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Climate Change Adaptation Plan for the Land Use Plan in the National District



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ABREVIATURAS Y ACRONIMOS

ADN. National District City Hall
AP. Protected areas
CAASD. Santo Domingo Aqueduct and Sewer Corporation
CODIA. Dominican College of Engineering
CP. Development Council of National District
CPPMR. Provincial Committee for Prevention and Mitigation of Risks
CRIO. River Commission
DDCADN. Community Development Department ADN
DGODT. Directorate General of Territorial Planning
DN: National District
ECORED. National Network of Business Support to Environmental Protection
EDESUR. Distributor of Electricity to the South
GC. Central Government
ICN. National Cartographic Institute,
INAPA. National Potable Water and Sewerage Institute
INDHRI. National Institute of Hydraulic Resources
IP. Public institutions
JBN. National Botanical Garden
MIC. Ministry of Culture
MINERD. Ministry of Education
MISPAS. Ministry of Health and Social Assistance
MITUR. Ministry of Tourism
MMA. Ministry of the Environment
NUZ. Non-urbanizable zones
P. Programs and projects
PD. Development Plan
POSC. Population and civil society organizations
POT. Land Use Plan
QV. Quisqueya Verde
R. Regulations
SIND. Industrial Sector
SP. Private sector
T. Time frame: Short (C) medium (M) and Long Term (L).
UNIV. Universities
Z. Zoning

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I. INTRODUCTION

The National District governs the economic and political life of the Dominican Republic, serves as administrative headquarters and is the most important urban, industrial and commercial center which concentrate most of the investments, services and economic, human and technical resources. But in turn, the territory is particularly vulnerable to various climatic threats, current and future, which will continue to have substantial impacts on the resources, services and sectors (environment and green spaces, land use planning, solid waste management, wastewater and stormwater, water supply, electricity, economic strengthening, urban mobility, culture, security and participatory governance) of the city. Therefore, it is essential to manage climate risks in order to achieve development objectives, and for this the present plan draws up strategies to improve resilience to climate change.

Climate change is increasingly recognized as a major global development challenge. Increasing temperature, changes in rainfall seasonality and amount, extreme weather events, and rising sea levels are already having an impact on sectors and key development services, and vulnerability is expected to continue to increase. The Dominican Republic's Third National Communication on Climate Change (TNCCC) indicates that by the year 2060, annual average rainfall may be reduced by as much as 17%, dry seasons will be more intense, and increases in extreme rainfall event intensity and frequency are likely to occur even outside of the rainy season. Likewise, climate models project a general increase in average annual temperatures of between 1°C to 3°C by mid-century. Sea level is projected to increase by as much as 5 mm per year over the next 100 years, which will have serious negative impacts on coastal resources and livelihoods (IPCC, 2017). These changes in climate conditions will result in impacts across resources, services, and sectors. Thus, it is increasingly a matter of importance to take into consideration these changes in strategic planning and investment, in order to adapt to a changing climate.

Adaptation is the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities (IPCC, 2017). Climate adaptation enhances the National District resilience by amplifying its capability to anticipate, prepare for, respond to, and recover from significant climate stressors with minimum damage. Adaptation planning can build a community's resilience through the development and implementation of a portfolio of complementary strategies and measures that will help it address vulnerabilities and risks. Once a community has identified primary vulnerabilities and risks, the adaptation planning process includes identifying adaptation measures; evaluating adaptation measures; building an adaptation measure portfolio; and monitoring, evaluating, and adjusting the plan.

To address these risks, this Adaptation Plan takes a portfolio approach that includes a variety of strategies and near- and longer-term adaptation measures identified and validated by the City Hall. In the framework of planning for climate adaptation, this Adaptation Plan offers key adaptation measures which should be considered within the National District Land Use Plan (POT) or its Development Plan (PD). There are a number of pathways the National District can follow to implement the adaptation measures, including through the land use plan, the development plan, and the annual operating budget (Figure 1). National District can incorporate land use adaptation measures into the territorial perspective phase of its municipal land use planning process. The National District can also incorporate adaptation measures into its municipal plan as a program or project or through the municipal development plan's associated annual operating budget. This Adaptation Plan outlines National District key climate stressors and risks across multiple sectors, identifies a portfolio of actionable adaptation measures, and provides next steps to implement the priority adaptation measures. This Adaptation Plan was developed by the City Council

with the collaboration of the International Cities and Municipalities Management Association (ICMA) and ICF International.



Figure 1. Pathway for implementation of an adaptation portfolio.

2. MAIN CLIMATIC IMPACTS AND VULNERABILITIES

According to the climate vulnerability assessment of the National District (ICMA/ICF/FEDOMU/ADN, 2016) the population and the urban infrastructure and of all sectors and key services for development are vulnerable to various climatic threats and stressors (Figure 2). We refer to the increase in temperature, greater intensity of extreme weather events with intense rainfall causing floods and landslides, changes in the pattern of rainfall (reduction of rains or its intensification out of season) and rise in sea level, with greater waves of storm, and coastal floods. The differences between circumscriptions in terms of their proximity to the Caribbean Sea and the Ozama and Isabela rivers (and their tributaries), infrastructure conditions, population density or poverty (Table 1), define different degrees of susceptibility to climate threats, so that climate impacts can cause a variety of impacts (Table 2) according to their vulnerability, i.e. their degree of exposure and sensitivity, the level of development of their adaptive capacity.

Table 1. Summary of data of the circumscription of the National District that become indicators of vulnerability. Source: (ICMA/ICF/FEDOMU/ADN, 2016).

Parameters	Circumscription		
	1	2	3
Population	309,612	293,695	359,740
Surface (km ²)	39.36	39.35	13.29
Density (inhabitants/km ²)	7,866	7,463	27,069
Poor households (%)	7.6	27.5	43.7
Poor people (%)	8,04	28,73	45,42
Ozama riverbanks length (km)	1.9	0.0	5.4
Isabela riverbanks length (km)	0.0	11.5	2.2
Other water courses (km)	0.0	22.6	31.6
Coastline (km)	16.5	0.0	0.0

2.1. Increase in temperature and heat waves

The National District is located in an environment with an average annual temperature of 27.1°C that has been increasing by 0.45°C since 1960 at an average rate of ~ 0.2°C per decade, with several reports of heat waves. Between 1977 and 2015, 22 heat waves were recorded with a duration of 3 to 13 days, from April to October, with the highest incidence in the month of August. Between May and October 1980, the longest heat wave in the country was observed in the National District. In the last fifteen years there has been an almost permanent presence of these events in Santo Domingo (CCNY, 2016). The population and urban infrastructure of all key sectors and services are vulnerable to the increase in temperature, possibly with territorial differences related to an unequal distribution of this parameter the

circumscriptions. High temperatures have a particular impact on public health due to the increase in thermal discomfort and the greater spread of diseases.

Table 2. Matrix of potential impacts of climate change on the sectors and services that are fundamental for the development objectives of the National District.

Sectors & services	Temperature increase	Sea level rise	Change in rainfall pattern	Extreme events
Green areas, parks and urban gardens	Thermal stress in the vegetation. Change of plant species. Increased need for maintenance and irrigation	Flooding of coastal green areas. Soil salinization in coastal parks	Vegetation under water deficit. Change to species with lower water demand. More maintenance. Alteration of the urban landscape.	Physical damage to vegetation and recreation infrastructures. Higher need for maintenance.
Solid waste management	Increase of gases and odors. Need for more frequent collection and more rigorous landfill management. Alteration of decomposition rates. Heating of collection vehicles. Increased pests. Increased risk of infectious diseases.	Reduction of collection routes	Water limitations for recycling processes	Damage and debris along the collection routes. Greater dispersion of waste. Physical impacts to infrastructure
Sewage water	Degradation of equipment and infrastructures of the treatment plant. Interference with treatment due to oxygen reduction, increase of algae and microorganisms, and generation of gases and odors. Thermal stress to plant workers.	Floods and damage of infrastructure equipment of the treatment plant near the coast	Reduction of wastewater dilution in treatment plants and dumping sites in rivers and coasts	Floods and damage to infrastructure and equipment in the treatment plant. Plants out of service due to interruption of electric service. Black water spills that pollute the environment and expose the population to pathogens
Storm drain	Thermal impact on infrastructure, equipment and pipes of the drainage system. Exceeding the working temperature range of the pipes	Damage to infrastructure and equipment of the drainage system near the coast.	Reduction of rainwater collected usable	Damage to infrastructure and equipment of the drainage system. Collapse of collection systems due to exceedance of their capacity of flows. Wastewater treatment plants out of service due to interruption of the electric service. "Disaster waste" that blocks the drain

Sectors & services	Temperature increase	Sea level rise	Change in rainfall pattern	Extreme events
Water services	Increased water demand Greater potential losses due to evaporation. Changes in water quality. Expansion of invasive aquatic species in water courses.	Advance of salt wedge and salinization of rivers. Saline intrusion in coastal aquifers.	Changes in water quality/availability. Drastic reduction of water in storage systems. Damage to storage and distribution systems due to flow reduction	Damage to treatment, storage and distribution infrastructures. Reduction of water quality. Interruptions in the operation of water treatment plants.
Electricity	Thermal expansion of electrical lines, reducing the amount of energy to be transmitted safely. Risks of distension of the laying and power cuts. Increase in demand for cooling	Drop in coastal electrical lines. Flooded generation, transmission and distribution sites	Exacerbation of the thermal impact. Higher maintenance and repair costs.	Fallen electric lines. Interruption of the energy service. Increase in maintenance and repair costs
Commerce and tourism	Possible reduction in the demand for major events and tourism.	Damage to roads and port infrastructure.	Possible floods. Possible reduction in the demand for major events and tourism.	Flooding of businesses and conference centers. Interruptions of essential electricity for business and industry.
Roads and transportation	Faster deterioration of the asphalt on the tracks. Increase in maintenance and construction costs.	Flooding and erosion of coastal roads. Damage to port infrastructure	Exacerbation of the thermal impact. Higher maintenance and repair costs.	Temporary flooding and higher costs of maintenance and repair of roads and ports. Closures for "disaster waste" and damage to infrastructure
Cultural heritage	Damage to physical heritage. Cracking and cracking of construction materials. Accelerated deterioration of the sites due to thermal stress and biochemical activity. Reduced time for outdoor cultural activities	Erosion and flooding of sites in low coastal or riparian zones.	Lack of water for the use and maintenance activities of heritage sites Damage to heritage. Erosion and corrosion of structures	Flooding of low heritage sites. Structural damage Erosion and corrosion of metal structures. Organic growths and physical changes in materials, cracking and rupture by moisture in porous materials
Public health	Increases heat stress and increases the spread of pathogens.	Damage to public health infrastructure in the coastal zone	Lack of water for health center activities. Greater thermal discomfort	Injuries and loss of human life. Increased demand for emergency response services. Damage to public health infrastructure
Protection and security	Increased demand for emergency response services due to thermal stress.	Flooding of essential coastal roads for emergency response.	Lack of water for protection and safety activities. Exacerbation of heat stress (thermal discomfort).	Flooding of key ways to respond to emergencies. Increased demand for emergency response services. Displacement of the population. Physical damage to emergency services goods and shelters.

Sectors & services	Temperature increase	Sea level rise	Change in rainfall pattern	Extreme events
Participatory governance	Climate impacts to livelihoods and service interruptions, increasing pressure on the City Council to better include the community in decision-making processes. Change in citizens' requests for public investment in participatory budget planning aimed at solving problems related to climate.			
Tax management	Reduction of outdoor activities that generate revenue for the City Council.			

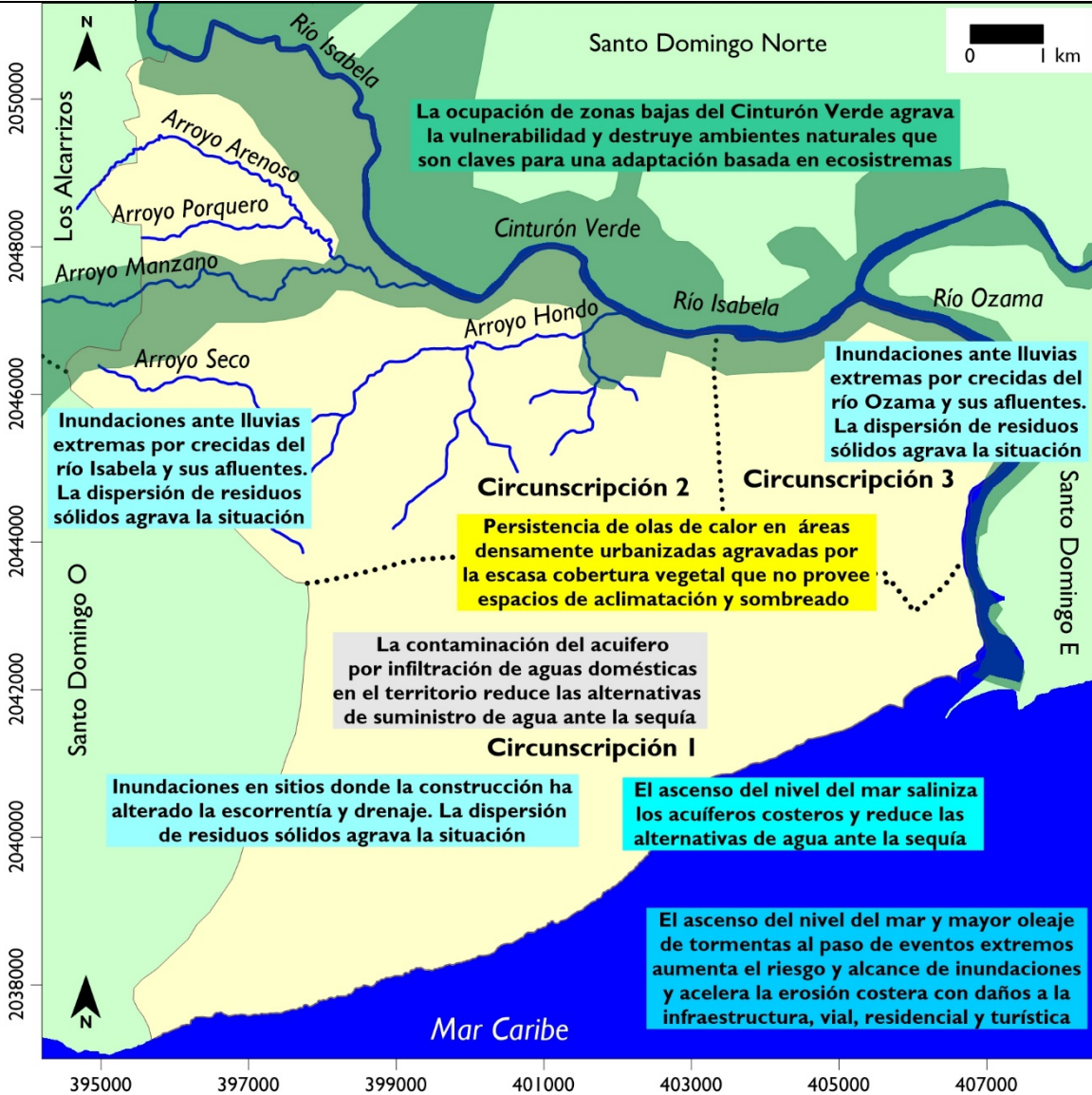


Figure 2. Threats and current and future climate impacts in the National District in relation to its hydrology.

Other sectors particularly affected by the increase in temperature are solid wastes, because high temperatures accelerate the physical-chemical processes associated with the transformation and decomposition of organic matter; the electrical system due to overheating in the transmission and distribution lines; and the loss of efficiency of generators; the supply of water due to the greater potential losses due to evaporation and changes in the quality of the water sources (algae blooms, concentration of pathogens and reduction of dissolved oxygen levels) or urban mobility due to the accelerated deterioration of the layer of asphalt due to prolonged heat and thermal expansion of the

roads. These situations may worsen in the future, since for low and high emission scenarios, respectively, the annual average temperature will increase to 2030 at 0.7°C and 0.8°C and at 2050 between 1.13 ° C to 1.56 ° C. Vulnerability is increased by non-climatic impacts such as low vegetation cover that does not favor spaces for acclimatization and shading; the contamination of water sources, which, under high temperature conditions, exacerbates health and environmental problems; to which are added the inadequacies of the services such as the dispersion of garbage or the deficiencies of works, designs and materials in the electrical system and traffic routes.

2.2. Extreme weather events with heavy rainfall and floods

The National District is located in the lower part of the Ozama River basin and the last 7.3 km of this water course borders the East before flowing into the Caribbean Sea. Its most important tributary, the Isabela River, flows for 13.7 km from the northern border of the National District. In Circumscription 2, at least ten streams flow from the Isabela River to the west and south forming a network of about 31.6 km. Circumscription 3 is not crossed by extensive watercourses, but more than 50 canyons flow from the West Bank of Ozama and the South Bank of Isabela, forming a system of micro-basins between the neighborhoods. The population and the urban infrastructure and of all the sectors and services in the area of influence of these water courses are vulnerable to the intense precipitations that provoke floods before the floods of the rivers (and their network of streams and gullies) by the accumulation of water in low areas naturally prone to flooding (areas of flooding) or where -product of uncontrolled urbanization- topography, runoff and drainage have been altered (Figure 3). Vulnerability is increased by non-climatic impacts such as unplanned constructions that reduce permeability and change the direction of runoff, and the dispersion of solid waste that obstructs drainage, making the flood problem more critical and widespread and generating environmental and sanitary problems.

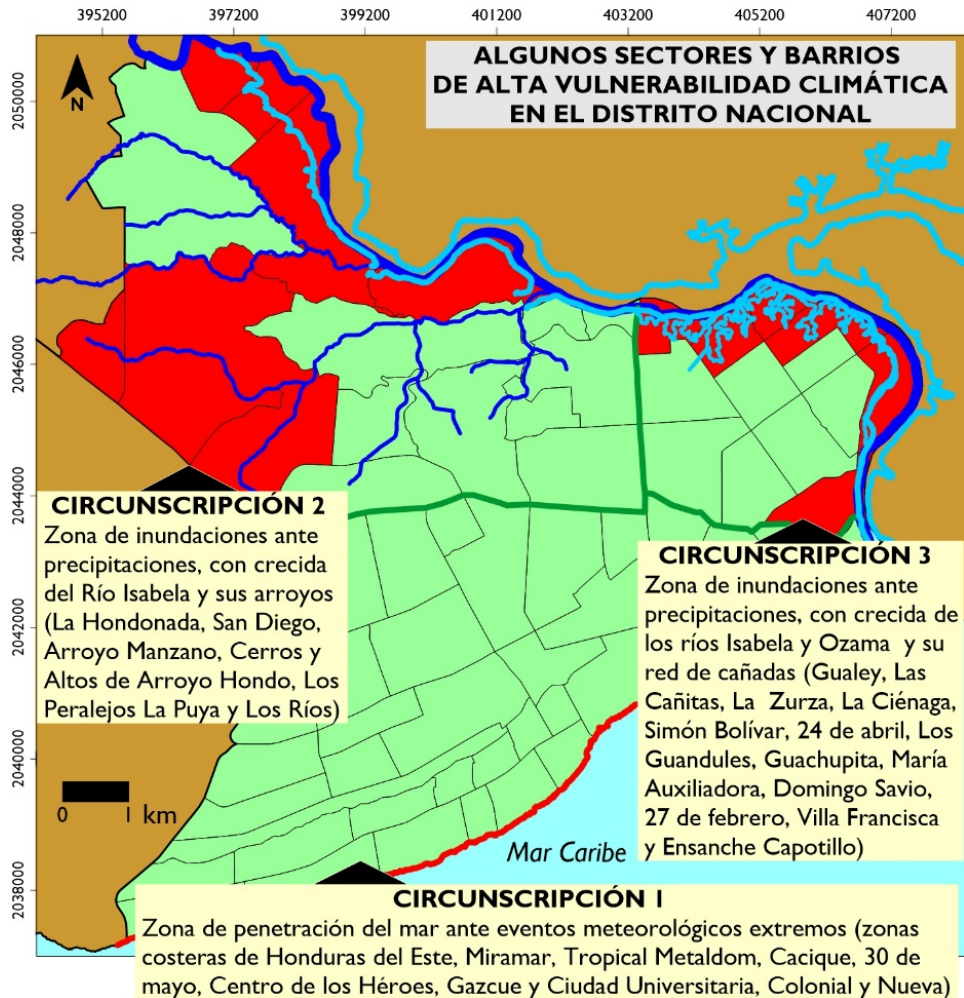


Figure 3. General map of areas vulnerable to flooding and sea penetration (in red) in the National District. The course of the Ozama and Isabela rivers and their main streams (dark blue line), the flood level for a return period of 100 years (light blue line) and the divisions between circumscriptions (green line), are indicated.

2.3. Changes in rainfall pattern

The water supply of the National District must meet a projected population by 2016 that will exceed one million inhabitants. The territory has been experiencing episodes of drought between 1966 to 2004 with an extreme drought in 2002 and entered a severe drought in 2014. All this caused a serious reduction of the water reserves of the Valdesia dam and of the flows (and therefore the production of water) of the Haina and Isabela rivers, causing a shift of priorities towards the water supply for the population to the detriment of the purposes of irrigation and energy. The population and urban infrastructure and all sectors and services are vulnerable to climate scenarios that indicate a reduction in average annual precipitation by 2030 (-6.73% to -3.24%), when the District's water supply system National should attend a projected population of 1,101,332 inhabitants. Vulnerability is increased by non-climatic impacts such as water leaks in the system (estimated at 60%) and deficiencies in drainage, wastewater and solid waste that leads to an uncontrolled influx of sediment and waste propagated in the sources of water supply, with risk to human health. The scenario of changes in rainfall also includes sudden extreme rains out of-season, as occurred at the end of 2016 where, although the dam once again reached its level of operation, there was a dramatic balance of flood, housing destruction and loss of life.

2.4. Sea level rise with greater storm surge and coastal flooding

The National District has about 16.5 km of coastline to the Caribbean Sea. The population and urban infrastructure and all sectors and services near the coastal zone (eastern Honduras neighborhoods, Miramar, Tropical METALDOM, Cacique, May 30, Center for Heroes, Gazcue, Ciudad Nueva, Ciudad Universitaria and Ciudad Colonial) are vulnerable to the entry or passage through the Caribbean Sea of extreme weather events with their impacts of storm surges that cause sea penetration and coastal flooding. These floods and their negative consequences may be greater in the future under the climatic scenarios that indicate more intense extreme weather events with larger storm waves due to the rise in sea level. Projections of sea level rise between 0.20 to 0.58 m to 2050 may cause the sea to cover part of the coast (depending on the slopes) and, in combination with the greater swells of storms, the risk of coastal flooding would increase. The proximity to the coast (less than 60 m) of a large part of the road infrastructure, residential or tourist, exacerbates the current vulnerability and in the future.

3. STRATEGIES AND ADAPTATION MEASURES

To implement the present adaptation measures and provide an organizational and methodological framework that allows the City Council of the National District to incorporate new measures in the future, this plan is based on seven interrelated adaptation strategies that have already been implemented in the remaining municipalities. These strategies address the situations of vulnerability of the territory, considering its three components: exposure, sensitivity and adaptive capacity (Table 3) considering changing climatic scenarios. Strategy 1 addresses a fundamental problem of the National District: exposure to threats, and focuses on reducing vulnerability by regulating the use of vulnerable soil. Strategy 2 assumes that vulnerable land is already occupied in the National District and is responsible for reducing vulnerability by acting more on sensitivity, although resettlement measures directly affect exposure. Strategies 3 and 4 focus adaptation actions basically towards the reduction of sensitivity, although they may have some impact on the increase of adaptive capacity, in which strategies 5, 6 and 7 are definitely focused. Considering land use planning, the measures of Strategy 1 are expressed mainly through the zoning of land uses and regulations, while in the rest of the measures the plans, programs and projects proposed for the POT or the PMD may be more relevant (Appendix 1).

Table 3. Adaptation strategies to climate change for the National District. Components of vulnerability: E. Exposure, S. Sensitivity, C. Adaptive capacity.

Adaptation strategies	Impacts and vulnerability related	E	S	C
1. Avoid urbanization in areas vulnerable to floods and landslides, preventing settlements through the instruments of zoning and leaving these spaces free for public use projects under regulations in an Urban Regulatory Plan with an adaptation approach	Vulnerable zones include the banks of the Ozama and Isabela rivers (and their tributary network), exposed to flooding by natural floods or overflowing in extreme events and intense rainfall; and the coastal zone exposed to rising sea levels and extreme events with storm surges causing sea penetration and coastal flooding.			
2. Reduce/eliminate the impact of floods on the population and infrastructure located in vulnerable sites through structural measures (technologies for management and control of floods), non-structural (early warning) or resettlement (Ciudad Juan Boch Project), to be implemented in the medium and long term	The population and infrastructure settled on the banks of the Ozama and Isabela rivers (and their tributaries), in areas of flooding or where topography and drainage have been altered is vulnerable to overflow flooding, extreme events and intense rainfall			

3. To take advantage of and promote the natural and constructed green infrastructure (urban trees) in a continuous green circuit (corridor) to favor urban adaptation by creating spaces for acclimatization and shading (in addition to drainage) with the co-benefit of landscape improvement and increase in biodiversity	The population and infrastructure are vulnerable to the increase of temperature and heat waves situation aggravated by the scarce vegetation cover. Urban trees provide shade and cooling, help reduce the temperature during heat waves; and offers rain infiltration spaces. The redoubts of riparian and lagoon ecosystems and the services they provide play a key role in adapting to climate change in the face of all climate vulnerabilities				
4. Implement actions that reduce/avoid synergy between climate and non-climate impacts and offer an environmental co-benefit and improvement in basic services	The vulnerability of the National District is increased by the dispersion of solid waste that obstructs drainage and worsens flooding, or deficiencies in the water supply system aggravate the scenario of reduced rainfall				
5. Create relationships and alliances and strengthen inter-institutional and inter-sectoral mechanisms and with civil society for the adaptation of the National District	The lack of coordination between institutions and sectors does not favor the approach of climate impacts that promote vulnerability and constitutes -in fact- one of the most serious non-climatic impacts that aggravate it				
6. Address priority information and research needs for a better understanding of vulnerabilities and a more effective and focused approach to adaptation	Vulnerability is conditioned by climatic, spatial and socioeconomic factors -historical and present- of the territory that must be known for adaptation under technical criteria				
7. Increase education and citizen awareness in the face of the needs of territorial planning and the risks of climate change in the National District	The ability to manage and understand climate information and a correct perception of risk are crucial to increase adaptive capacity and reduce vulnerability to climate variations.				

In the next section each of the adaptation measures is presented and described in relation to the strategies that correspond to them. All measures were assessed through the ICF tool (2016). In each case, adaptation measures are listed, organized by resources, sectors and services. Its geographical area of action is indicated; the responsible institutions are identified, the territorial ordinance instrument of the DGODT (2016) is identified, through which it is incorporated into the land use plan (zoning, regulations and policies, programs, plans and projects) and finally assigned a temporary implementation framework (short, medium or long term). These measures can be complemented with the technical sheets to support climate adaptation and land use planning of ICMA / ICF (2017).

3.1. Strategy I. Reduce exposure in vulnerable sites

Strategy I addresses the fundamental problem of the National District: the exposure to threats, and focuses on reducing vulnerability by regulating the use of vulnerable land (mainly riverine and coastal floods) and ensuring that its natural characteristics are respected (e.g. vegetation cover) that help soil infiltration and conservation. To do this, it relies on the results of the vulnerability assessment of the territory to propose measures (Table 4) that give criteria for mapping a set of zones that should not be occupied (Figure 4) and establishing a non-urbanization zoning that must be endorsed by a body of regulations in an Urban Regulatory Plan (Table 5).

Table 4. Adaptation measures within Strategy I validated by the City Council of the National District. Note. The first number of the measure relates to an adaptation strategy.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
Planning, population,	I.1. In the context of the classification of land use of the DN establish a zoning with ZNU handling multiple criteria as they apply: a) 30 m	ADN, DGODT,	X			C

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
infrastructure and environment	strip along the banks of the Ozama and Isabela rivers and their tributaries, lakes and lagoons (Art. 129, Law 64-00), b) coastal strip of 60 m under the criterion of the Littoral Park in its landscape value (Law 305-68), c) areas of the Green Belt without occupation, d) areas of fragile ecosystems and special values of biodiversity, d) known flood areas, e) urban parks and reserves, f) slopes prone to landslides, and g) areas of the seismic microzoning study	MMA, MOPC, SGN, MITUR				
Planning, population, infrastructure and environment	1.2. Review and update the land use regulations of the DN Urban Regulatory Plan with adaptation approach, incorporating elements such as: a) new urban infrastructure construction models b) design and material changes c) wiring layout and d) infrastructure increase green	ADN, DGODT, MMA, MOPC, SGN, MITUR, JBN	X	X		C

Table 5. Criteria for regulatory proposals of the Urban Regulatory Plan of the National District derived from the strategies and adaptation measures proposed and validated by the City Council.

Regulations	Description
I. Urban infrastructure constructions	Promote constructive models of urban infrastructure that do not alter runoff and drainage (natural gutters in the islets), changes of pavement material for ramps / sidewalks / parking with permeable covers (e.g. gramaquines and trenches of excavation) and new criteria to decide the permeable surfaces
II. Distance from constructions (residential or commercial) to the coastal edge	As a precaution against the rise in sea level and the increase in storm surge the distance of any construction to the coastal edge may be behind the 60-m indicated in the law, and even at a greater distance. This distance should be defined with an assessment of the coastal topography, modeling of sea level rise and storm surge to ensure long-term protection of residential and tourist infrastructure.
III. Underground wiring	Underground wiring of high and medium voltage cables in areas with greater vulnerability or high risk to reduce the danger in case of extreme events
IV. Increase in green infrastructure	Urban regulations for green belt width increases on sidewalks or sowing, management and conservation of urban trees with a new ecological-adaptive approach to urban green infrastructure and increase of green infrastructure through urban gardening, green roofs, vertical gardens and others.

The new regulations of the National District must incorporate the adaptation to guarantee the reduction of the vulnerabilities of the territory through the land use planning. A first aspect is to incorporate climate terms, vulnerability, adaptation and resilience as terms of the document. In particular, adaptation regulations are required to increase the protection of coastal infrastructure and the electricity system, and promote green infrastructure. One of the problems of the urbanization of the National District has been the modification of the permeability, which has altered the urban runoff inducing floods. A regulation focused on adaptation must be particularly accurate in terms of permeability criteria in new urban projects. The amount of soil to be waterproofed becomes one of the most important regulations due to its intimate relationship with flood vulnerability. When defining a percentage of waterproofing, it is advisable to take into consideration different non-exclusive criteria. The first is to always carry out a preliminary evaluation of the arboreal coverage of the property and its surroundings (species, heights, diameters, age, shadow spaces and drainage) to handle design adjustment criteria, cutting negation or in situ transplants. This procedure is applied by the Ministry of the Environment to all tourism projects. The City Council can help with the National Botanical Garden. A second criterion is to consider the vulnerability of the property and its surroundings. Thus, a low area with flood potential or located in an area of urban heat waves, must maintain a greater green coverage and more than waterproofing it is necessary to forestall. Another criterion that would also bring novelty and modernity is the incorporation of flood control engineering techniques that manage the infiltration

capacity of the soil (from biofiltration to permeable pavements). Collaterally, the compensation of the waterproofing of private urban projects can be managed by expanding the permeable percentage of public spaces (e.g. 30%).

3.2. Strategy 2. Reduce vulnerability in vulnerable occupied sites

Although the previous strategy proposes the creation of NUZ in areas of high vulnerability, it must be considered that in the National District, as the result of informal settlements, unplanned urbanization and construction without appropriate drainage designs, there are several areas vulnerable to floods that have been occupied and that cannot be forgotten in a municipal adaptation plan. Therefore, Strategy 2 includes actions (Table 6) to reduce or eliminate the impact of climatic threats on the population and infrastructure located in vulnerable places, through structural measures (e.g. flood management and control technologies) and non-structural (housing census, early warning systems or contingency plans), which contribute to reduce sensitivity. If a resettlement is being carried out, it would be helping to reduce exposure, but this alternative requires time, resources and coordination with the Central Government.

Table 6. Adaptation measures within Strategy 2 validated by the City Council of the National District.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
Planning, population, infrastructure and environment	2.1. Projects of neighborhood design adapted to the floods (for example, directed paving, ditches and ditches of water conduction, arborization and creation of spaces of drainage) through changes of the configuration of the districts to guarantee the drainage of the waters and eventually the selective resettlement of part of the population.	ADN, CAASD, MOPC, POSC, GC			X	M
Storm drain	2.2. Make feasible the inclusion in the work of the CAASD of sectoral and neighborhood solutions to the floods that manage the infiltration capacity of the soil making use of the multiple existing engineering technologies (from biofiltration to permeable pavements).	CAASD, ADN, GC			X	M
Industry and risk management	2.3. Prepare climate contingency plans for coastal and coastal industrial infrastructure in the face of extreme weather events.	SIND, CPMR, ADN,			X	C
Participatory governance	2.4. Incorporate flood reduction actions (channeling and drainage) into a participatory budget for adaptation with plans by sectors and neighborhoods.	ADN, POSC			X	C

3.3. Strategy 3. Increase the urban green coverage

A similar principle that the previous strategy manages Strategy 4, but in the urban area, with actions (Table 7) to develop the vegetation cover (forests, parks and urban gardens) in a continuous green circuit as a corridor (Metropolitan Green System) that favors the adaptation with the co-benefit to the urban landscape and increase of the biodiversity. The urban trees provide shade and cooling by evaporation, helping to reduce the temperature, as well as storage spaces and infiltration of rainwater. It is advisable to use the ITree tools (2017) that are already implemented in the country (Domínguez and Bauer, 2016) ¹. As part of the increase in green spaces should also include facades, green roofs, vertical gardens and other innovative systems.

¹ These tools bring information on the number and species of trees and their diameters, coverage (%), removal of pollutants (tons /year), storage (tons) and sequestration (tons/year) of carbon, production of oxygen (tons/year) avoided runoff

Table 7. Adaptation measures within Strategy 3 validated by the City Council of the National District.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
Biodiversity and green spaces	3.1. Define a Metropolitan Green System ² (and its buffer space) from the Green Belt and natural areas, seeking continuity at the metropolitan level (adaptation based on ecosystems) and managing the legal basis (current or proposed).	ADN, JBN, MMA	X			M
Biodiversity and green spaces	3.2. Increase the green infrastructure of the city through an urban reforestation program in selected sites, applying ITree tools and managing the criterion of green corridors that link different parts of the city and complement the metropolitan green system.	ADN, JBN, QV, MMA, CRIO, MGSD, MOPC, USFS				M
Biodiversity and green spaces	3.3. Creation of green buffer zones around DNA service facilities (for example, cemeteries) integrated into the Metropolitan Green System, to limit interventions.	ADN, JBN, MMA	X			M
Biodiversity and green spaces	3.4. Support the development of the Environmental Management Plan of the Metropolitan Green System to strengthen the zoning proposals.	MMA, ADN, JBN				C
Biodiversity and green spaces	3.5. Review and update, with adaptation approach, the measures of the Management Plan of the upper basin of the Ozama and Isabela rivers.	MGS, ADN				M

3.4. Strategy 4. Reduce synergies between climate and non-climate impacts

As already stated, climatic impacts are aggravated by non-climatic impacts that have their origin in poor management of some basic services. In the National District the floods are aggravated by the scarce coverage of the stormwater drainage system, which is joined by the dispersion of solid waste that obstructs the scarce drainage. In the impact of heat waves affect the anthropogenic heat sources that contribute to urban warming, such as industry and transport. The deficiencies of the sanitary sewer system can cause sewage to overflow from the rains, exacerbating the problem of flooding with health risks. Considering this problem, Strategy 6 focuses on actions that avoid or help reduce this negative synergy (Table 8). In this strategy, the approach of climatic risks and environmental management converge, which has important co-benefits for the environment and for the improvement of basic services.

Table 8. Adaptation measures within Strategy 4 validated by the City Council of the National District.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
Water supply	4.1. Develop a comprehensive water resource management plan with evaluation of new sources, improvement of distribution, control of losses, promotion of savings and collection and storage of rainwater, reuse of gray water, quality monitoring and conservation promotion.	CAASD, ADN			X	M
Solid waste	4.2. Review the Integrated Solid Waste Management System of the National District to complement measures to adapt to climate	ADN, MMA			X	M

(m³/year), energy saving of buildings (\$) and avoided carbon emissions (tons/year) offering a structural and functional assessment of the urban forest.

² This measure requires coordination between the institutions for the removal of the current green areas according to their vocation and update the Green Belt diagnosis.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
	change for the sector					
Urban mobility	4.3. Develop an urban mobility plan aimed at: a) promoting more sustainable journeys, b) optimizing journeys in time and distance, c) reducing mobility needs with criteria in urban planning (compact and diverse neighborhoods), d) studies of a new massive public transport system, e) encourage non-motorized transport modes with a bicycle mobility strategy, f) discourage the use of private vehicles and g) regulations on the emission of pollutants in existing mobility systems.	MOPC, INTRANT, ADN			X	L
Sewage water	4.4. Articulation between the central government and the National District to expand the coverage of the existing system in the urban area of the DN and improve the final treatment of these waters.	CAASD, ADN			X	M

3.5. Strategy 5. Institutional and sectoral strengthening for adaptation

The lack of coordination between institutions (e.g. decisions found regarding the use of land between the City Council and a ministry), the lack of recognition and respect for the functions of each entity or the assumption by certain sectors of responsibilities that they do not correspond, it is a serious problem that prevents problems of vulnerability from being addressed from an integral perspective and therefore harms adaptation. In addition, this problem causes neglect of basic services with deficiencies that end up interacting negatively with the impacts of climate to aggravate its consequences. This situation is addressed by Strategy 5, which creates alliances and commitments, and strengthens institutions and sectors as part of participatory governance, focused on the growth of institutional adaptive capacity, having a definitive impact on the creation of new forms of relationships and structures. organizations that guarantee that each entity plays the role that corresponds to it in a framework of complementation of functions and agreed solutions (Table 9).

Table 9. Adaptation measures within Strategy 5 validated by the City Council of the National District.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
Participatory governance	5.1. Concentration of efforts and interests around the City Council to achieve inter-sectorial and inter-institutional coordination that guarantees the recognition and respect of the functions of each entity and complementation to address the solution of vulnerability problems, the offer of services quality, the protection of natural resources and the proper use of public spaces.	ADN, several institutions		X		C
Participatory governance	5.2. Strengthening of the ADN-CAASD institutional relations and complementation of functions for joint projects, under guidelines that guarantee the solution of floods at the same time as the adequate use of public spaces.	ADN, CAASD, POSC, MGSD		X		C

3.6. Strategy 6. Information and research to focus on adaptation

Strategy 6 contains actions to meet the information and research needs that the National District requires to focus on adaptation under technical criteria (Table 10). The strategy aims at the growth of adaptive capacity in technology (available adaptation technologies, flood control options, technical capacity, early warning systems or availability and management of climate information). Vulnerability is conditioned by climatic, spatial and socio-economic factors -historical and present- that are particular to the territory that should be investigated and known, since adaptation works best when it is based on

technical criteria (for example, precision topography allows the identification of areas of flooding, safe areas of urbanization and design drainage systems following the natural conditions of the land).

Table 10. Adaptation measures within Strategy 6 validated by the City Council of the National District.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
Investigation and development	6.1. Prepare an integral vulnerability map of the DN (mainly floods and landslides) as a basis for land use planning, which in turn allows objectively assessing, by sectors and neighborhoods, structural measures (protection, accommodation or withdrawal) and non-structural measures (early warning) in the medium term.	ADN, SGN, ICN, COE, MMA, CRIO, IGN				C
Investigation and development	6.2. Fully evaluate the situation of the underground basins of the DN (availability, uses, extraction levels, water quality, pollution indicators, health problems related to water) before the scenarios of rainfall reduction.	CAASD, ADN, MSPAS INDHRI,				L
Investigation and development	6.3. Carry out research on the distribution of temperature in the territory of the DN to support the effect of heat islands and detect critical spaces that require specific adaptation measures (e.g. special trees) with emphasis on health prevention.	ONAMET, UNIV, MSPAS, ADN, POSC	X			M
Investigation and development	6.4. Climate vulnerability assessment of the coastal area of the DN (rising sea level, coastal flooding, erosion) with criteria of geology, oceanography and ecology	UNIV, ANAMAR				C

3.7. Strategy 7. Training and awareness for adaptation

The ability to manage and understand climate information and a correct perception of risk are crucial to increase adaptive capacity and reduce the vulnerability of the population and urban infrastructure and of all basic services and sectors to climate variations. Strategy 7 proposes actions within a comprehensive program of education, training and awareness (workshops, lectures and diploma courses) for the population, teachers at the basic and secondary level, the incorporation into the student curriculum of the climate issue, use of murals (graffiti) as part of the citizenship education program and the dissemination of education and climate messages at different levels and sectors (Table 11).

Table 11. Adaptation measures within Strategy 7 validated by the City Council of the National District.

Sectors and services	Adaptation measure	Responsible	Z	R	P	T
Education	7.1. Project of education and climatic training in several subjects and levels of the population, by different means, emphasizing the problematic in the vulnerable communities.	DDCADN, MINERD, UNIV, POSC			X	M

4. IMPLEMENTATION CRITERIA

4.1. Creation of a technical team

Adaptation to climate change is a complex and transversal process that must be undertaken as part of the development of the National District with the commitment of a range of stakeholders including local government, public institutions and civil society. In this context, the first step is the definition of an operational structure, a Municipal Technical Team for Climate Change (ETMCC) to facilitate the

implementation of cross-sectoral and sectorial actions and monitor these actions as part of a monitoring, evaluation and updating system. The scheme of the operational structure for implementation corresponds to an intersectoral approach, led by the City Council and the participation of public institutions and civil society. The creation of an ETMCC responds to the action plan to concentrate efforts and interests around the City Council and the Development Council to achieve intersectoral and inter-institutional coordination to ensure the recognition and respect of the functions of each entity and the complementation solution for address the problems of vulnerability, offering quality services, protection of natural resources and the proper use of public spaces. After the creation of an operational structure for the implementation of the adaptation plan it is necessary to develop operational work plans to address the adaptation actions in direct coordination with those responsible for the sectors involved.

4.2. Implementation times

Of the adaptation measures of the portfolio, the City Council considers that thirteen can be implemented in the short term, ten medium term and seven long term. The measures that can be implemented in the **short term** include the establishment of NUZ on the banks of the rivers, the lagoon and the coastal zone and the extension and complementation of this zoning with an Urban Regulatory Plan; the inventory, cataloging and updated cartography of the historical heritage (as the first phase of this great patrimonial rescue project) and the selective urban reforestation. In the short term, appropriate actions can also be taken to reinforce inter-sectoral and inter-institutional coordination that allows to begin to efficiently address and solve environmental problems and risk situations (e.g., interruptions of electricity service in the potable water system) and start the comprehensive education program at different levels on land use planning, climate change and risk management.

The **medium-term** measures include neighborhood design projects adapted to floods that can be supported with the measure of a participatory budget for adaptation. Also, the plan of integral management of the water resource (sources, distribution, control of losses, saving, capture and storage of rainwater, reuse and monitoring) that incorporates local solutions to the floods managing the infiltration capacity of the soil (biofiltration to permeable pavements) through the CAASD. Likewise, the urban reforestation program for the development of the Metropolitan Green System (with its buffer zones) and the coordination so that the management plan for the upper watershed of the Ozama and Isabela rivers also manages ecological restoration activities. Also in this temporary framework are the research on the distribution of temperature and the education and climate training project. Finally, the implementation of a solid waste management system may be possible in the medium term considering that the National District is part of the Dominican Clean Program that will offer assistance and funds to provide definitive solutions to the problem of solid waste in several Dominican municipalities.

Long-term measures include projects that require previous studies and subsequent investments in works, such as the climate adaptation of the Littoral Sur Park that includes three stages: a) Plaza Juan Barón-Ave. Máximo Gómez, 2) Ave. Máximo Gómez- Ave. Abraham Lincoln and 3) Ave. Abraham Lincoln- Ave. Núñez de Cáceres. Also, the actions for the improvement of urban mobility; and especially those that demand support from the central government, such as expanding the coverage of the sanitary sewer system and the construction of the stormwater drainage system.

4.3. Adaptive management

Building the climate resilience of the National District is an ongoing process. Climate conditions change over time. Likewise, the district is dynamic—growing and changing in ways that cannot be fully predicted. New challenges and opportunities continuously arise, technologies advance, and community

priorities change over time. Further, adaptation implementation may face challenges in execution and adaptation measures that are implemented may not perform as expected. For all of these reasons, it is necessary to monitor conditions and the effectiveness of adaptation measures, and take additional action to adjust to these changes and increase resilience. Adaptive management is an iterative process for revisiting and improving adaptation practices that utilizes flexible decision making to promote resilient systems and continuous learning through monitoring.

The monitoring and evaluation and adaptive management process should be led by the ETMCC. During the implementation phase, adaptation measures identified in this plan must undergo a process of monitoring and evaluation to track the progress and performance and serve as a starting point for improving adaptation practices. Monitoring and evaluation will require defining specific indicators to estimate the estimate the progress of implementation and effectiveness of the adaptation measures. Through this evaluation, the National District can identify the reasons the measures have been effective or ineffective and begin the process of identifying techniques to change, supplement, or add to the adaptation measures in place and continually advance National District towards resilience.

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Appendix I. Plans, programs and projects derived from adaptation measures to be incorporated into the Territorial Ordinance Plan (POT) or the Development Plan (PD) of the National District.

Measure	Proposal
1.2	<i>Regulatory Plan of the urban area - DN:</i> instrument to regulate the growth of the urban area of the National District, in which the non-urbanizable and urbanizable areas with boundaries, heights, buildable surface, waterproofing index, etc. are defined; in attention to the urban polygons defined in

Measure	Proposal
	the POT.
1.2.	<i>Climate Adaptation of the Littoral Sur Park.</i> Incorporate adaptation criteria with zoning of first and second line uses based on coastal vulnerability and incorporating measures that guarantee safety and sustainability (eg, designs and materials, climate resistant, permeable pavement criteria and engineering solutions in the spaces affected by erosion)
2.1.	<i>Flood management in neighborhoods in vulnerable areas:</i> Neighborhood design projects adapted to floods through changes in the configuration of neighborhoods to ensure drainage of waters and eventually the selective resettlement of part of the population
2.2	<i>Analysis and identification of local solutions to floods:</i> Make feasible the inclusion in the work of the CAASD of sectorial and neighborhood solutions to the floods that manage the infiltration capacity of the soil making use of the multiple existing engineering technologies (from biofiltration to permeable pavements) to give specific solutions to vulnerable places in the city.
2.4.	<i>Participatory budget for adaptation.</i> Incorporate actions to reduce vulnerability to flooding (canalization and drainage works) to the municipal participatory budget with projects by sectors and neighborhoods
3.1 y 3.3 y 3.4.	<i>Metropolitan Green System Design:</i> Definition of the system and its buffer space (including the environment of municipal services facilities) from the Green Belt and all natural areas, seeking continuity at the metropolitan scale (adaptation based on ecosystems) and managing the legal basis current or propose to three of an Environmental Management Plan that strengthens the zoning proposals.
3.2.	<i>Urban reforestation.</i> Urban reforestation program in selected sites of the Metropolitan Green System, applying the tools of ITree and under the criterion of corridors and green rings that link different parts of the city with large green areas
3.5.	<i>Adaptive management of watersheds.</i> Review and update, with an adaptation approach, the measures of the Management Plan of the upper watershed of the Ozama and Isabela rivers to incorporate actions in the identified runoffs that have been occupied by the population; through awareness raising, training, relocation of housing in areas of high vulnerability, cleanup of runoff and integration into a green circuit.
4.1	<i>Comprehensive water resource management plan.</i> Evaluation of new sources, improvement of distribution, control of losses, promote savings and rainwater collection and storage, reuse of gray water and quality monitoring, promotion of water conservation programs and awareness of the different residential users , commercial and industrial.
4.2.	<i>Integrated management of solid waste:</i> Review and update of the solid waste integral management system of the National District for its complementation with measures of adaptation to climate change for the sector.
4.3	<i>Urban Mobility Plan:</i> Instrument designed to improve the urban connection, organize the displacements (pedestrian and motorized) of the population that circulates through the urban area; adapting the needs of its inhabitants, improving inter-institutional articulation and fostering public-private articulation.
4.4	<i>Construction of sanitary sewer system:</i> Articulation between the national government and the National District to expand the coverage of the existing system in the urban area and improve the final treatment of these waters.
5.1.	<i>Institutional Cooperation.</i> Concentration of efforts and interests around the City Council to achieve inter-sectorial and inter-institutional coordination that guarantees the recognition and respect of the functions of each entity and complementation to address the solution of vulnerability problems, the offer of services quality, the protection of natural resources and the proper use of public spaces
6.1 y 6.3.	<i>Assessment of urban vulnerabilities.</i> Environmental and climatic vulnerability assessments, with cartographic output, focused on: a) temperature distribution to support the effect of heat islands and support the selection of urban reforestation sites, b) situation of the underground basins (availability, uses, water quality and health) in the face of rainfall reduction scenarios; and c) coastal zone (rising sea level, coastal flooding, erosion) with criteria of geology, oceanography and ecology.
7.1.	<i>Strengthening of capacities for the management of land use:</i> training for City Council staff, acquisition of hardware, updating of the National District to new technologies, recruitment of key personnel to implement a monitoring and management system of the territory.

Measure	Proposal
7.1.	<i>Permanent training in territorial planning, climate change and comprehensive risk management:</i> Conducting workshops, talks and graduates, for elementary and middle school teachers, incorporating the theme of climate into the student curriculum, using murals (graffiti) as part of the education program citizenship, to spread positive messages.