community feedback on resilience center programs and activities	■ Center for student services ■ Technical training ■ Medical services and pharmacy ■ Spaces for recycling and waste management training ■ Play areas for children ■ Technology-related play areas for teenagers ■ Sports areas ■ Productive spaces for the community to generate income for common services ■ Green spaces	■ Activities that generate noise and pollution ■ Spaces that encourage crime ■ Private commercial spaces ■ Religious or political activities

Children and adolescents participated in a visioning session, where they were asked to draw and design their own ideas for their community and the future resilience center (Figure 19). The drawings included their own and other families in the community, vegetation and green spaces, shaded and quiet spaces, places for sports, quality housing, and a clean community.

Recommendations from the Community Assessment

- Community members want the center to be productive and provide training and education for income-generating activities and services in the community. They want the center to function as a public space and not solely as a municipal office building or technical training center.
- It would be beneficial to raise community awareness about climate change and the mitigation actions that the community can carry out, alongside municipal programs.
- The community wants to improve and engage in damage assessment before and after natural disasters, including training of local youth in the use of technology to do so.
- The resilience center should work with local groups currently involved in risk management, including neighborhood councils, civil defense, Red Cross, and community organizations, and can play a role in strengthening the Juntas de Vecinos via training and resources.

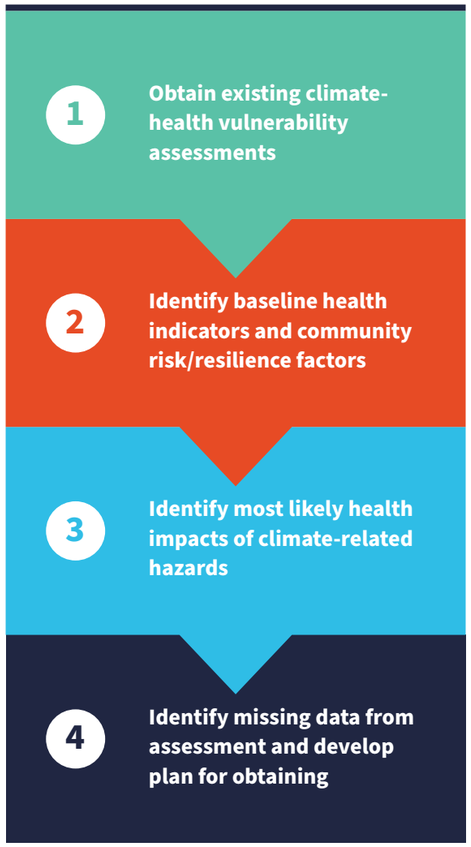
Health Infrastructure Assessment

Methodology

The health assessment was led by the Columbia Mailman School of Public Health Global Consortium on Climate and Health Education in consultation with the Centro de Operaciones de Emergencias, Fundacion Cruz Juminian, Fundacion Plenitud, Hospital General de la Plaza de Salud, and Profamilia. The assessment included:

- *A climate and health vulnerability and resilience rapid assessment* to understand what current health and health system vulnerabilities exist within the community of Cristo Rey, as well as identify missing data. The goal was to understand how climate-related exposures will affect the health of the community of Cristo Rey, now and in the future, and to understand how social factors and the built environment are currently impacting the health of residents. The approach to assessing the climate and health vulnerability of Cristo Rey was modified from the United States Centers for Disease Control and Prevention Building Resilience against Climate Effects (BRACE) technical guidance document[26] on climate and health vulnerability assessments (Figure 13). The BRACE framework that helps health departments to understand how climate has and will affect human health and enables health departments and actors to employ a systematic, evidence-based process to customize their response to local circumstances.

Figure 13: Modified approach to assess climate and health vulnerability in Cristo Rey



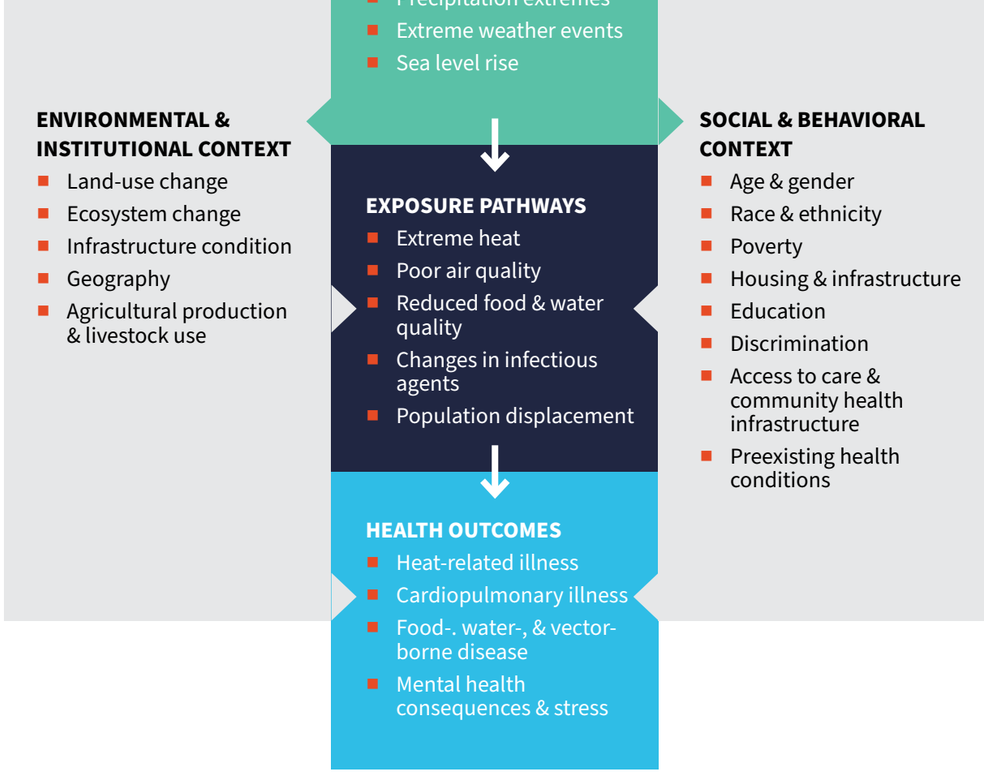
- *Health resources and asset mapping* to identify existing community resources, health care, public health, and emergency response system capacities; identify gaps and perceived needs among local actors; and identify opportunities to strengthen existing structures. Information gathering was achieved through 10 in-person interviews and discussions with stakeholders (health care, government, civil society, education and community leaders), follow-up virtual meetings, and internet-based sources.

Findings

Climate and Health Vulnerability and Resilience Rapid Assessment

Individuals and communities differ in their exposures, their inherent sensitivity, and their adaptive capacity to respond to and cope with climate-related health stressors. Biologic, social, and structural factors mediate individual and community-level vulnerabilities[27] to climate and health impacts (Figure 14). The health assessment included obtaining data (where available) for the community of Cristo Rey, the National District, and on the country level to understand how certain social and behavioral factors may affect the resilience of the Cristo Rey community.

Figure 14: Climate impacts in human health.[28]



Health indicators, several of which are summarized in appendix II are currently not available at a more granular level than the national level and, therefore, may not be representative of the community of Cristo Rey.

Assessment of Likely Health Impacts of Climate-Related Hazards

Based on available data, the community of Cristo Rey is at-risk of multiple chronic and acute climate and health hazards (see Table 6). The most vulnerable in Cristo Rey includes children, women of childbearing age, especially adolescent mothers, and those living in overcrowded, impoverished, and informal housing. Geographically, those households most at risk include those located near the canals and rivers, those with roofs made from material other than concrete, and those in informal settlements where the construction is unregulated. Cristo Rey has comparatively high levels of poverty and a high population density. Its population is younger, with high numbers of working-age adults, making education and the creation of job opportunities key factors in building resilience.

Table 6: Climate-related hazards, potential exposures, and resulting health impacts

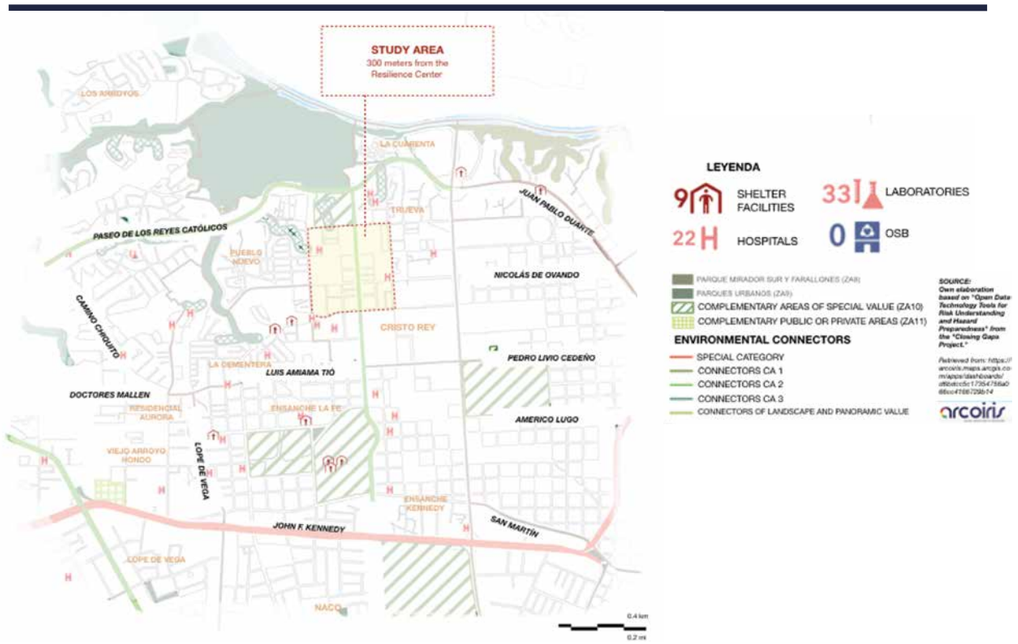
HAZARDS	EXPOSURES	POTENTIAL RESULTING HEALTH IMPACTS	VULNERABLE POPULATIONS	EXACERBATING FACTORS
Climate-related chronic impacts	■ Air pollution ■ Food insecurity	■ Increased burden of cardiovascular disease, respiratory disease, and diabetes ■ Malnutrition/ food insecurity ■ Metabolic disease	■ Children ■ Pregnant women ■ Elderly ■ Impoverished	■ High rates of poverty ■ Poor access to primary and secondary health care ■ Low levels of education
Climate-related acute hazards	■ Extreme heat ■ Extreme precipitation and flooding ■ Drought ■ Sea level rise ■ Vector-borne illnesses ■ Wildfire ■ Hurricane/ cyclone	■ Exacerbations of chronic underlying health conditions ■ Outbreaks of vector-/water-/ food-borne illnesses ■ Traumatic injuries		■ Mobility and communication barriers ■ High rates of chronic disease ■ Low access to consistent, reliable health facilities ■ Lack of modern sanitation/water systems
Environ-mental/ structural hazards	■ Inadequate wastewater and/ or solid waste management ■ Inadequate grid reliability ■ Infrastructure failure/collapse ■ Hazardous material exposure	■ Acute and chronic gastrointestinal and skin infections ■ Unreliable use of medical devices/ oxygen		■ Lack of modern power/water/ sanitation systems ■ High levels of chronic disease ■ Mobility and communication barriers

There is a significant amount of health and social data that were not available for Cristo Rey, specifically. Future work should include eliciting such data through collaboration with government agencies and academic institutions.

Assessment of Health Care Resources and Asset Mapping in Cristo Rey

There are several health actors in Cristo Rey, both public and private, from hospitals to clinics to pharmacies and laboratories (these health actors are described further in the design section that follows). Per the report developed by UNIBE for the social component of this project, there are nine hospitals and 88 pharmacies in the study area of Cristo Rey (see Figure 15). Additionally, there are several additional hospitals and clinics in close proximity and easily accessible to Cristo Rey, although they are outside of the boundaries of the neighborhood proper.

Figure 15: Health infrastructure of Cristo Rey[29]



Recommendations

Disasters are events that occur at unpredictable times; thus, the resilience center must be structured to build and promote resilience on a daily basis, thereby reducing disastrous levels of health vulnerability in the event of a disaster. There is health infrastructure in place in Cristo Rey; however, more coordination and capacity building is required, as well as more data to analyze specific vulnerabilities and needs of the community related to health and resilience.

Based on climate- and health-related risks and existing capacity, partnerships, and perceived needs of stakeholders in the community, it is recommended that the design of programmatic initiatives at the resilience center, including those related to health, be organized into three operating levels:

- Everyday resilience-building programs and activities
- Programs and services during disasters and large-scale disruptions
- Postdisaster and recovery programs and activities

Designing the Blueprint for the Community Resilience Center

Vision
The Cristo Rey resilience center is designed as a place where the community can feel safe, learn, play, gather, and build knowledge, capacities, and overall resilience (Figure 16). This is an ongoing vision, built from the multiple partners and stakeholders that have collaborated on the project thus far, and one that will continue to evolve as the center is implemented.

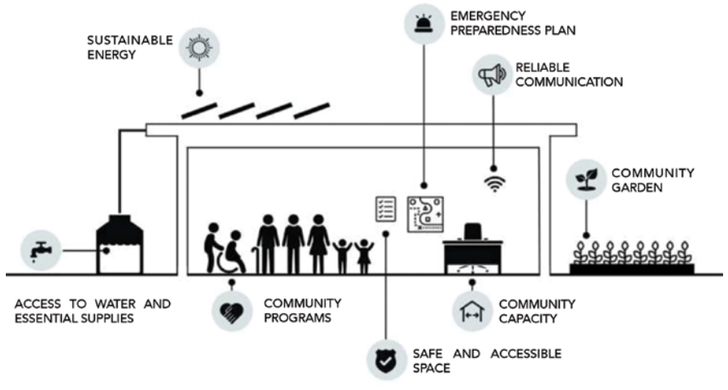
The project team drew from the assessment findings and recommendations to develop a design plan, or blueprint, to integrate a resilience center into the ADN capacity building center in Cristo Rey. The proposed design aligns with, and builds upon, the completion and launch of the ADN satellite office and community capacity building center, projected for completion in 2023.

The proposed design of the resilience center at the ADN space in Cristo Rey has two primary components: (1) physical and energy retrofitting and upgrades, and (2) community resilience-building activities and programming. The proposed activities are designed in a way that they can be phased in as resources are available and to not disrupt any plans and service delivery for the community already underway (Appendix III).

Figure 16: Vision of the community resilience center in Cristo Rey

Values:

- Community engagement and ownership
- Equity
- Coordination and cooperation
- Reduce GHG emissions



Upgrade the Physical, Digital, and Energy Infrastructure

Central to any resilience center is to ensure the physical building is a safe space for the community before, during, and after any natural or other disaster. This includes ensuring the physical building can withstand winds, rain, flooding, seismic activity, and any other weather-related challenge, as well as providing sustainable, consistent electricity, internet connectivity, and water for the center in the event the community loses electrical power.

Based on the findings and recommendations from the physical and digital infrastructure assessment conducted by INTEC, the following is a summary of retrofitting and upgrades that could build on what exists at the current center (Figure 17) to integrate a resilience center (FIgure 18).

Figure 17: "The before": ADN's plans for the building that will host their municipal office and capacity building center

Figure 18: "The after": Proposed rendering of the building that will host the resilience center

Upgrade/replace the roof. A fundamental characteristic of the resilience center is that it needs to be able to withstand the effects of extreme natural and geophysical events without suffering any important damage; these events include hurricanes, earthquakes, flooding, extreme winds, and rainfall, among others. The center needs to be able to operate during and after these severe events. As such, a roof upgrade was designed to be able to withstand the wind forces expected from strong hurricanes and other extreme weather events and support the weight of the proposed photovoltaic system.

A new roof structure was designed based on the weight of the photovoltaic system to be installed and the wind forces expected from strong hurricanes. Figure 19 shows the 3D computational model used to analyze the structure. In order to minimize changes to the current building configuration, the same geometry and type of truss were considered, with the member sizes and connections designed for the loading conditions considered.

Figure 19: Computational model of the roof structure proposed for the resilience center

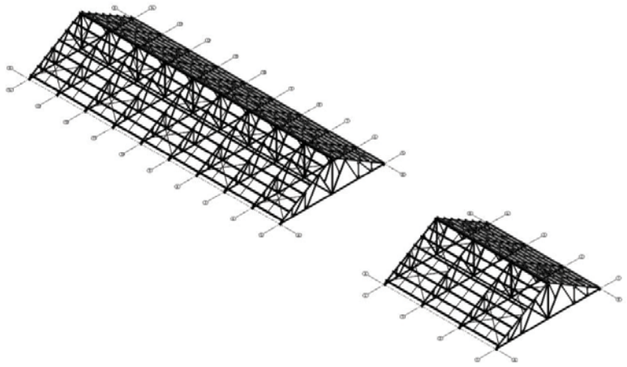
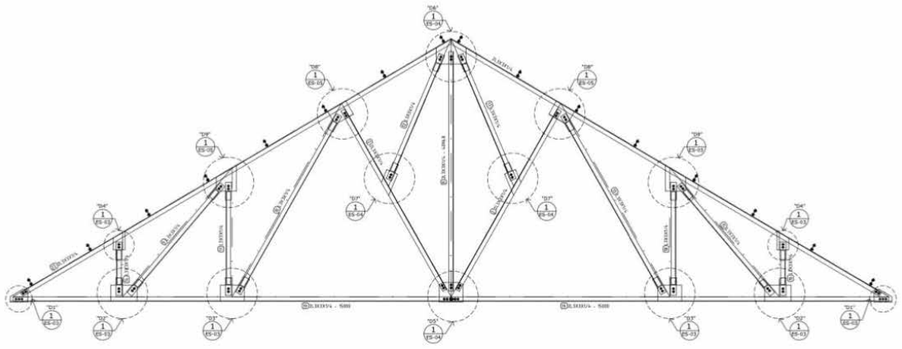


Figure 20 shows an example of results of the structural design; the figure shows the sections needed for the truss, keeping a geometry configuration consistent with the existing truss. A complete set of structural drawings was developed as part of the design and submitted to be considered in the retrofit of the structure.

Figure 20: Truss structure section showing member sizes based on structural design



The plan for the project is to decommission the existing truss and replace it with the new design. The truss would be supported by the existing masonry walls and foundations, which, based on a preliminary design, were deemed to be appropriate. A second check of the masonry walls and foundations is recommended after the preliminary design is approved by the roof contractor.

Replace the windows. Window panels will need to be replaced with those designed to resist hurricane winds and limit water entry.

Install a renewable, photovoltaic energy system. The center will be equipped with a renewable energy system that will enable it to maintain power, uninterrupted and for up to three days, in the event that power is lost from the grid. This system will store energy through batteries and be able to supply energy to the main grid each year, reducing greenhouse gasses and ultimately recovering costs from the initial investment in batteries and ongoing maintenance. There are two options for the energy system:

- ***Option 1:*** A hybrid photovoltaic system for the resilience center (includes a 9.6 kW inverter, 14.85 kW from the panels, and a 49.2 kW storage capacity), sufficient for the operation of the system for three to four days.

- ***Option 2 (preferred):*** An added photovoltaic grid tie system for the entire technical institute that will be operating from the resilience center building. The system would help to reduce the overall demand of the computers and the rest of the equipment installed in the building that would be *in addition to* the system installed for the resilience center operations only.

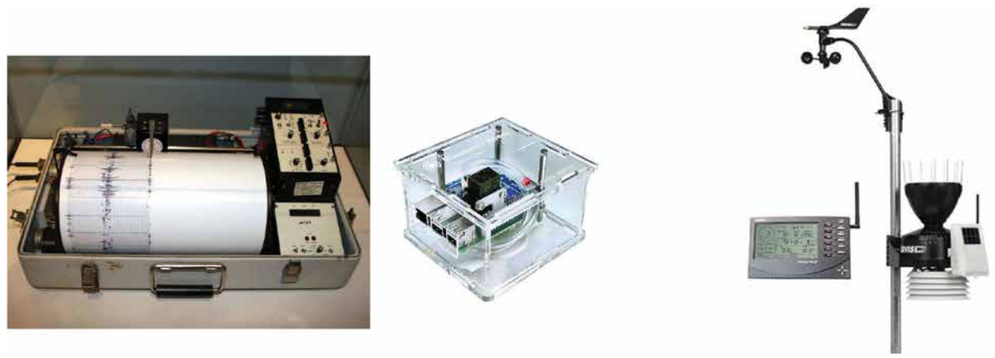
Due to the location of the resilience center and the potential of solar photovoltaic systems in the Dominican Republic as discussed in reports such as studies from the International Renewable Energy Agency, the resilience center should be equipped with this type of system to fulfill the electricity demands of the center and potentially its surroundings, taking into account technical parameters specified in the country's codes and norms.

Typically, the first constraint in the applicability of a photovoltaic system is the space (generally on the roof) needed for the panels. In the case of the ADN building, the available roof space is sufficient to design a solar energy system to partially supply the energy demand of the building and to serve as an energy backup in the aftermath of a natural disaster. The system will be designed to power the emergency response components of the center for a short period of time, ideally at least three days. An appropriate roof drainage system needs to be designed for the center. Figure 21 shows an aerial view of the building roof. The front face of the building faces southwest, and due to the roof inclination, it is proposed to place panels on the southeast face of the building in order to maximize energy efficiency.

Figure 21: Potential locations of photovoltaic panels to maximize energy efficiency

Establish a weather station to collect data on weather and geophysical events. Ideally, the resilience center should be equipped with a weather and geophysical data collection, monitoring, and management system (Figure 22). This system will be in the resilience center and thus operational even during severe events, gathering data that could potentially be used in future assessments. The proposed data system will include a rain gauge, a wind anemometer, and a ground motion (earthquake) accelerometer. This data collection system can be part of the Climate Change and Resilience Observatory (Observatorio de Cambio Climático y Resiliencia),[30] a network of data collection stations that measure quantities related to climate change implemented and managed by INTEC. Data collected from the observatory would be available for use by the municipal (e.g., Environmental Management Unit, ADN) and national infrastructure in the Dominican Republic.

Figure 22: Weather station with wind and rainfall measuring capabilities; seismograph for ground motions measurement



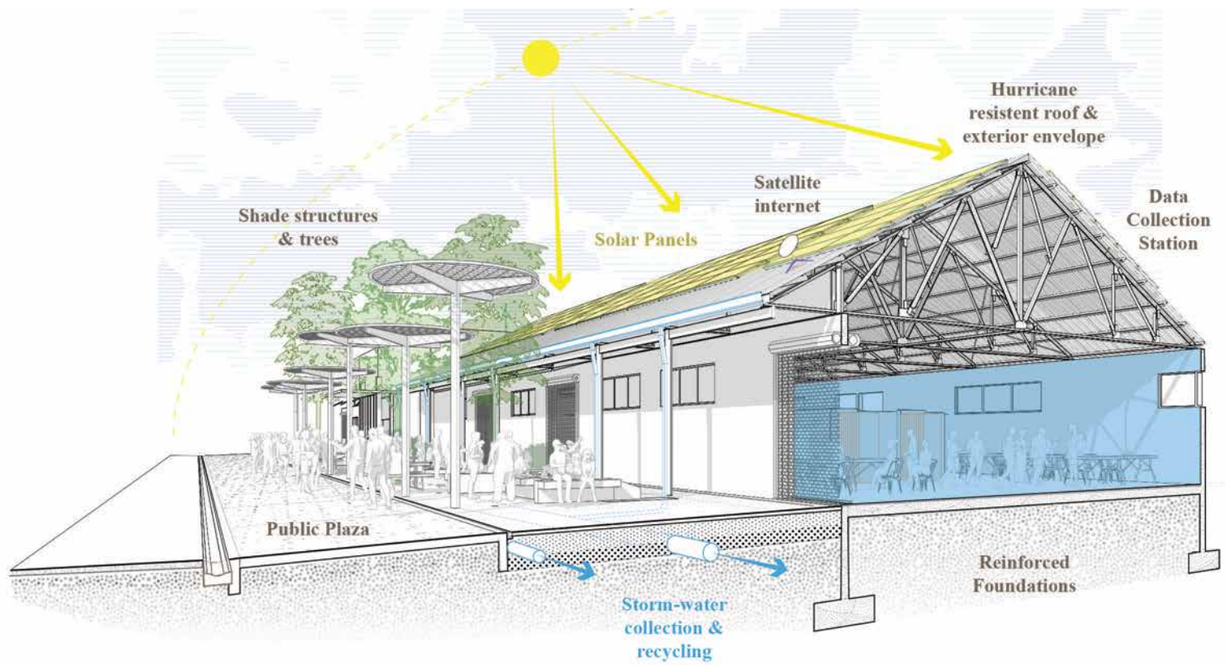
Upgrade the digital infrastructure, including installing a satellite information system. The resilience center needs the capability to operate without interruption during a severe event. This includes the digital infrastructure needed to collect and transmit data, as well as to operate the center. Further, the control system of the photovoltaic system will leverage the power used based on climate and demand conditions. The design includes installation of a satellite internet system that would provide continuous communication in the days after a severe event. The system would require a satellite dish, a transceiver, and a modem. The design proposes to use a commercial satellite system (such as Starlink), which, although might be temporarily interrupted during the severe weather time window, would restore the connection to the information systems significantly faster than the internet landlines if there is a major collapse of the city infrastructure and the power grid. Any equipment of the satellite system exposed to the weather (for example, an antenna) will be designed to resist severe wind and rain effects. In addition, all the digital infrastructure equipment will be connected to a UPS emergency system with surge protection.

Create space for essential services. Physical building upgrades include proposals to create space for essential services—for example, space to deliver basic health services, a multiuse community space that can be transformed into a food and water distribution site in times of crisis, and storage space for needed, everyday disaster supplies (Figure 24).

Make green infrastructure upgrades. The resilience center could become a model of how integrated green infrastructure interventions can create new synergies and partnerships between the community members, local leaders, academics, government agencies, and private sector (Figure 23). These upgrades could include:

- ***Stormwater collection and filtration:*** Incorporating a system for collecting and filtering stormwater on the new roof. Water cisterns can provide emergency water supply during and after disasters.
- ***Permeable green public spaces:*** Transforming the nonporous surface parking lot into a multiuse public space with permeable paving, rain gardens, swales, and street trees.
- ***Urban agriculture:*** Implementing innovative urban agriculture approaches, such as ground-level and rooftop farming, hydroponics, and living wall systems. This could protect the community against food shortages and promote health and wellness. The resilience center could host community nutrition classes that provide families with information on healthy food choices and behaviors, as well as seasonal access to fruits, vegetables, and herbs at low or no cost.
- ***Reflective cool roofs:*** The new roofs should be designed to reflect more sunlight than a conventional roof, which would lower the temperature of the building, helping to reduce energy bills and improving indoor comfort and safety for spaces that are not air conditioned.

Figure 23: Recommendations for physical and digital infrastructure upgrades



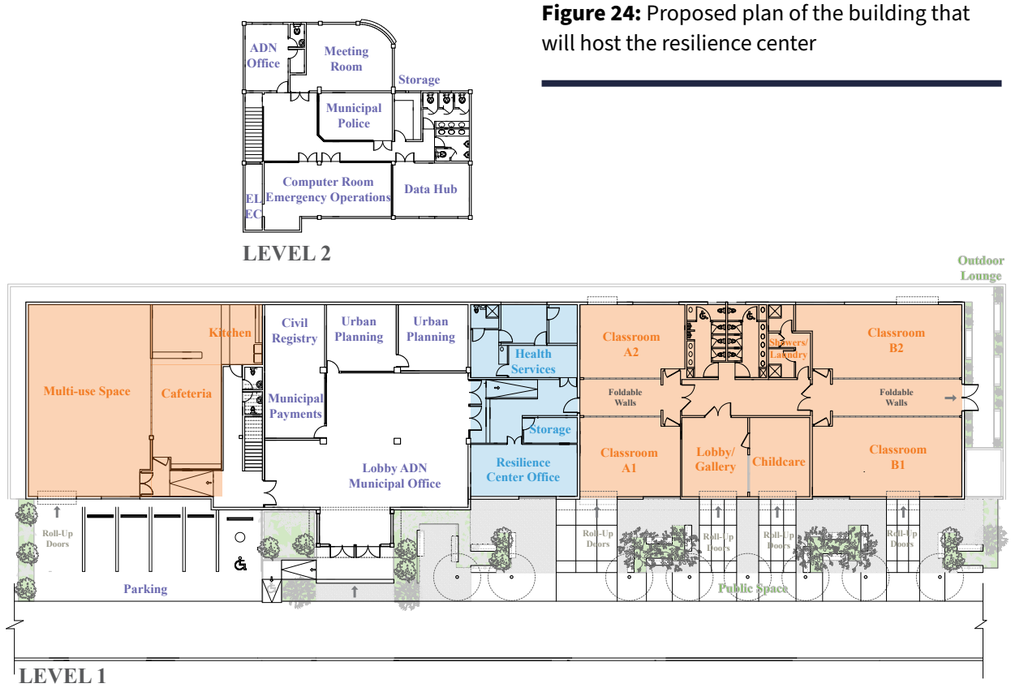


Figure 24: Proposed plan of the building that will host the resilience center

Proposed Sequencing of Infrastructure Upgrades

The physical upgrades to the building are proposed in stages so as to not disrupt any continued services and access for the community. An efficient construction project plan can minimize the disruption to the facility's function during different phases of construction. Clearly defined locations for construction parking, dumpsters, and site access are critical and should be isolated from the community visitors and ADN daily operations. Wayfinding signage should be clear, helping to guide visitors and staff safely around any temporary disruptions. Plans for efficient phasing, site logistics, access/utility disruptions, and communications are a few processes that should be coordinated before starting construction.

Depending on the availability of resources, permitting and contracting, and other factors, the authors propose the following sequence of upgrades:[31]

Stage 1: Multiuse space and cafeteria renovations

- Site logistics, foundation and excavation work, and partial demolition of interior and exterior walls
- Installation of the metallic roof structure, windows, doors, and foldable walls; permeable parking area and sidewalk construction
- Installation of solar panels and the water collection system and electrical wiring of panels/battery storage

Stage 2: Resilience center building renovation

- Side logistics, foundation and excavation work, and partial demolition of interior and exterior walls; conversion of a temporary multiuse space in the lobby area

- Installation of the metallic roof structure, windows, doors, and foldable walls, showers, laundry room, and construction of permeable public space with sidewalk, furniture, and planters
- Installation of solar panels and the water collection systems and electrical wiring of the panels/battery storage

See appendix III. for more on the proposed sequencing plan.

Coordination of Retrofitting with ADN Contractors

A further design recommendation is the importance of coordinating the retrofitting of the current building with ADN contractors, Comisión Nacional de Emergencias and EDESUR Dominicana, to ensure that it is recognized by the Programa de Medicion Neta (PMN) program. The PMN program, managed by the electricity distribution companies of the Dominican Republic, regulates how buildings with renewable energy systems can operate while connected simultaneously to the power grid. Any building that plans to operate using energy from both the power grid and a renewable energy system (such as a photovoltaic system) needs to be registered in the PMN program, in accordance with local laws and regulations. The renewable system and connections need to pass an inspection in order to obtain the PMN registration.

Potential Expansion to a Microgrid

Part of the proposed design includes a microgrid that could potentially provide energy to the surrounding neighborhood in the event of a major disruption to the electric grid. The microgrid would use the roof space of the school being built behind the resilience center to install a photovoltaic system (Figure 25). The community sites connected to the microgrid (for example, nearby houses, light posts, Club Los Cachorros, etc.) would be connected to both the regular electric grid and the resilience center renewable energy microgrid. This type of system is novel and has not been previously applied in the Dominican Republic; typically either the elements being powered are connected to the main electrical power grid or completely isolated and solely rely on the renewable energy photovoltaic system. Given the high energy demands of typical households, it is not possible to permanently supply energy to the community with only the microgrid based on renewable energy, and thus the team is exploring this dual system with the microgrid serving as a backup emergency system in the aftermath of a major disaster. A further challenge is that the electricity companies would need to approve the installation of this system in agreement with the government power-regulating agencies.

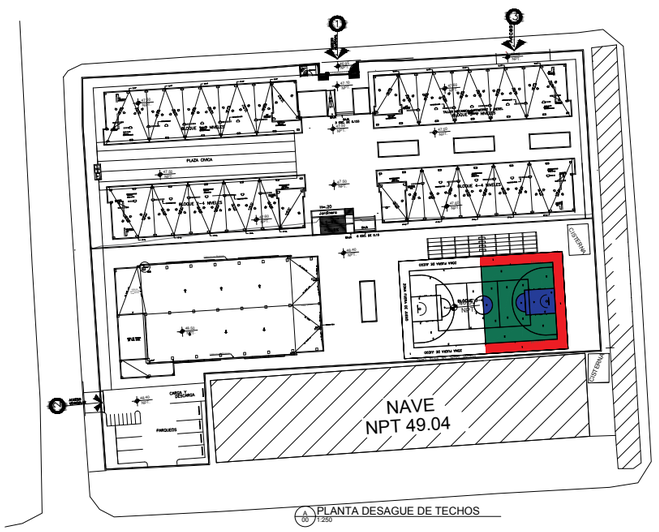


Figure 25:

Potential energy generation using a photovoltaic system installed on the available roof area available at the Politecnico Movearte Flor (behind the resilience center)

Design for Integration of Health, Social, and Resilience-Focused Programming

Resilience centers are physical community spaces developed with the goal of increasing resilience. Resilience is never complete, nor is a resilience center. By nature, resilience center components will evolve over time to align with changing climates, contexts, and hyperlocal community needs and assets. A healthy, cohesive, connected community is a resilient community; therefore, the design of a resilience center goes beyond traditional disaster preparedness and response to include social resilience, education, wellness, and community connectivity.

The proposed design of resilience center programming is organized and presented at three operating levels, summarized in Table 7 and expanded upon below. In addition to the specific proposed programs and activities, there are a number of additional ideas listed at the end of this section that can be more fully developed depending on community demand, funding, available resources, and other factors.

Based on the assessment findings and the opportunities and needs in Cristo Rey, the resilience center needs to provide the essential health and social services at each operating level as summarized in Table 8.

Table 7:

	EVERYDAY RESILIENCE-BUILDING ACTIVITIES	ACTIVITIES DURING DISASTERS AND DISRUPTIONS	POSTDISASTER AND RECOVERY ACTIVITIES
Design of resilience center programs and services	**Improve baseline knowledge and skills, social cohesion, and disaster preparedness.** ■ Safe, open community space and hub ■ Trainings to improve baseline health knowledge, skills, and disaster preparedness ■ Safeguard mental health via community approaches ■ Hub for health and social services resources ■ Support for community research	**Serve as a central point of access to information and basic services.** ■ Centralized information hub for the community ■ Internet and phone services ■ Disseminate key information from local authorities ■ Basic services—first aid, food, hygiene supplies, clean water, shelter capacity, restrooms, showers ■ Space for Centro de Operaciones de Emergencias (COE) satellite operations in the community ■ Support for first responders/emergency workers ■ Trained, volunteer community crisis response team	**Support vulnerable families and help the community recover and rebuild.** ■ Continuation of basic services provided during the disaster (first aid, clean food distribution, clean water, restrooms, etc.) ■ Hub for the community to receive information and referrals to needed services and supplies (resources for rebuilding, support to apply for aid, etc.) ■ Community space for local and community organizations to convene, support to reduce duplication of effort ■ Conduct postdisaster analysis with the community and make recommendations

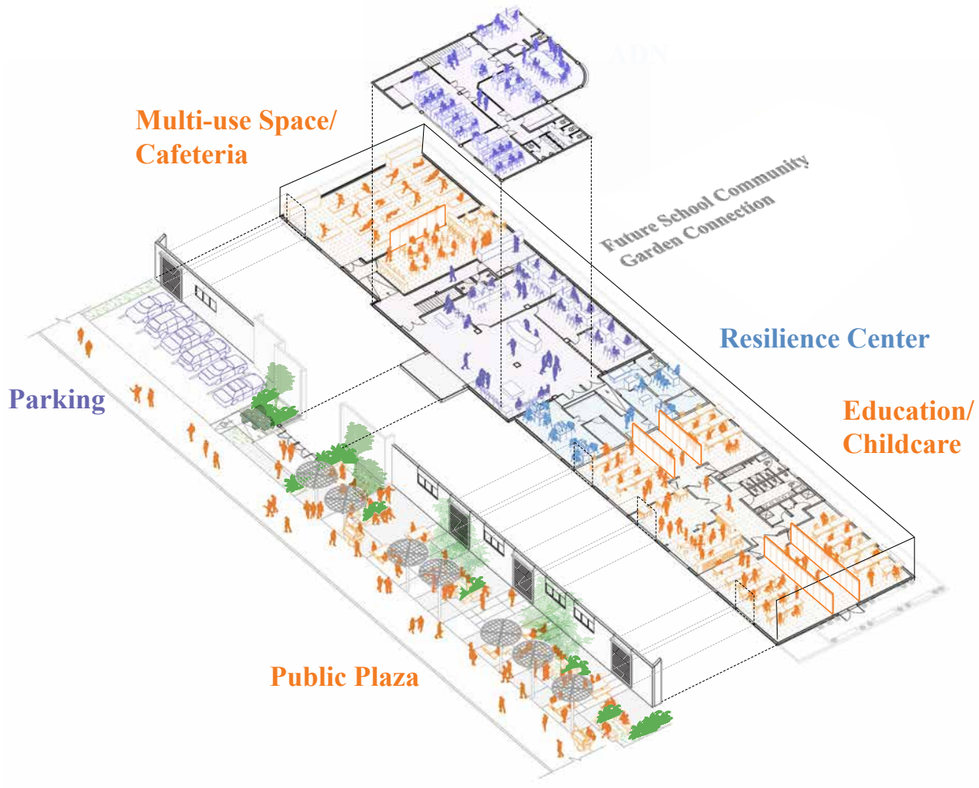
Table 8: Recommended essential health services, by operating level[32]

RESILIENCE CENTER SERVICE CATEGORIES	OPERATING CONSIDERATIONS: EVERYDAY MODE	DISASTER MODE	RECOVERY MODE
MEDICAL SUPPLIES/ SERVICES	■ Basic first aid capacity on-site	■ Basic first aid and some community health support to prevent overburdening of local hospitals ■ Hosting for international aid organizations to provide trauma care ■ Hosting of emergency women's health providers	■ Basic first aid and community health support ■ Hosting of emergency women's health providers
SUPPORT FOR HEALTH AND EMERGENCY WORKERS	■ Provision of trainings, location for meetings/ collaboration	■ Provision of rest areas, food and mental health support for health and emergency workers	■ Provision of ongoing refuge and mental health support for health and emergency workers
WATER PROVISION	■ Access to clean water/ drinking fountains	■ Clean (filtered) water and/or bottled water for 500+ families	■ Clean (filtered) water and/or bottled water for 500+ families
FOOD STORAGE/ PREPARATION/ PROVISION	■ Ample storage for meals	■ Kitchen space and supplies to provide meals for 100+ families and emergency workers for 3 days	■ Storage space for food and cooking supplies that can be used on-site or distributed to residents
COOLING RELIEF	■ Sufficient to provide for facility and users	■ Relief for vulnerable community members and staff during heat waves	■ Relief for vulnerable community members and staff during heat waves
RESTROOMS	■ Operational restrooms	■ Operational restrooms	■ Operational restrooms
WOMEN'S HEALTH AND HYGIENE	■ Provision of resources for reproductive health services/safe space	■ Provision of showers and hygiene supplies ■ Safe/quiet area for pregnant and lactating women	■ Provision of showers and hygiene supplies ■ Safe/quiet area for pregnant and lactating women
CHILD CARE	■ To be provided during educational events and trainings	■ Additional support for single parents or children with special or additional needs	■ Additional capacity and staff support for child programming and care

Everyday Resilience-Building Programs and Activities

Vulnerability begets vulnerability. At its core, the resilience center aims to serve as a central point to address population vulnerability and help the community thrive on a daily basis (Figure 26). Based on the social and health infrastructure assessment findings and recommendations detailed above, the activities are designed to support day-to-day community resilience, which is foundational for resilience during disasters. Improving baseline health, knowledge, skills, and social cohesion, in addition to formal disaster preparedness activities, will improve community resilience during a disaster.

Figure 26: Everyday resilience-building programs/activities at the resilience center



Increase community knowledge and skills. The center will serve as a safe, open community space and hub to increase knowledge and skills among community members, in health, wellness, environmental preservation, climate risk, disaster preparedness and response, governance, and others as deemed important by the community. Training programs will be ongoing, free or low-cost, and tailored to specific populations including community members, professionals, and special populations (e.g., youth, women, elderly). Training activities will be designed and implemented in partnership with local academic, NGO, and government partners and integrated into the existing training and capacity-building programs offered through the center. Example topics include first aid, CPR, and climate and health preparedness.

Support innovative approaches to safeguard and promote mental health. Anxiety, depression, post-traumatic stress disorder, and other mental disorders are both under-recognized and undertreated in the Dominican Republic.[33] Many effective interventions can be performed by lay people through a structured, community-based approach. Building capacity in nonemergency times will increase resilience during times of crisis. The resilience center will build and support preventative approaches to mental health through the engagement of community members, teachers, peers, parents, clergy, and others. Programs for mental health and well-being that the center could provide or facilitate include the following: psychological first aid training, Mental Health Gap (course from World Health Organization for existing health professionals), yoga, meditation, group exercise, and dance classes.

Position the resilience center as a social services hub. A key function of the center is to serve as a connector and hub for the community. There are many resources and services available in Cristo Rey, and as such the center will serve as a central and inclusive place for people to find information and services. In addition, as the center collects information on community needs, this data will inform the center programming, and the consideration of additional programs and services such as childcare, youth stewardship, and specific capacity-building and training programs can be developed and scaled up in times of community stress. Finally, the center will continually share and report community resource inquiries with stakeholders and advisors in the community to identify and continue to build referral networks and address gaps in service and resource needs.

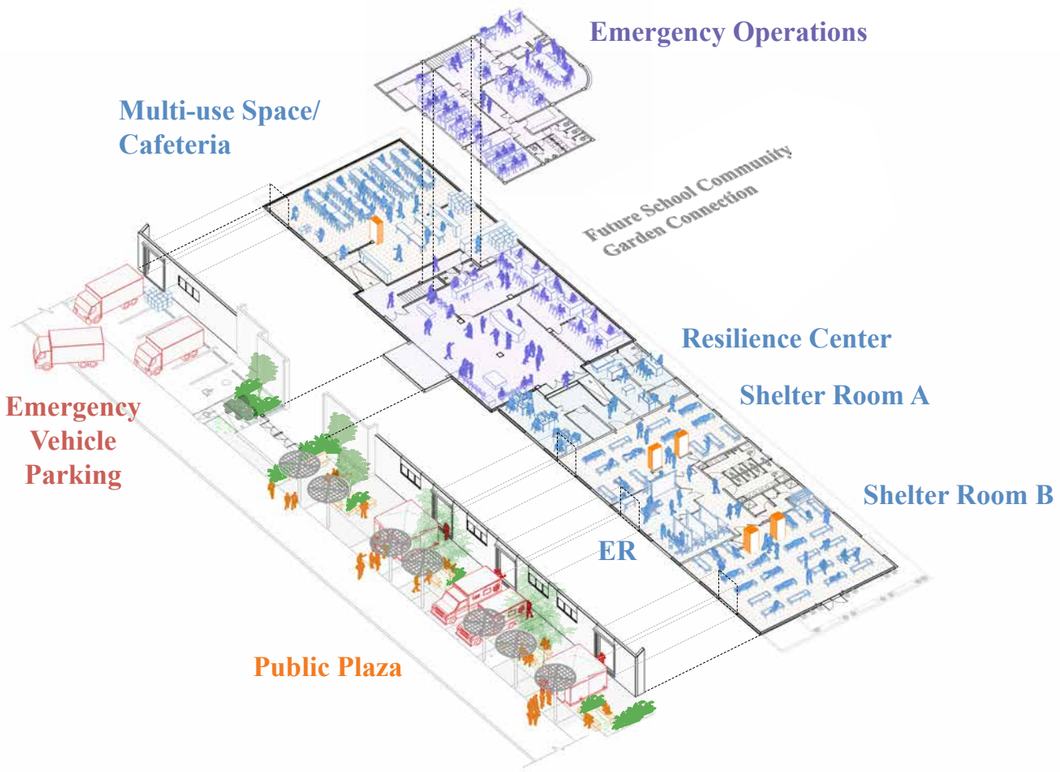
Supply basic provisions. The center could offer a community kitchen that provides free or low-cost meals, basic medications and first aid supplies, and clean drinking water. Additionally, the center will be air-conditioned so that people, especially the elderly, have a cooling center and place of reprieve from the heat, a simple intervention that has been shown to help people's bodies cope with heat stress, daily and during heat waves.

Support research in the community. The center will promote and support community-level research to better understand the health status and needs of the population. This will include building upon the existing risk and vulnerability data collected by UNIBE students and community members as part of phase one, and continuing to input new data so the community has real-time information on vulnerabilities and risks in the community. Other potential areas of research include analysis of vector reservoirs, weather patterns, and community-level climate change risks.

Programs and Activities during Disasters and Large-Scale Disruptions

During a disaster or large-scale disruption, it is essential that people have easily accessible and reliable information and immediate access to basic necessities and life-saving services to protect both their physical health and mental well-being. The resilience center will serve as a central point of community access for these needs, including the potential to support the work of emergency responders and other frontline health and emergency response workers (Figure 27). The center will work in close coordination with COE and ADN to ensure essential information is transmitted to the community, and likewise, pertinent information regarding key issues and needs of the community is communicated to the municipality.

Figure 27: Resilience center programs and services during disasters and large-scale disruptions



Serve as a hub for centralized, community-level information. People are able to make the best decisions for themselves and for their families when they have up-to-date and relevant information. The most helpful information is community specific. The resilience center will serve as a central communication hub for the community, providing internet and/or phone services, WhatsApp or other resources, disseminating key information from local authorities (e.g., Alerta COE, the COE app for emergency updates), reimbursement for phone credit and/or satellite phone if services are down.

Provide basic services during disasters. During a crisis, people need fast and reliable services at the community level. The first people to respond and provide care in an emergency are always neighbors and local organizations who are already operating and present before disaster strikes. The training and preparation from the "everyday resilience" phase, described above, will be essential for scaling up during an emergency.

A foldable wall system is recommended to enable expansion of small classrooms into large shelter areas during emergencies and community gatherings. The center will house a storage room for basic supplies that can be used in a crisis. Supplies would include first aid supplies, nonperishable food/meals, hygiene kits, etc. Additional services could include access to a water filtration system with a capacity to provide water for several days; a dedicated shelter for women, children, and families; a sleeping area for health and emergency response workers; and access to washing machines, showers, and toilets.

Provide space for COE satellite operations. The resilience center would coordinate with COE representatives to function as a base for satellite operations in the community. This ideally would be one of many communities with satellite COE operations that could form a network to efficiently and quickly provide resources and information across a large geographic area. The center in Cristo Rey could serve as a pilot for other communities in this capacity, even if they did not have the capability to create an entire resilience center.

Assemble and support a community crisis response team. Community members are always the first to respond in an emergency. The resilience center would have a standing roster of trained volunteers that could be called upon by the community to be dispatched as a mobile response team during an emergency. They could directly provide aid, including basic health care and support to evacuate people with mobility issues or who are trapped for other reasons, and potentially transportation for those who cannot get to the center or to health care facilities. This could also be done in a distributive way through a mutual aid WhatsApp group where community members send out requests directly, with monitoring by the resilience center, as needed.

Post-disaster and Recovery Programs and Activities

Recovery from a disaster can take weeks to months. Physical and mental health impacts occur throughout this phase, and often this is the period during which vulnerable people and families in the community need the most support.

Serve as a hub for ongoing support of basic necessities. Ongoing support of basic necessities following a disaster is essential as people work to rebuild their lives and their communities. Often, support ends too quickly and communities are not able to make a full recovery. The resilience center will offer postdisaster services including the following: basic first aid and triage capacities, mental health support for health and emergency workers, clean drinking water and/or bottled water, storage and distribution of food, operational restrooms, shelter capacities for women and children (on-site or off-site), hygiene supplies/services, and personal protective equipment for safe cleanup. These postdisaster programs and services can usually be phased out over time, with continuous support to the most vulnerable community members, as needed.

Serve as an information hub. While the center cannot provide all recovery services, it can continue to be a hub for people to receive quality information and referrals to needed services and supplies. Projected community needs and services after a disaster often include resources for rebuilding efforts, where to obtain basic supplies (food, water, sanitary products for women), health services, where to obtain financial support, and support to apply for NGO or government sponsored aid, among others.

Design for Resilience Center Communications

Communications are an essential part of community preparation, response, and short- and long-term recovery. In addition to serving as a central hub for community information and services, as well as providing ongoing educational materials and resources for the community to build and strengthen their knowledge and skills for emergency preparedness and response, the center will develop resources and materials to build awareness and engagement in the center through a robust communications strategy. This will include, but is not limited to, written materials designed for community consumption, materials for partners and collaborators to be aware of and engage with the center, regular updates on the center's programming and resources via a website, a newsletter, and interactive space within the center itself where community members can go to receive key information. The center will also make use of visual tools including photos and videos, the integration of key information and resources via mobile technology (e.g., apps and alerts), and audio pieces via the radio and/or digital recordings.

Additional Resilience Center Infrastructure and Programmatic Ideas
Programs and activities at the resilience center and in the surrounding community can be explored and developed based on need, funding, and stakeholder interest. This list can be adjusted over time:

- Developing a microgrid, expanding throughout the community, and connecting to the grid
- Positioning the center as the hub or model for regional and national expansion
- Public green areas/spaces
- Community gardens, sustainable food source, and distribution hub
- Health and wellness center (e.g., yoga classes, mental health services, etc.)
- Multigenerational training and capacity building center
- Child care and early childhood development programs
- 24-7 community center and resource
- Decentralized and community emergency operations (planning and meeting center for emergency services)
- Data hub to serve as a central location for detailed information at the community level for preparation and response, including individual, household, and block level information, weather data, services and referrals for everyday resilience as well as during/after emergencies
- Women's support and safety services (health, education, training, shelter, etc.)
- Essential services/resources (water, energy, sanitation, shelter, nutrition, and other basic services)

Offer community space. During the recovery phase, there are often many NGOs and community organizations that help with rebuilding. The resilience center will provide space for these organizations to convene, both to bring people together as well as help to reduce duplication of efforts.

Convene and process post-disaster analysis. One of the most essential steps toward resilience following a disaster is to analyze what happened. Participatory discussions of what went well and what was unsuccessful before, during, and after the disaster, and how things could be done better in the future, are critical for future planning and response. The resilience center will take the lead on convening people from the local community, COE, and other stakeholders to conduct a postdisaster analysis and put forward lessons learned and recommendations on how the response could be improved, both at the center and larger community levels.

Design for Resilience Center Management and Operations

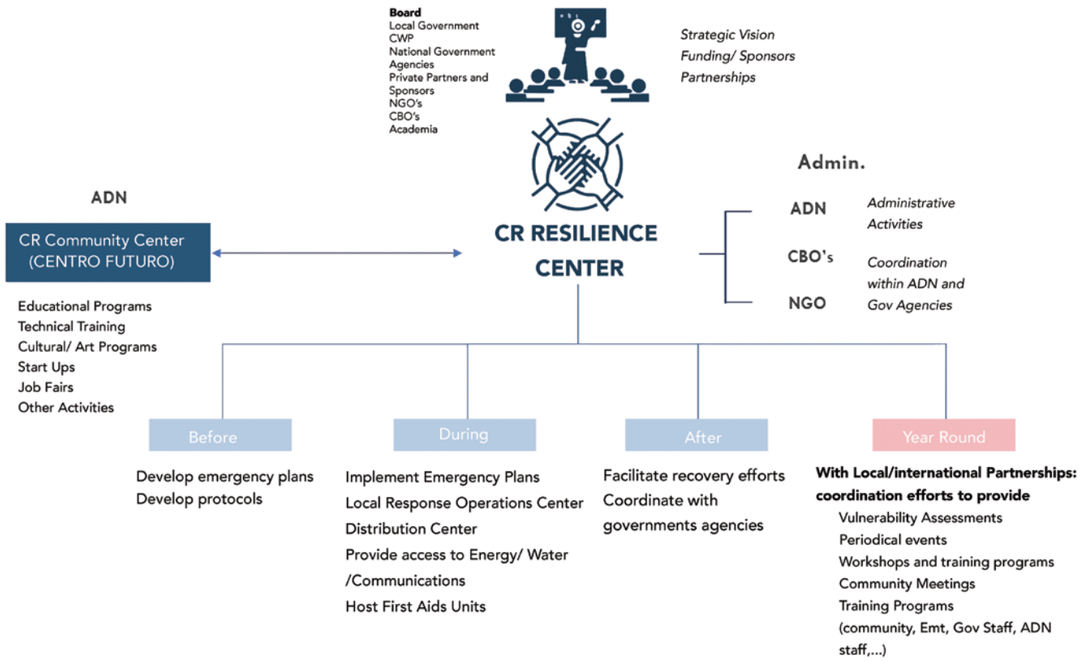
This design of the resilience center, including its governance, maintenance, management, and funding structure, is a proposal to be considered by ADN.

Resilience Center Management Plan

While the final management structure of the center will be determined in the future, during the implementation phase, and also informed by funding, the design of the management structure reflects the collaborative nature of the center's development, leveraging the diverse expertise of community, institutional, and agency partners (Figure 28).

- ***Initial management structure:*** The site of the Cristo Rey resilience center is a municipal building, owned by ADN. ADN has finalized construction and will lead the management and operations for a hybrid municipal office and community space that offers capacity building programs for local youth. The resilience center programming, operations, and management structure will be integrated into the planned municipal operations for the center. As the center begins operations, the resilience center staff, programming, and services will be managed by a partner entity, ideally a Dominican nonprofit organization with expertise in community resilience. This organization would manage the center with funds outside of the municipality but work in close collaboration with ADN to align and build the center over the course of several years. As capacity, structures, and resources are established within ADN, the management and operations of the resilience center programming could eventually transition fully over to ADN, or the management could remain in the form of a public-private partnership.
- ***Long-term management structure:*** As the center takes shape, long-term management and operations could be overseen by what would eventually be a new municipal office of *Climate Change and Risk Management Unit*, bringing together environmental management and emergency response departments. This newly created unit would take responsibility for overall community resilience programming, long-term resilience and adaptation planning, day-to-day management and operations of the resilience center staff, programming, and services, all with an eye toward sustainability. This option allows all resources and management of the center's programming to be managed by a singular, municipal entity.

Figure 28: Illustrative implementation and management plan for the Cristo Rey community resilience center



Proposed Staffing

The center will require staff with a strong vision, exceptional organizational skills, intimate knowledge of the Cristo Rey community, and a passion for community resilience, environmental health, and disaster response. Ideally, there will be a minimum of three full time staff, preferably from Cristo Rey, one or more youth interns from the community, and an advisory board (see below) made up of community members, stakeholders, and collaborating organizations. These staff members will be instrumental in establishing partnerships, engaging with the community, and growing the center.

Community Advisory Structures

The advisory board would provide overall strategic guidance, facilitate connections with key resources and organizations, and assist in the dissemination center's programs and impacts more broadly. Advisory board members will represent stakeholders at different levels and could include:

- Community members: Juntas de Vecinos, leaders
- Academic partners: Columbia University, INTEC, UNIBE
- Government and public entities: Dominican Republic executive branch, ADN, COE, Defensa Civil, fire department, Instituto Nacional de Formación Técnico Profesional
- Nongovernmental organizations: Fundación Plenitud, Arcolris, Profamilia, Fundación Cruz Jiminián, and Hospital General de la Plaza de la Salud
- International donors and organizations: USAID, Inter-American Development Bank
- Private sector: American Chamber of Commerce of the Dominican Republic, Banco BHD-Leon, INICIA and/or others representing private sector partners to the resilience center

The community advisory committee would inform the community outreach and engagement plan, as well as overall programming, day-to-day operations, and evaluation of the center. Committee members should be inclusive and diverse, including, for example, community leaders, youth, and women.

Design for Resilience Center Monitoring, Evaluation, and Learning System

Measuring the resilience center's outputs, outcomes, and impact, including its successes and limitations, will be critical. This effort can be fundamental in distilling lessons from the work and inform adjustments to its processes as well as serve to inform other communities in efforts to replicate and scale such centers.

The monitoring and evaluation of the center will assess how effective the center has been at increasing resilience. The center is expected to contribute to increasing the neighbors' resilience as a physical space and in terms of the programming it will host. An impact and outcome evaluation of the center should assess the evolution of the resilience center components, the alignment of the components with changing climates, contexts, and hyperlocal community needs and assets. This assessment should include identifying how much the center contributes to a healthy, cohesive, connected community through the programming on social resilience, education, wellness, and community connectivity.

Information about the progress of the programming and related activities through monitoring outputs, will be used locally to guide improvements in program activities (Table 9). Columbia University and the local university partners (UNIBE, INTEC, etc.), are well placed to design and implement such a system, which would include building the capacity of local community leaders and partners to collect, interpret, and use data for decision-making and support dissemination at community, national, regional, and international levels, including via publications.

Table 9: Illustrative monitoring, evaluation, and learning outputs and outcomes

OUTPUTS AND OUTCOMES LINKED TO EVERYDAY RESILIENCE-BUILDING ACTIVITIES	OUTPUTS AND OUTCOMES LINKED TO ACTIVITIES DURING DISASTERS AND DISRUPTIONS	OUTPUTS AND OUTCOMES LINKED TO POSTDISASTER AND RECOVERY ACTIVITIES
Outcome 1: **Neighborhood members improve knowledge and skills, social cohesion, and disaster preparedness.**	Outcome 2: **Neighbors and others use a central point of access to information and basic services.**	Outcome 3: **Vulnerable families receive support, and neighbors recover and rebuild.**
Outputs: ■ There is an increased perception of safety of the users of the space and hub. ■ Diverse neighbors and members of neighborhood organizations participate in trainings to improve baseline health knowledge, skills, and disaster preparedness. ■ An anchor institution will support innovative community mental health approaches. ■ Neighbors receive social services. ■ Neighbors receive support for participatory research. ■ Lessons from the monitoring system are incorporated to fine-tune service delivery.	Outputs: ■ Neighbors have one point of access to information. ■ Neighbors have access to affordable and quality internet and phone services. ■ Neighbors are aware of key information from local authorities. ■ Neighbors will receive access to basic services—first aid, food, hygiene supplies, clean water, shelter capacity, restrooms, and showers. ■ There is space for COE satellite operations in the community. ■ Support is available for first responders/emergency workers. ■ Trained, volunteer community crisis response team is available. ■ Lessons from the monitoring system are incorporated to fine-tune service delivery.	Outputs: ■ Neighbors in need can continue to use basic services provided during the disaster (first aid, clean food distribution, clean water, restrooms, etc.). ■ Neighbors receive information and referrals to needed services and supplies (resources for rebuilding, support to apply for aid, etc.). ■ There is an increased efficiency in service delivery—NGOs and other service providers use the hub to deliver information and services. ■ Participatory postdisaster analysis with the community conducted. ■ Lessons from the monitoring system are incorporated to fine-tune service delivery.

The evaluation team will disseminate findings and lessons to the community and share for further replication of the model for potential citywide, national, and/or regional expansion.

When implementation of the center is well underway, a "playbook" could be developed that incorporates lessons learned and describes key steps on how to set up and run a resilience center.

Conclusions

UNIBE students conducting risk mapping

Community resilience centers, including the proposed design for a center in Cristo Rey, offer a promising, decentralized model of urban disaster preparedness and response. They can provide opportunities to build the community's capacity to prepare for, and respond to, disasters and crises, recognizing that it is often the local community and its institutions that are the first responders in the event of a disaster. Supporting local-level resilience and response can not only save the lives of community members but also help to achieve national goals on climate resilience in the Dominican Republic and across the region as a whole.

Community and stakeholder engagement and consultation have been essential to the team's work to design the blueprint for a sustainable community resilience center in Cristo Rey. The community of Cristo Rey and the city of Santo Domingo have a wealth of resources, organizations, and individuals committed to building and strengthening resilience. The processes undertaken to develop a design for the center and the proposed programming and operations can and should support increased awareness, coordination, and integration of available resources and efforts, as well as provide the opportunity to recognize where there are essential resource gaps such as in service, communications, and funding. Continuing to support local coordination, education, and capacity building is essential to building long-term resilience and sustainability, as it is the institutions and leaders that are rooted in the community who are ultimately impacted by increased threats and who will be responsible for preparation, response, and rebuilding in the long term.

The role of the municipal government in resilience generally, and the community resilience center specifically, is critical. Strengthening the capacity and ability of the municipality to support local resilience is also key. This includes ensuring that policies, programs, and resources designed at the central level support the municipality to prepare and build long-term resilience, thereby ensuring cities and communities become more resilient and better respond before, during, and after natural and other disasters.

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Appendices

Appendix I: Glossary[34]

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.

Climate change: A change in state of the climate or water cycles that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change, in its article 1, defines climate change as a change of climate, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Climate justice: A concept that frames climate change as an ethical and political issue, rather than one solely environmental in nature. It recognizes the disproportionate impacts of climate change on people who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality. It also recognizes that climate impacts can exacerbate inequitable social conditions and allows for critical reflections about solutions that address a broad range of social, racial, and environmental injustices.

Community resilience: Capacity of the social system and institutions to cope with adversity and to subsequently reorganize themselves to improve their functions, structure, and identity. It identifies the way in which human groups respond to adversities that affect them collectively at the same time and in similar ways, such as earthquakes, floods, droughts, attacks, political repression, and others, while showing how the community's existing resources are developed and strengthened (La Perspectiva Comunitaria de la Resiliencia, Juan de Dios Uriarte Arciniega).

Community resilience centers: Community resilience centers are disaster-resistant infrastructures that facilitate access to services on a temporary basis during emergencies. These spaces, through partnerships with institutions and the integration of community organizations, support the development of information and knowledge about hazards to progressively increase community resilience. Resilience centers can, in some cases, be temporary shelters for people and provide basic services without interruption during emergencies, but their greatest added value is the joint construction with the community of knowledge and capacities for action. Adapted from the Community Resilience Centers Program, California Strategic Growth Council.

Disaster: A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic, and environmental losses and impacts.

Disaster risk management: Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of current and future disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, prevention and protection, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development.

Distributed systems: The distributed model sees infrastructure and critical service systems (for water, food, energy, etc.) positioned close to resources and points of demand. Individual systems may operate as separate, adaptive units but are also linked within ever-wider networks of exchange—at the local, regional, or global level. Distributed systems involve a decentralized division of physical components, ownership, and responsibility, overseeing a more cyclic movement of resources. The distributed systems model's four defining characteristics are: *localized*—systems are designed for and positioned as close as feasible to points of resource supply and demand, reflecting the scale and context of local needs, conditions, and resources; *networked*—systems are linked and have the capacity to exchange, allowing information and resources to be transferred; *modular*—critical resources or services are generated by the collective capacity of multiple systems that can operate autonomously but also in connection with each other (via distribution networks); and *open*—ownership and responsibility for the operation of systems is (more) democratic (distributed systems: a design model for sustainable and resilient infrastructure).

Informal settlement: These are residential areas in which inhabitants do not have tenure rights over their land or home, ranging from squatting to informal renting; these neighborhoods often lack basic services and urban infrastructure. Housing may not comply with building and planning regulations and is often geographically and environmentally located in hazardous areas (World Bank and UN-Habitat 2002).

Infrastructure resilience: The timely and efficient prevention, absorption, recovery, adaptation, and transformation of national infrastructure's essential structure and functions, which have been exposed to current and potential future hazards (Principles for Resilient Infrastructure, United Nations Office for Disaster Risk Reduction).

Marginalization: The lack of participation in social benefits and resources, in the network of social decisions; their groups lack internal integration. The marginal man cannot overcome his condition by himself (Cortés 2002).

Mitigation: Planning and implementation of intervention measures aimed at reducing or decreasing risk.

Mitigation (of climate change): A human intervention to reduce the emission or enhance the sinks (any process, activity, or mechanism that removes a GHG or aerosol from the atmosphere) of greenhouse gasses.

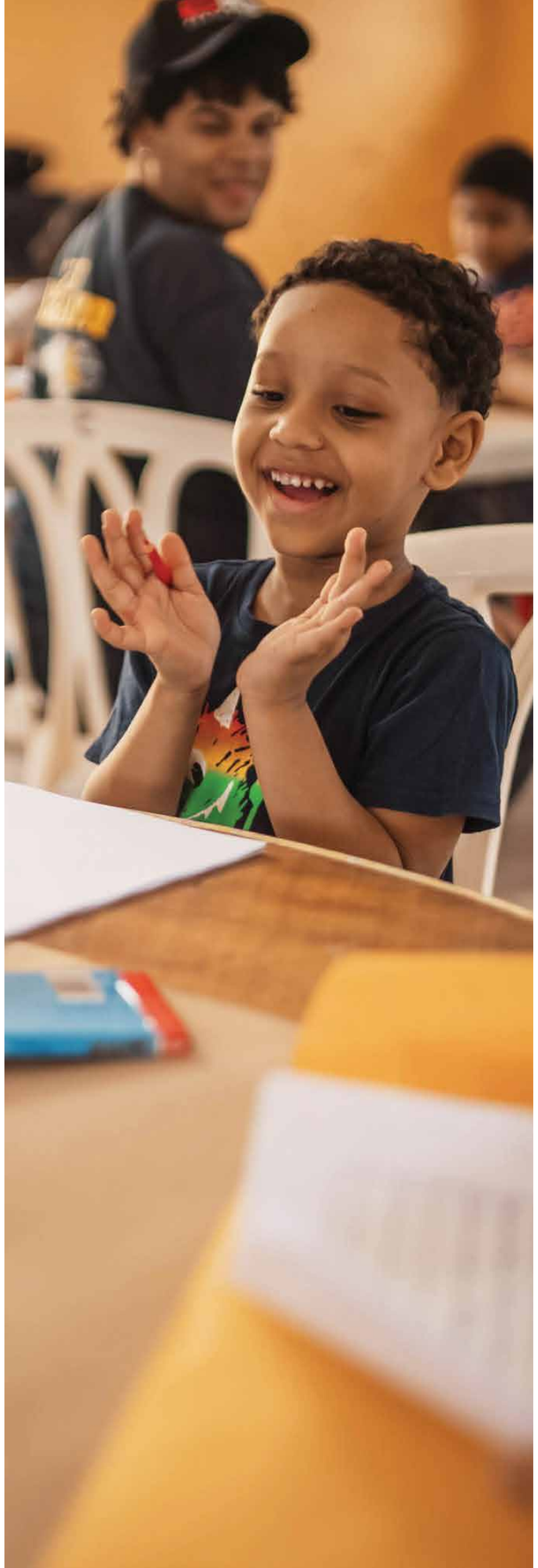
Mitigation measures: In climate policy, mitigation measures are technologies, processes, or practices that contribute to mitigation—for example, renewable energy technologies, waste minimization processes, and public transport commuting practices.

Policies (for climate change mitigation and adaptation): Strategies that enable actions to be undertaken to accelerate adaptation and mitigation. Policies include those developed by national and subnational public agencies and with the private sector. Policies for adaptation and mitigation often take the form of economic incentives, regulatory instruments, and decision-making and engagement processes.

Resilience: The capacity of interconnected social, economic, and ecological systems to cope with a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning, and/or transformation (Arctic Council 2016; IPCC AR6 WGIII Annex I Glossary).

Risk: The potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being; economic, social, and cultural assets and investments; infrastructure; services (including ecosystem services); and ecosystems and species.

Urban resilience: Capacity of urban systems to recover quickly from any event caused by disturbing phenomena of natural or anthropogenic origin. Its purpose is to prevent an event from evolving into a disaster (UN-Habitat).



Appendix II: Summary of Health Indicators for the Dominican Republic

Health Indicators

As shown in Table 10, in general, residents in the Dominican Republic have a relatively long life expectancy, and infant mortality rates are equal to the world average (16 per 1,000 live births) and are on the decline. There are approximately 15 doctors and 4 licensed nurses per 10,000 individuals. According to the Institute for Health Metrics and Evaluation, approximately 52 percent of Dominicans have universal health coverage.[35]

Table 10:

		DOMINICAN REPUBLIC	NATIONAL DISTRICT	CRISTO REY
Key basic health indicators[36]	Life expectancy, 2019	**74.1**		-
	Infant mortality, 2019 (per 1,000 live births)	**16**	**10.7**	-
	Neonatal mortality, 2019 (per 1,000 live births)	**19.4**		-
	Maternal mortality, 2107 (per 100,000 live births)	**95**		-
	Under 5 mortality rate (per 1,000 children)	**26.5***		-
	Adult undernutrition	**8.3%****		-
	Stunting, children under 5	**7.1%****		-
	Wasting, children under 5	**2.4%****		-
	HIV/AIDS, 2019 (per 100,000 people)	**53.6**	**58.9**	-
	Doctors per 10,000 people	**15.1**	**48.9**	-
	Licensed nurses per 10,000 people	**4.1**	**13.5**	-
	# of hospitals	**1819**	**167**	-
	Hospital beds per 1,000 people	**1.4**		-
	# of primary health care centers		**153**	-

Sources: World Bank, unless otherwise indicated

*Dominican Republic Demographics, 2020

**FAO, Dominican Republic Nutrition Profile

Chronic diseases, disability, and causes of mortality: According to the Institute for Health Metrics and Evaluation,[37] neonatal disorders are ranked as the leading cause of death and disability combined. Following neonatal disorders, the leading risk factors for death and disability combined are malnutrition, high blood pressure, and high body mass index. Overall, Dominicans suffer resultantly from high rates of heart attacks, strokes, and diabetes (Table 11). Neonatal and noncommunicable diseases (NCDs) are both highly climate sensitive.

Table 11:

		DOMINICAN REPUBLIC	COSTA RICA	MEXICO
Chronic disease mortality rates for the Dominican Republic and similar LAC countries; chronic disease mortality rates (per 100,000) age standardized[38]	Heart attack	**144.4**	**40.7**	**92.4**
	Stroke	**76.9**	**24.4**	**32.1**
	Diabetes	**34**	**26.3**	**94.5**
	Cirrhosis	**26.5**	**6.2**	**24.6**
	COPD	**18.1**	**21.4**	**30.8**
	All cause mortality (per 1,000 people)	**7**	**3.9**	**5.8**
	NCD mortality	**508.3**	**310.2**	**465.7**

Mental health: The mental health burdens associated with climate change include well-described escalations in traumatic disorders, depression, suicide, substance use, and violence caused by extreme weather events or acute environmental changes. Such burdens will further increase as these changes become long lasting and cause disruptions to food and water security, displacement, and economic vulnerability. Within the Dominican Republic, approximately 20 percent of the general population suffer from mental health disorders, drug use is reported to be low, and men are more likely than women to consume alcohol.

The current burden of mental disorders within the National District and Cristo Rey in particular is unknown. Additionally, the authors suspect there is significant underreporting and under diagnosis due to underlying stigma, a lack of community recognition, and a low number of mental health providers, especially outside urban centers. As of the most recent analysis by the WHO, in the Dominican Republic there are approximately 2.2 psychiatrists (per 100,000 people), 0.3 social workers working in mental health (per 100,000 people), and 7.5 psychologists (per 100,000 people) working in the mental health sector.[39]

Table 12:

		DOMINICAN REPUBLIC	NATIONAL DISTRICT	CRISTO REY
Rates of mental illness, suicide, and substance abuse in the Dominican Republic, 2018 data[40]	% of population that suffers from mental disorders	**20%**	-	-
	% suffering from depression	**4.7%**	-	-
	% suffering from anxiety	**5.7%**	-	-
	Drug use, ages 15–49	**1.4%**	-	-
	% of DALYS lost due to mental disorders, ages 5–14	**10%**	-	-
	# of suicides, total	**578**	-	-
	# of suicides, men	**480**	-	-
	# of suicides, women	**98**	-	-
	Alcohol consumption, men	**21%**	-	-
	Alcohol consumption, women	**9.1%**	-	-

Women's health: As noted by the United Nations Framework Convention on Climate Change and the American College of Obstetricians and Gynecologists, women—especially those in poverty—experience a greater burden of health-related impacts from climate change. This is especially true for health impacts, making climate change a risk multiplier for gender-based health disparities. Due to physiologic, cultural, and socioeconomic factors, women are at an elevated risk of infectious diseases, malnutrition, sexual violence, mental health disorders, lack of reproductive control, negative obstetric outcomes, and death compared to men. In the community of Cristo Rey, women are likely at an elevated risk of multiple climate-driven exposures that pose immediate and long-term risks to their health. See Table 13 for statistics specifically related to women.

Table 13:

		DOMINICAN REPUBLIC	NATIONAL DISTRICT	CRISTO REY
Statistics with a focus on women[41]	Adolescents between 16 and 19 who have been mothers	89 per 1,000	14.5%*	32%*
	% of pregnant adolescents who reach university			4.7%*
	Nonsingle women who have experienced domestic violence	33%**		
	Women who suffer domestic violence seeking medical attention	19%**		
	Contraceptive use in nonsingle women	69.6%***		
	Maternal mortality, 2019 (per 100,000 live births)	90.2***	70.6***	

*Ayudamiento del Distrito Nacional—Demographic data

** Plan Nacional de Salud Mental, República Dominicana, 2019–2022

***PAHO, “Tablero de los Indicadores Básicos”

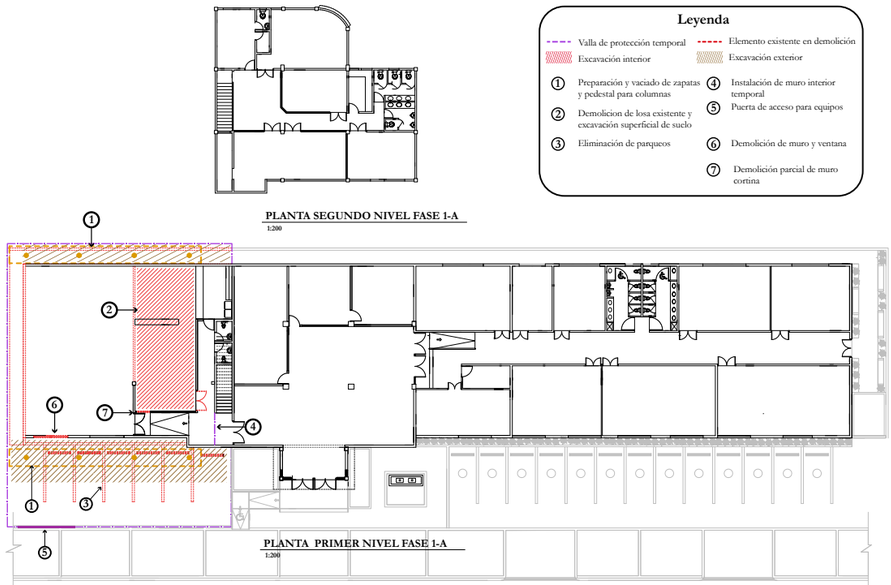
Community consultation workshop

Appendix III:
Proposed Staging for Infrastructure Upgrades and Retrofitting

Stage 1

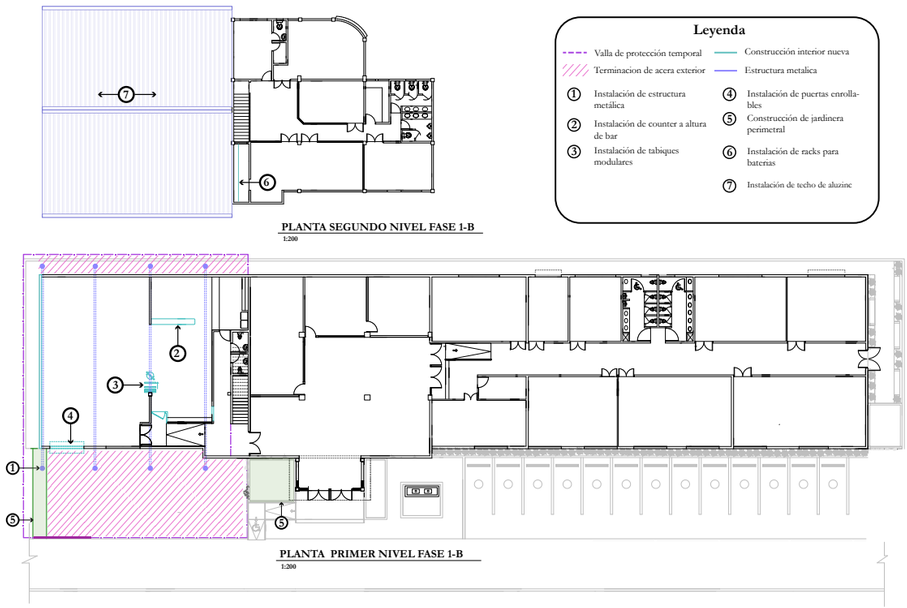
1A: Multiuse Space and Cafeteria Renovation

Site logistics, foundation and excavation work, partial demolition of interior and exterior walls



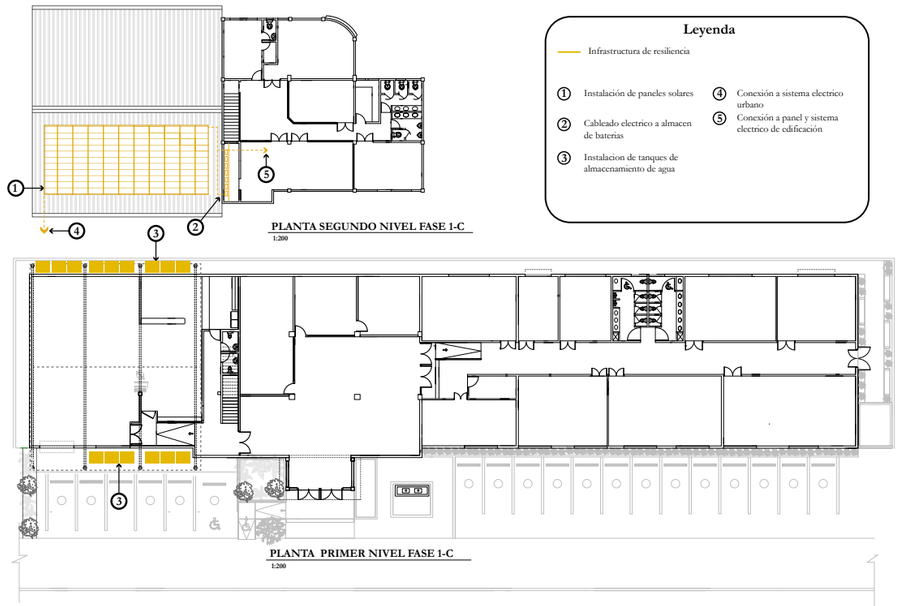
1B: Multiuse Space and Cafeteria Renovation

Installation of the metallic roof structure, windows, doors, and foldable walls; construction of permeable parking area, sidewalk, and planters



1C: Multiuse Space and Cafeteria Renovation

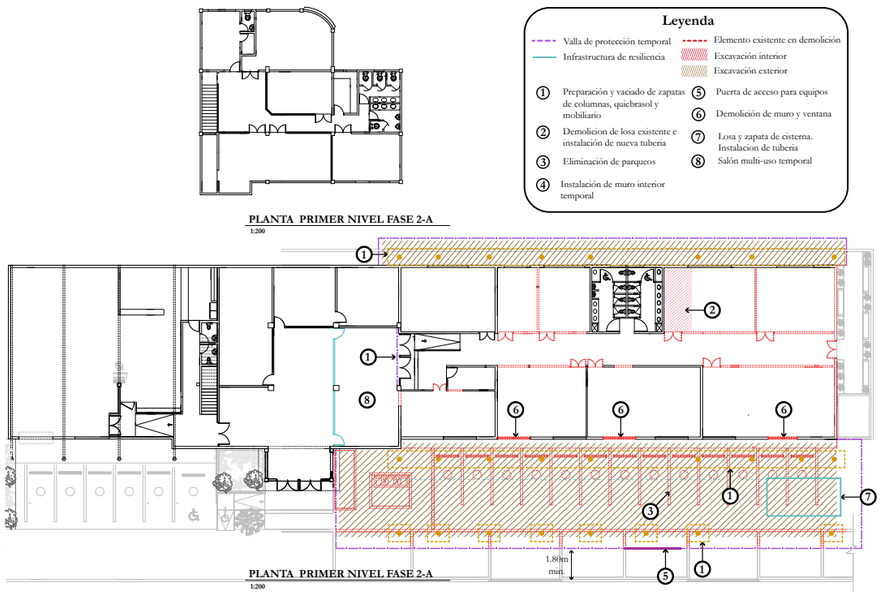
Installation of the solar panels, water-collection system; electrical wiring of the panels/battery storage



Stage 2

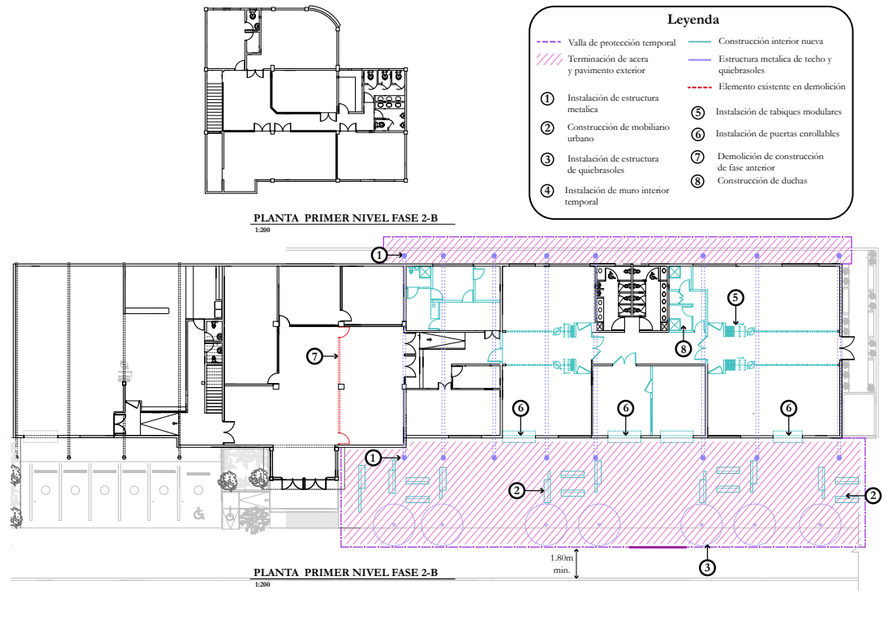
2A: Resilience Center Building Renovation

Site logistics, foundation and excavation work, partial demolition of interior and exterior walls, temporary multiuse space in the lobby area



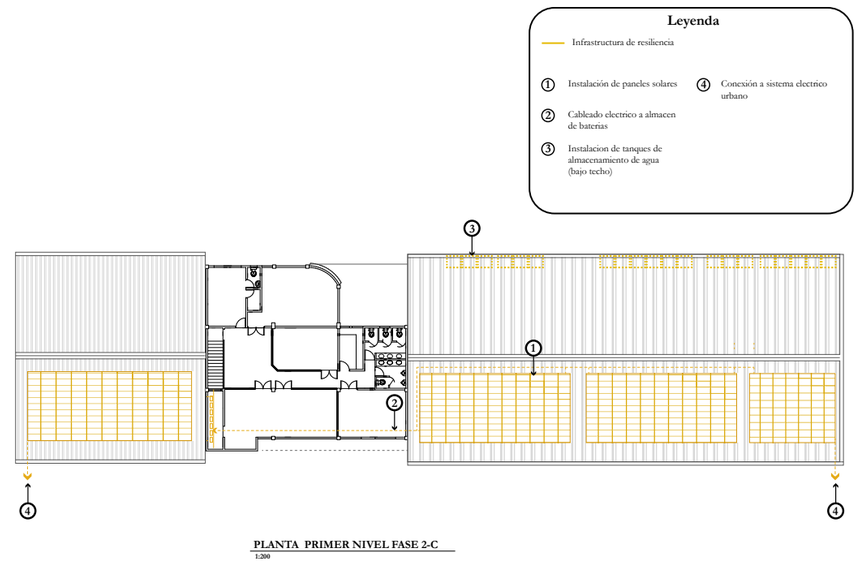
2B: Resilience Center Building Renovation

Installation of the metallic roof structure, windows, doors, foldable walls, showers, laundry room; construction of permeable public space and urban furniture, sidewalk, and planters



2C: Resilience Center Building Renovation

Installation of the solar panels, water-collection system; electrical wiring of the panels/battery storage



UNIBE students conducting vulnerability survey

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