2045 Puerto Rico
Long Range Multimodal Transportation Plan

Puerto Rico Highways and Transportation Authority (PRHTA)

Highway and Transportation Authority

Final Report December 2018

Long Range Transportation Plan for Puerto Rico

APPOVED BY PUERTO RICO METROPOLITAN PLANNING ORGANIZATION

December 12, 2018

The Puerto Rico Department of Transportation and Public Works and the Puerto Rico Highway and Transportation Authority after a 45-day public comment period for revision and comments, has presented and approved this Plan by the Puerto Rico Metropolitan Planning Organization Policy Board Committees.

December, 20, 2018

Carlos M. Contreras Aponte
President, PR Metropolitan Planning Organization

Date

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1 CHAPTER 1 INTRODUCTION

This report presents the 2045 Long Range Multimodal Transportation Plan (2045 LRTP) for the entire Island of Puerto Rico (Island-wide). This chapter is divided into 3 sections:

1. Background;
2. Plan Context and Importance; and
3. Report Organization.

The Puerto Rico Department of Transportation and Public Works (DTPW) and the Puerto Rico Highway and Transportation Authority (PRHTA) acting as the Puerto Rico Metropolitan Planning Organization (MPO) elaborated the 2045 Long Range Multimodal Transportation Plans (LRTP) consisting of two documents for the Transportation Management Areas (TMAs) for San Juan and Aguadilla, one for the Island-wide Transportation Plan, and one for the Transportation Plan for other urbanized Regions of less than 200,000 inhabitants (includes five transportation planning Regions) as required by federal regulations (23 U.S.C 134 and 135; 42 U.S.C. 7410 et seq.; 49 U. S. C. 5303 and 5304). This document represents the Puerto Rico Island-wide 2045 LRTP.

Puerto Rico has a population of 3,411,307 based on estimates for 2016; it has 9,943 route miles (bi-directional), 11,838 lane miles and 54.3 million daily vehicle miles in an area of 9.104 km². It has 78 Municipalities divided into:

- 2 TMAs, San Juan and Aguadilla, accounting for 60.3% and 8.5% of the population respectively;
- 5 Transportation Planning Regions (TPRs) with:
  - the South TPR holding 11% of the population;
  - the North TPR having 8% of the population;
  - the Southwest TPR with 6.5% of the population;
  - The Southeast TPR with 3% of the population; and
  - the East TPR 2% of the population.

This 2045 LRTP updating process had been characterized by important challenges conforming the transportation infrastructure and its vision of developing livable and economic competitive Island. The PR MPO and its transportation agencies considered the Puerto Rico Oversight, Management, and Economic Stability Act (PROMESA), a 2016 federal law that established an oversight board, and procedures for approving critical infrastructure projects to improve the Puerto Rican government-debt crisis. As a result, the certified Fiscal Plan for the PRHTA was considered as the financial basis of this analysis. The investment plan for infrastructure in this 2045 LRTP is thus fiscally constraint to current Puerto Rico financial and fiscal conditions.

On the other hand, the island experienced hurricanes Irma and María impacting significantly the road infrastructure around the island in August 2017. The 2045 Plan included a component of vulnerability analysis for resilient infrastructure integrated to assess risk of the transportation system's conditions during and after extreme weather events. Although the specific project investment for resilient conditions needs further analysis, the 2045 Plan establishes a policy to prioritize these efforts toward reducing vulnerability in all Regions.

This document reports the planning process in the following steps as set out in Figure 1.1.

Figure 1.1: Planning Steps

Source: SDG and PRHTA

Public participation is fundamental throughout the whole process in defining the vision and reviewing the order of importance of the goals and objectives for participants. The goals and objectives allowed to define the key performance indicators and weights to prioritize and establish a ranking for the list of requested projects. The representation of the extended stakeholders was done throughout pre-defined Committees.

The 2045 LRTP presents challenges and opportunities in infrastructure investment along a long-range period. This 2045 LRTP follows a performance-based planning process according to federal regulations with an average annual investment of $341M in Puerto Rico from Fiscal Year (FY)2020 until FY2045 with a firm commitment with national goals of reducing fatalities, an unprecedent emphasis on pavement and bridges preservation and rehabilitation in order to upgrade its conditions, improve freight mobility, as well as reduce congestion.

BACKGROUND

Since Congress's passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, and through to the Fixing America's Surface Transportation (FAST) Act, the planning process in

Puerto Rico has strived to be a comprehensive framework for making transportation investment decisions in the TMAs and Island-wide. The DTPW is the designated MPO for all urbanized areas and Island-wide. As such, it is ultimately responsible for and compliance with the US Department of Transportation (DOT) statutory requirements under the FAST-Act, and with the Rule Makings and Policy Guidance of the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA). The DTPW carries out its responsibilities as a MPO[1] through Public Policy Committees whose members are the Mayors of the municipalities under the planning designation, as well as the heads of all agencies that have transportation, land use and planning tasks:

- Planning Board (PB);
- Department of Environmental and Natural Resources (DENR);
- Environmental Quality Board (EQB);
- Puerto Rico Integrated Transit Authority (PRITA);
- Public Service Commission (PSC);
- Metropolitan Bus Authority (AMA);
- Puerto Rico Highway and Transportation Authority (PRHTA);
- Ports Authority (PA);
- Maritime Transportation Authority (MTA); and
- Permissions Management Office (PMO).

Additionally, the MPO encompasses Technical Committees that develop and manage federal and local programs, plans and certifications that are ultimately considered for approval by the Public Policy Committees and adopted by the MPO.

Under this institutional framework, the PRHTA staff carries out the day-to-day workings of the MPO including the oversight of the timely preparation of the LRTP. The 2040 LRTP is valid until December 2018, when an updated 2045 LRTP will be required. The 2045 LRTP must be approved in order to set out the planning framework for all transportation projects (including all modes) for Puerto Rico considering the two-large population TMAs: San Juan and Aguadilla; and the five smaller population TPRs comprising nine other Urbanized Areas; as set out here:

- Island-wide;
- San Juan Transportation Management Area (TMA);
- Aguadilla Transportation Management Area (TMA); and
- Transportation Planning Regions:
    - East Region:
        - Fajardo Urbanized Area;
    - North Region:
        - Arecibo Urbanized Area; and
        - Florida- Barceloneta Urbanized Area.
    - Southeast Region:
        - Guayama Urbanized Area.
    - South Region:

[1] Metropolitan Planning Organization means the policy board of an organization created and designated to carry out the metropolitan transportation planning process, according to regulations (23 CFR §450.104).

  - Ponce Urbanized Area;
  - Juana Díaz Urbanized; and
  - Yauco Urbanized Area.
- Southwest Region:
  - Mayagüez Urbanized Area; and
  - San Germán-Cabo Rojo Urbanized Area.

The 2040 plan considered the planning factors required by MAP-21 (the previous federal surface transportation funding and authorization legal framework). It recognized the "Planes de Ordenamiento Territorial" (POTs), local Environmental Laws, addressed the principles of environmental justice, and considered ongoing capital plans and projects, among many other elements, to propose, evaluate and identify future investments in mobility systems in a multimodal approach. It also considered Performance-based Planning and Programming (PBPP). Significant Island-wide projects related to highways, non-motorized facilities, ports and airports are considered in the 2040 LRTP.

The updated 2045 LRTP considered these aspects and additional key issues as set out by the new federal legislation (FAST-Act) and the local public policy (Law 201 of 2010[2] , Law 74 of 1965 as amended by Law 97 of 2012[3] and Law 22[4]) including a wider emphasis on non-motorized modes, complete streets, freight mobility, livability, resilience infrastructure, reliability, environment, energy, tourism considerations, and principles of sustainability and smart growth. The new plan must also involve stakeholders and residents seeking social consensus through a communications strategy that aligns aspirations and policies with realistic opportunities for investment and improvements. In order to successfully have the insight from community stakeholders, the plan included comprehensive Public Involvement Process (PIP) including open houses with a more dynamic approach of going to where the people are, committee's meetings, surveys and social media.

Considering the economic situation in Puerto Rico and the fact that the Island is facing an aging population trend, the new Plan and model paid closer attention to system preservation (considering the Asset Management Plan), the integration of alternative transportation modes and their infrastructure requirements including public transit, non-motorized modes facilities and an overall Complete Streets approach (considering the local public policy).

In the same context, the continuation of migration patterns exacerbated by the hurricanes Irma and María, that affected the local area in September 2017, required a strong socio-economic forecasting team that was able to rigorously-model, thoroughly thought-out scenarios to set the

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[2] Law 201, 2010 to declare the public policy regarding the adoption of the concept of Complete Streets.

[3] Law 74 of the 23 of June 1965, PRHTA Law ("Ley de la Autoridad de Carreteras y Transportación de Puerto Rico") amended by Law 97 in 2012 to include a disposition of adding a fence to all bridges with pedestrian facilities.

[4] Vehicle and Traffic Law of Puerto Rico, as amended by Law 132 of June 3, 2004 which includes the Charter of rights and obligations of cyclists and drivers.

basis for the modeling strategy based on a well informed and researched approach in order to ensure local and federal approval of the employment and population projections.

Through the LRTP planning process, the mission, vision and development of transportation system in Puerto Rico was updated and reevaluated for the next 27 years (2045). This updated 2045 LRTP performed studies regarding to journeys and travel patterns to the whole Island in order to assess infrastructure needs, define projects to invest for construction and development over a planning period of 5 years.

The multimodal transportation system in Puerto Rico encompasses highway and roadways networks, airports, ferry systems and seaports. These facilities provide travel options for people and freight movement.

The proper calibration of a model representing this system is highly dependent on the availability of data used as inputs to the model. The modelling approach took advantage of the wealth of travel pattern information available from cell phone and Global Positioning System (GPS)sources.

The vision, goals, objectives and priorities of the LRTP influence different planning efforts and programs. The basis for the definition of these was the 2040 document, strengthened by more in-depth consideration of resilience, alternative modes of transportation, freight, intermodal improvement opportunities, and Intelligent Transportation System (ITS) technologies. Additional scope in the planning effort is to support the economic vitality of the Regions, increase safety, and promote the effective use of existing infrastructure.

The development of the LRTP followed well-established regulations and guidelines from both the Federal and the Commonwealth Governments and their agencies (FHWA, FTA, PRHTA and others). The Plan development is viewed as a continuing, cooperative and comprehensive process involving on-going communications with the public, stakeholders and responsible government officials.

PLAN CONTEXT AND IMPORTANCE

In order to fulfill main elements of a performance-based transportation plan the following were considered throughout the 2045 LRTP development process:

- Performance measures, targets, system performance reports, and investment strategies;
- Public, stakeholder, and agency engagement role;
- Supporting materials and baseline information, which includes a description of the multimodal transportation system, existing system performance, anticipated challenges, and revenue forecasts;
- Strategic elements of the transportation plan: Strategic Vision, Goals and Objectives;
- Performance measures such as national measures established by US DOT, as well as community-driven measures; and target-setting methods based on factors such as available resources, trend analysis, and data;
- Existing performance of the transportation system, State or Region, regarding established performance measures and targets;

- Identification of investment needs to meet desired performance outcomes, screen strategies, projects concepts, and estimate costs;
- Scenario analysis and approaches for evaluating and choosing investment priorities in the transportation plan based on performance information; and
- Discussion about the transportation plan being translated into programming decisions that reflect priorities recognized over the planning process[5].

Some of the resources supporting a long-range statewide transportation plan includes:

- 23 CFR 450 - Planning Assistance and Standards: are federal transportation planning regulations which announce that each state implements long range statewide transportation plan and Statewide Transportation Improvement Program (STIP);
- FAST-Act Fact Sheet: Metropolitan, Statewide, and Non-Metropolitan Planning: is a program that offers funding and technical requirements for transportation planning which results in short-range and long-range plans programs of transportation investment priorities;
- FHWA FAST-Act Fact Sheet; Metropolitan Planning: is a program that give continuity to the Metropolitan Planning Program; and
- U.S. Code Title 49, Chapter 53 - Transit: is a section of US Code regarding the transit. Includes:
    - The Metropolitan Transportation Planning statute (Section 5303);
    - Statewide Transportation Planning (Section 5304);
    - Planning Programs (Section 5305); and
    - The Metro and Statewide Planning sections (23 U.S.C. 134 and 135)[6].

According with the US Census Bureau 2010, Puerto Rico is an island with a land area of 3,423.78 square miles where the 93.8% of its population lives in urban areas. An analysis of World Bank Data showed that Puerto Rico's population grew at a rate of 0.7% a year from 1985 to 2004. Thereafter, a significant reversal has occurred, culminating in annual decreases of over 1% a year since 2011.

In 2013, the Puerto Rico government approved five executive orders to begin executing his environmental policy, beginning with a guideline for the Land Use Plan, which will establish the parameters to achieve the Island's economic development in a manner consistent with the protection of the environment:

- OE-2013-019: To order the Department of Natural and Environmental Resources to carry out the National Demarcation of the Maritime Terrestrial Zone;
- OE-2013-018: It orders the quantification of emissions of greenhouse gases in Puerto Rico and the elaboration of a plan for the reduction of these emissions in order to get closer to the carbon neutral goal;

[5] US DOT FHWA, Model Long - Range Transportation Plans: A Guide for Incorporating Performance-Based Planning, 2014.

[6] https://www.transit.dot.gov/regulations-and-guidance/transportation-planning/long-range-statewide-transportation-plan.

- OE-2013-017: It orders the creation of the Action Council for the Sustainability of Puerto Rico;
- OE-2013-016: It orders the development of a study on the vulnerability of public infrastructure to climate changes and the adoption of adaptation plans to confront the findings of the study; and
- OE-2013-015: Orders the Planning Board to finalize and adopt the Land Use Plan of Puerto Rico.

In 2015 the Puerto Rico Planning Board approved unanimously the Land Use Plan (*Plan de Uso de Suelos PUT*), this document defines its main goals as:

1. Concentrate development and redevelopment in communities where infrastructure already exists and development is planned;
2. Preserve and protect natural, archaeological or agricultural resources, rural soils and environmentally sensitive ones from the adverse effects of uncontrolled construction; and
3. Ensure a desirable quality of life in cities, communities and neighborhoods in a sustainable and fair manner.

Plans Considered as Part of the LRTP

The 2045 LRTP is based on federal and local policies regarded sustainable development and resilience. There are several planning documents that are part of the LRTP as appendices and have been considered in the development of the documents; these are:

- Puerto Rico Complete Streets Plan and Design Guidelines;
- Comprehensive Bicycle and Pedestrian Plan;
- Puerto Rico Strategic Highway Safety Plan (SHSP); and
- The PR Asset Management Plan.

In 2016, PRHTA developed, and the PR-MPO adopted on September 2018 the Puerto Rico Complete Streets Plan and Design Guidelines and the Comprehensive Bicycle and Pedestrian Plan.

The main objectives the Comprehensive Bicycle and Pedestrian Plan are:

- "To guide state and local efforts to improve access and mobility conditions and develop new facilities to improve the quality of life of Puerto Rico communities;
- To improve and/or provide pedestrian and bicycle access to the transit system and the public spaces; and
- To provide safe and affordable access for people of all ages and abilities in accordance with the FHWA's Livability Initiative, the American with Disabilities Act of 1990, the goals set forth by the Puerto Rico Law 207 of August 25, 2000 for the development along the Tren Urbano Corridor, as well as by the Puerto Rico Law 201 of December 16, 2010 for Complete Streets"[7].

The main objectives the Comprehensive Bicycle and Pedestrian Plan are:

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[7] PRHTA, Puerto Rico Complete Streets Plan and Design Guidelines, 2016.

- "Promote and increase the use of cycling and walking as alternative modes of transportation;
- Foment the physical integration of urban centers thru a cyclist and pedestrian network that improves accessibility to different land uses;
- Incorporate the development of projects and bicycle/pedestrian facilities to Statewide and Municipal Transportations Plans;
- Provide cycling and walking infrastructure to improve mobility, accessibility, and safety for all users of our public roads; and
- Develop Educational Programs for all users to share the public roads in a safely manner"[8].

The SHSP states that the overall objective and public policy adopted by the Commonwealth of Puerto Rico is to reduce the number of annual traffic fatalities to less than 300 fatalities by 2018, the lowest level ever recorded. This translates to approximately a 13% annual reduction in the number of fatalities and serious injuries on the highways of Puerto Rico between 2013 and 2018[9]. The main objectives of the Plan include:

- "Reduce the average time for crash data entry from 775 days to 400 days;
- Decrease the Puerto Rico EMS Annual Average Response Time to Crash Scene to less than 11.50 min by 2018;
- Reduce the 5-year moving average of unrestrained occupant fatalities from 124 to 118 by 2018;
- Reduce the 5-year moving average of speeding related fatalities from 144 to 129 by 2018;
- Reduce the 5-year moving average of young driver serious injuries (15-20 years) from 378 to 327 by 2018;
- Reduce the 5-year moving average of serious injuries involving vulnerable users, from 758 to 554, by 2018;
- Reduce fatalities involving roadway departure using 5-year moving average from 134 to 124 by 2018; and
- Reduce fatalities occurring at intersections using 5-year moving average from 47 to 42 by 2018."[8]

2017 Context

The plan update kicked off in August 2017; Hurricane María struck and affected Puerto Rico on September 20, 2017. This powerful Category 4 hurricane with 150 mph winds bisected the entire island having catastrophic effects. This event had a direct effect on this Plan including:

- The data collection process was not possible considering that mobility patterns were affected by the climatic effect as the infrastructure was affected for over 8 months after the hurricane:
    - As a result, calibration of the model was made using 2016 year;

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[8] PRHTA, Comprehensive Bicycle and Pedestrian Plan, 2016.

[9] 2014-2018 PR Strategic Highway Safety Plan; 2014; http://carreterasegurapr.com/Content/docs/Puerto_Rico_SHSP_2014-2018_English.pdf.

- Major source of data related impacts of major climatic event on everyday life and mobility:
    - Therefore, resiliency analysis was completed based on evidence; and
    - Household surveys and public involvement was tailored to gather this data.

Further Analysis in Appendix A.

REPORT ORGANIZATION

This report will be divided in 7 main chapters:

- Chapter 1 Introduction;
- Chapter 2 Context Current Situation Assessment;
- Chapter 3 Transportation Planning Process for The Future;
- Chapter 4 Planning Process, Public Involvement, And Needs Assessment for The 2045 Plan;
- Chapter 5 Finance;
- Chapter 6 2045 Plan; and
- Chapter 7 Policy Guidelines Toward the Transportation Infrastructure.

2 CHAPTER 2 CONTEXT: CURRENT SITUATION ASSESSMENT

This chapter presents an overview of the local context in terms of planning, demographics and transportation infrastructure; it also presents the forecasts demographics and public policy towards the 2045 horizon. This chapter is divided into 4 sections:

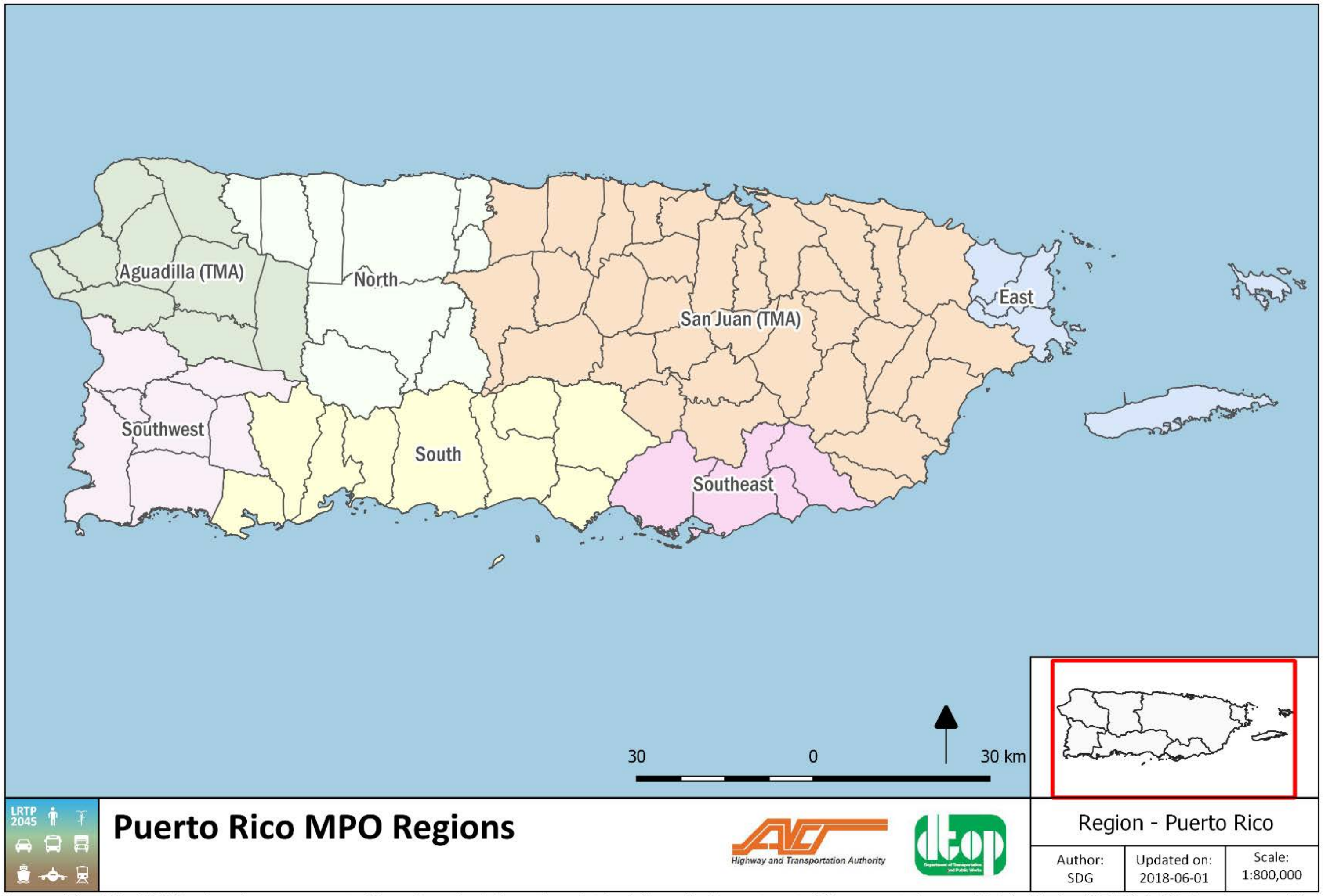
1. The Region In Brief;
2. Land Use;
3. Demographics; and
4. Transportation.

THE REGION IN BRIEF

As shown in Figure 2.1, there are seven planning transportation Regions under the Puerto Rico Metropolitan Planning Organization (MPO), which includes:

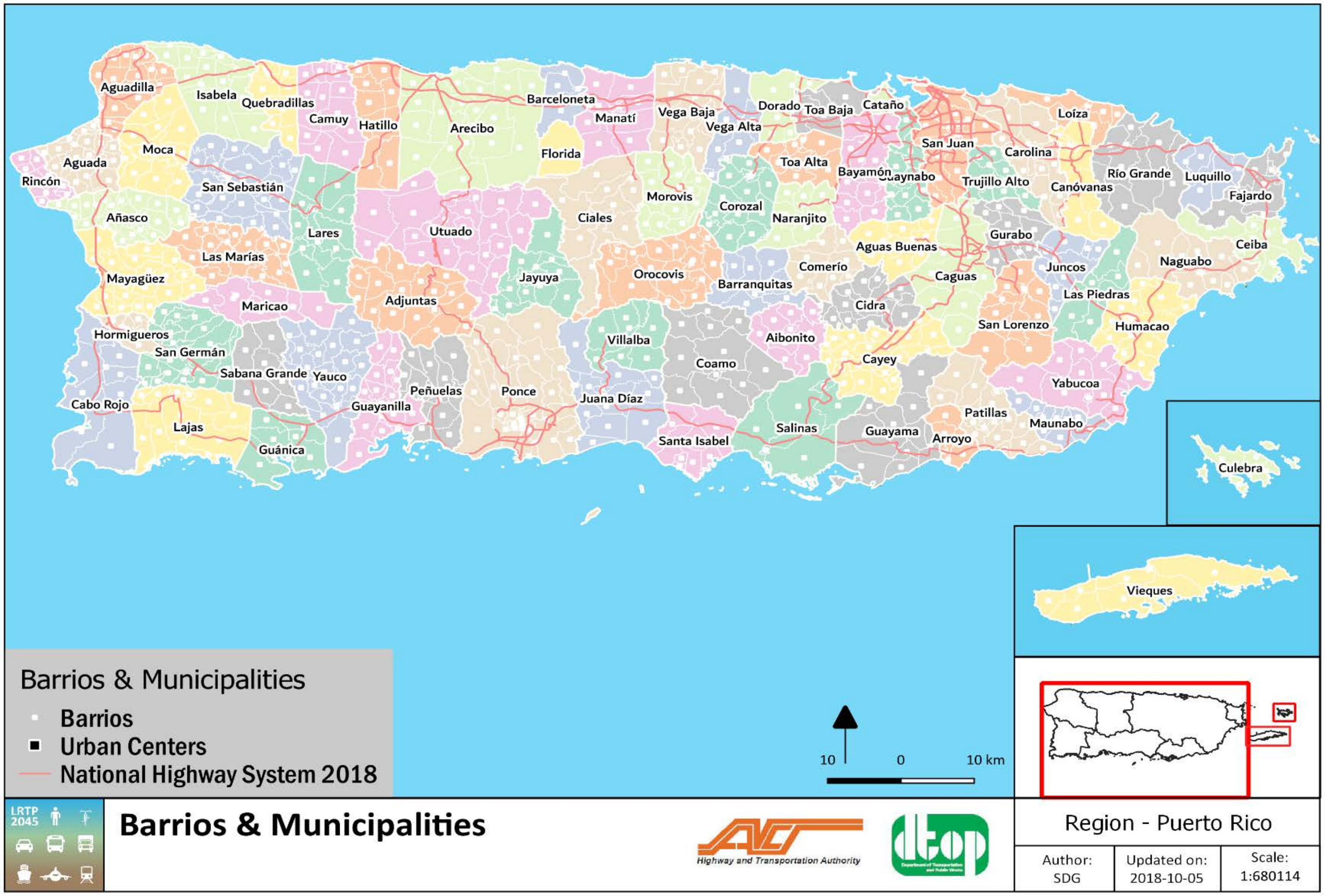
- San Juan TMA;
- Aguadilla TMA;
- North;
- South;
- East;
- Southeast; and
- Southwest.

Figure 2.1: Seven Regions in Puerto Rico



Source: The P.R. MPO Regions layer was created based on the information obtained from the Department of Transporatation and Public Works (DTOP) Public Involvement Plan found at http://www.dtop.gov.pr/fotos/coordinacionfederal/2015-july29-publicinvolvementplan.pdf

Figure 2.2: Municipalities in Puerto Rico



Source: The Municipios and Barrios Shapefile Layers were obtained from the Puerto Rico Planning Board Web Feature Service on March 2018

The San Juan TMA is the largest Region of Puerto Rico taking just over 1/3 of the land area, it represents over 60% of the island total population. The San Juan TMA is the main employer of the Island having over 60% of total formal and informal employment in Puerto Rico; thus, managing the largest numbers of commuter movement internally and from the other Regions. In turn this TMA has the most complex highway system including major principal arterials and expressways and most of the toll roads within its territory. It also manages the most complex transit system on the Island having a combination of systems including the only rail system on the Island and a state manages bus network. The San Juan TMA is also the main point of goods entrance to Puerto Rico as well as air/cruise passenger arrivals/departures.

Aguadilla is one of the Transportation Management Areas (TMAs) defined by the Puerto Rico MPO framework. The Aguadilla TMA is the 4th largest Region of Puerto Rico, covering around 11.0% of the land. Its residents represent 8.5% of the total population. Just over 8% of Puerto Rico employment exists in Aguadilla, making it the third largest employment Region behind the San Juan and South Regions.

The North Transportation Planning Region (NTPR) accounts for approximately 15% of the Puerto Rico's land area. Its residents represent 8.3% of the island total population. NTPR is responsible for close to 7% of total formal and informal employment in Puerto Rico.

The East Transportation Region is the smallest in Puerto Rico, covering approximately 4% of the land area. It represents 2.2% of the island total population. East TPR, which has the smallest population of the seven regions, composes just over 2% of total formal and informal employment in Puerto Rico.

The South TPR accounts for approximately 15% of Puerto Rico's total land area. It residents represent 10.9% of the island total population. The South TPR is the second largest employment region after San Juan, composing just over 10% of total formal and informal employment in Puerto Rico.

The Southeast TPR is the second smallest of all seven Regions, taking just over 6% of the land area. Its residents represent 3.1% of the island total population. The Southeast TPR has employment levels slightly above that of the East TPR, composing close to 2.5% of total formal and informal employment in Puerto Rico.

The Southwest TPR Region has 10% of the Puerto Rico's land area. It residents represent 6.7% of the island total population. The Southwest TPR in 2016, had employment levels composing close to 6% of total formal and informal employment in Puerto Rico.

LAND USE

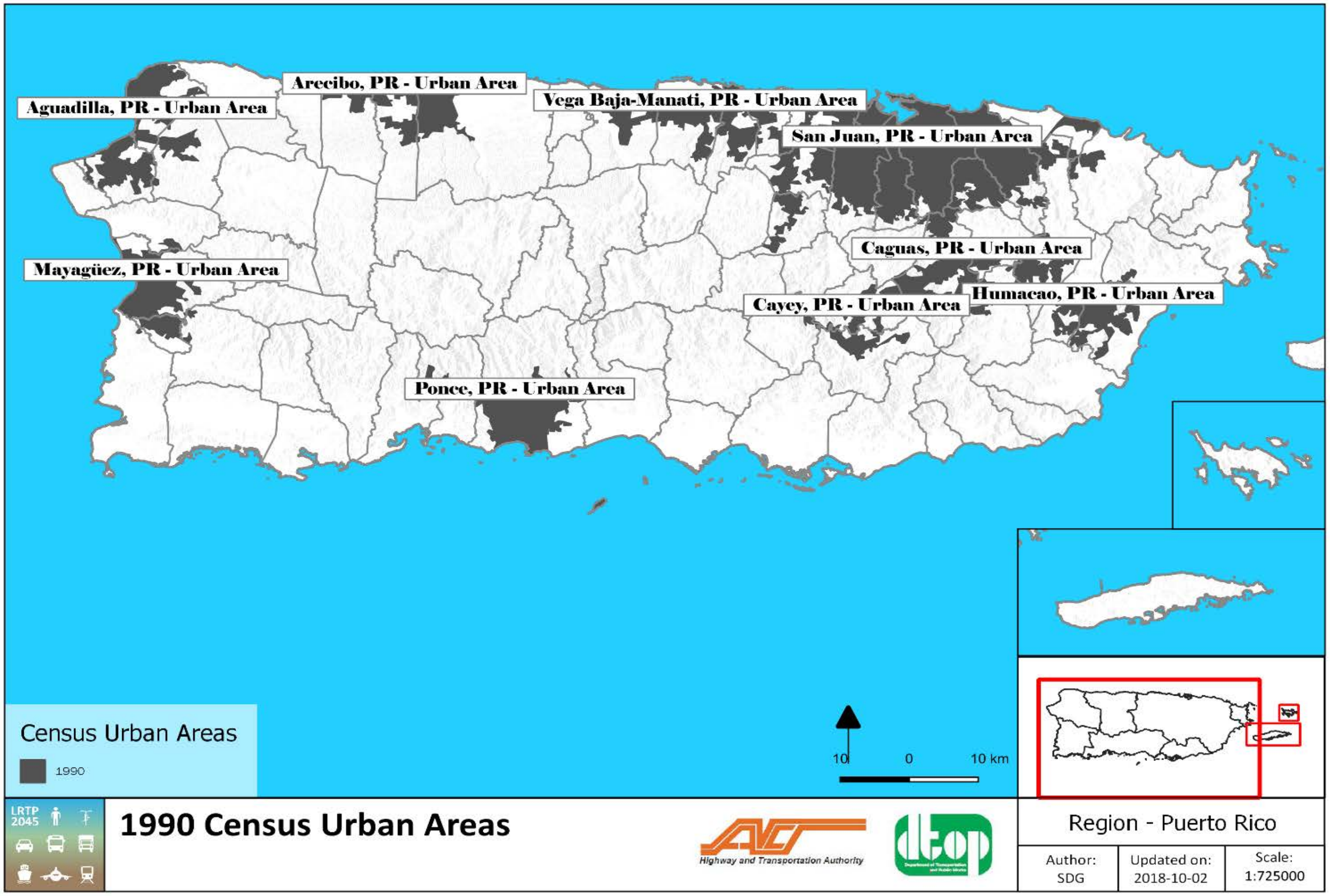
Development and Urbanization

In recent years, the whole Island experienced economic recession, an increasing rate of out-migration to the United States and a decline in both birth rates and manufacturing employment. Those trends resulted in an overall lower economic and population growth as compared with previous decades.

The identification and development of urbanized areas is a key element in the transportation planning process because it serves as a bridge to economic activity and the access of resources. Figure 2.3 through Figure 2.5 show the Puerto Rico urbanized areas for each decade between 1990 and 2016[10]. As clearly noted, between the 1990s - 2000s decade, the island-wide urbanized areas increased notably. This expansion trend slowed during the following decades. The definition of new or expanded urbanized areas in the island was muted between the 2000s and the 2010s. From thereon, the period between 2010 to 2016 also reflected little to no changes in terms of urbanized area definitions.

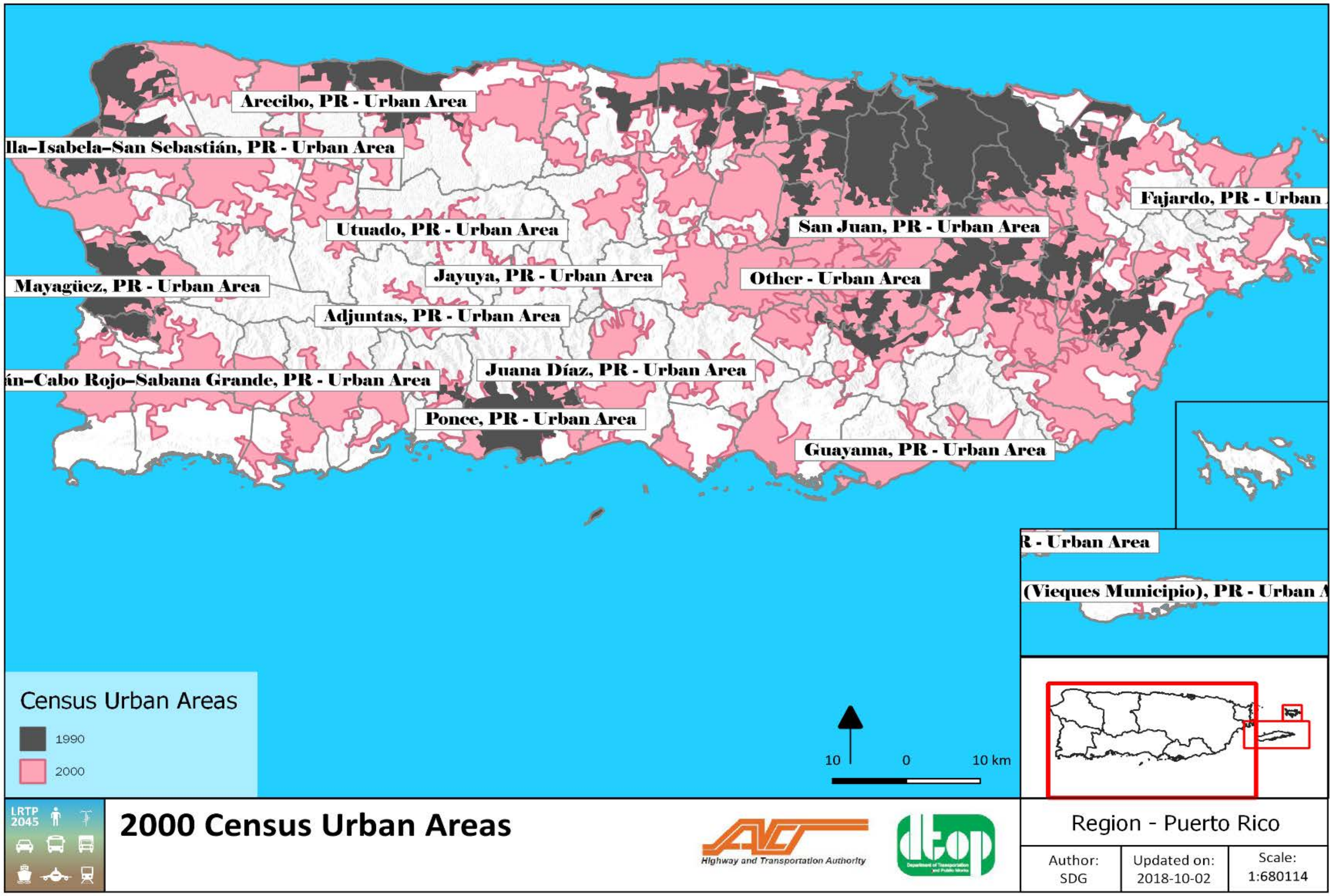
[10] The 2010 Census Urban Area delineation remained similar for 2016.

Figure 2.3: Puerto Rico Urbanized Areas 1990



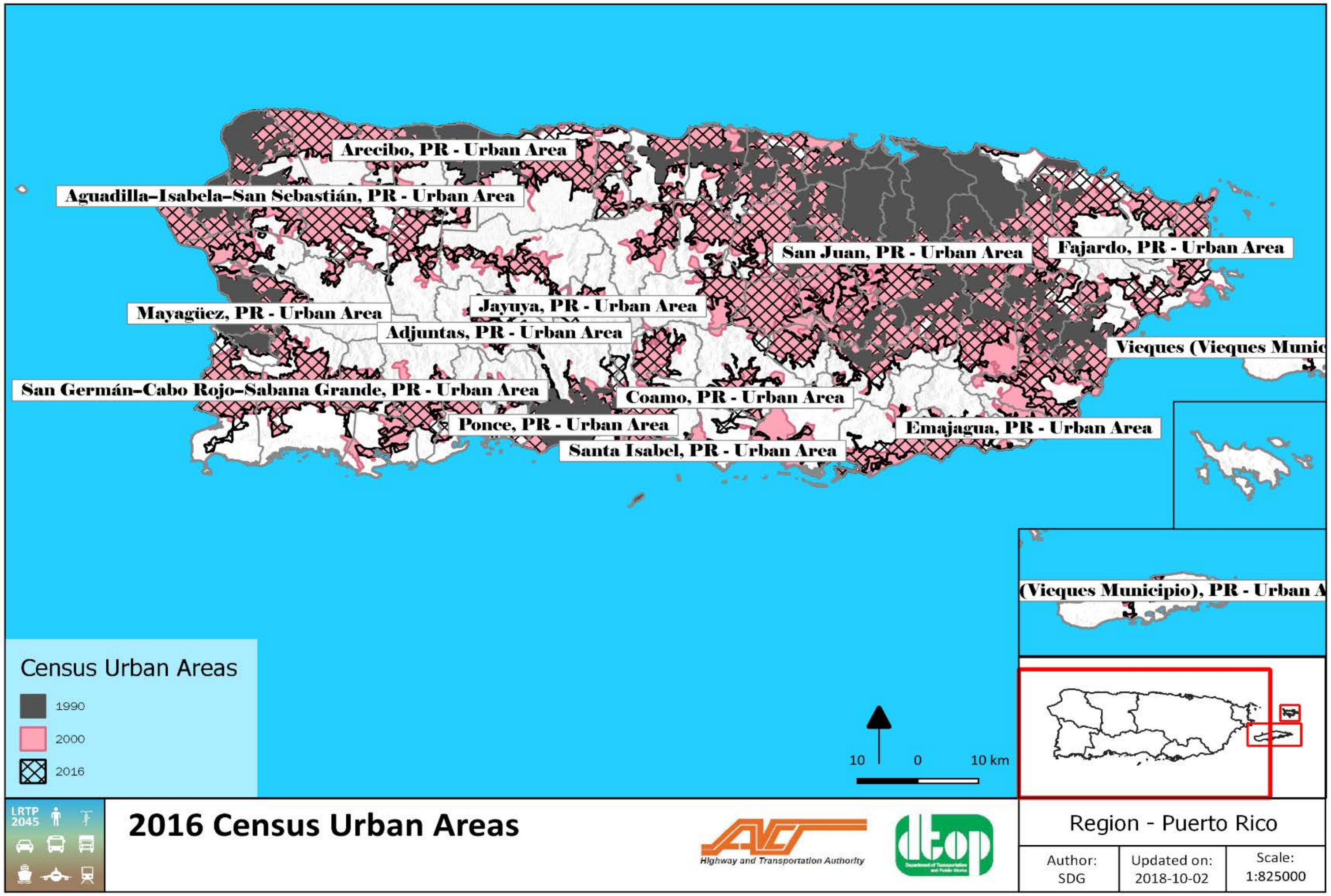
Source: Census Urban Areas for the year 1990 were acquired on March 2018 from the Puerto Rico Planning Board Web Feature Service at: http://geoserver.gis.pr.gov/geoserver/wfs

Figure 2.4: Puerto Rico Urbanized Areas 2000



Source: Census Urban Areas for the year 2000 were acquired on March 2018 from the U.S. Census website: https://www2.census.gov/geo/tiger/PREVGENZ/ua/ua00shp/

Figure 2.5: Puerto Rico Urbanized Areas 2016



Source: The 2016 Census Urban Area shapefile was acquired on March 2018 from the U.S. Census Website at: https://www2.census.gov/geo/tiger/GENZ2016/shp/

Land Use Patterns

In general, land use patterns for the Island are a function of conditions such as:

- Site topography;
- Adequacy of infrastructure (i.e., electric power, potable water, sewage sewer system, etc.);
- Adequacy of access to highway and/or maritime facilities; and
- Availability of Qualified Labor force.

The availability or lack of each one of the mentioned conditions, has resulted in specific area characteristics dictating land use patterns across the Island. Areas exhibiting significant land use patterns for industrial and residential purposes share and easy access to major highway corridors while agricultural uses have been typically flourished within the mountainous interior of the Island, which lacks adequate primary terrestrial connections.

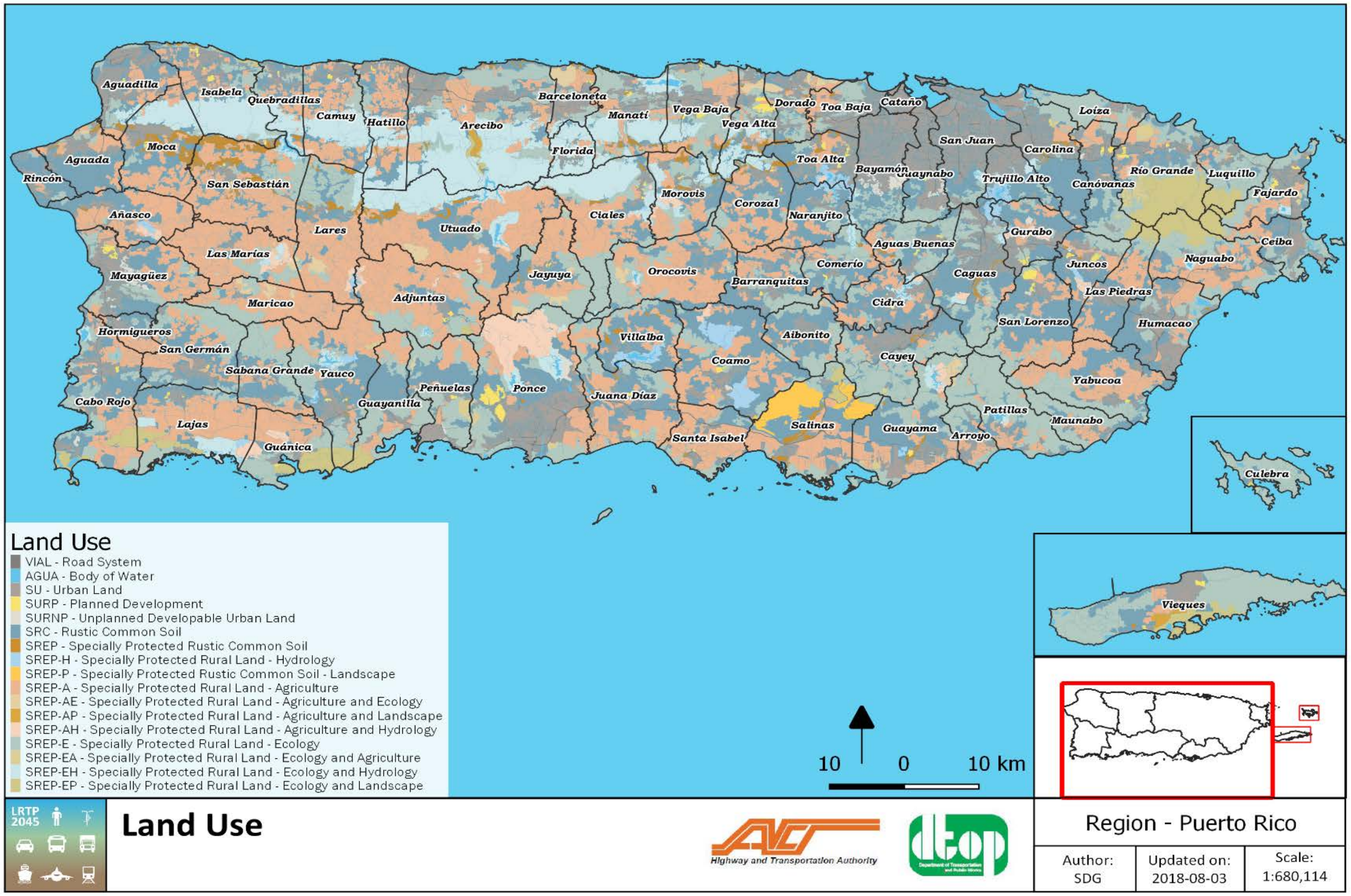
A review of available land use patterns in an Island-wide basis shows that:

- Old residential and urbanized areas are located within the coastal areas of Puerto Rico;
- Current residential development is taking place far from the coastal areas, mostly in the outskirts of already urbanized areas, including interior valleys;
- Industrial complexes have been established in the municipalities of Aguadilla, Barceloneta, Guayama, Manatí and Peñuelas, where there us a variability to easy access to and from major highways facilitate heavy traffic movement;
- Commercial land uses abound along the corridor of primary highway corridors such as the tolled highway system, PR-2 and PR-3; and
- Agricultural land uses prevail in the Isabela, Juana Díaz, Lajas, and Patillas Valleys, and municipalities of the center mountainous part of the Island such as Adjuntas, Lares, Las Marías, Maricao, and Utuado.

Since the areas amenable for their easy development have been already utilized, remaining ones designated for agricultural and preservation purposes have been experiencing development pressure. In the specific case of the pressure being exerted over agricultural lands, their preservation is important since there is an ever-growing need of agricultural products of the population. Currently, more than 50% of the agricultural products needs is supplied by imports, a fact that is exacerbated after extreme storm conditions such as María, where port facilities operations were impaired as result of the hurricane inflicted damages. Therefore, it is important that future planning efforts take into consideration future population growth needs, self-sufficiency, and resilience.

As may be observed from Figure 2.6, existing and proposed urbanization areas lean upon or overlap environmentally sensitive areas in most of the Regions of the Island. It is also noted that the growing expansion of urban areas into rural areas and the center of the Island increases the pressure being exerted over the sensitive tropical island ecosystems. This observation implies that special emphasis shall be provided for the advancement of sustainable growth development practices, including those pertaining to transportation. .

Figure 2.6: Puerto Rico Land Uses



Source: Land Use layer provided by Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym), the shapefile layer was created by the Puerto Rico Planning Board and was adopted on November 19, 2015.

It is important to mention that the Puerto Rico Planning Board approved the first Land Use Plan for Puerto Rico in 2015 with the objective of establishing the public policy on the management of land use that allows to maximize the potential of the Puerto Rican soil within a framework that guarantees the protection of natural resources and sustainable development. It is the framework that guides the public policy on land use for Puerto Rico.

The Land Use Plan for Puerto Rico in 2015 was a collaborative process where the Municipal land use plans or already autonomous municipalities and its Territorial Plans (Plan de Ordenamiento Territorial), where considered or integrated since the Planning Board regulates and approves the Territorial Plan process for the municipalities. This is required so that all municipalities move towards achieving the goals of: "(1) development and redevelopment in communities where infrastructure already exist, (2) preserve and protect the natural, archeological, agricultural, rural soils, and sensitivity environments to the adverse effects of uncontrolled construction, and (3) ensuring a desirable quality of life within cities, communities and neighborhoods in a fair and sustainable way"[11].

The Comprehensive Bicycle and Pedestrian Plan and the Complete Street Plan and Design Guidelines adopted on September 2018 will also foster a positive impact on the land use patterns. Both documents aim to encourage a physical integration of urban centers by providing alternatives modes of transportation.

Land Use Development Opportunities

There are some land use development opportunities with the potential to exert impacts on a regional basis during the course of decades. They are:

Roosevelt Roads Naval Base Redevelopment

The premises of the now closed Roosevelt Roads Naval Station encompasses an estimated area of 8,720 acres, located between the municipalities of Ceiba and Naguabo. Since the cease of its operations in March 31, 2004, the local government has been planning for a re-development of the property in an attempt to jump start the economy of the area which suffered a major blow when the Navy was forced to close this base which was in operations since 1940's, promoting a significant economic activity for the municipalities of the east Region. So far, these efforts have not given much results, but in its most recent attempt, the current government is proposing the development of this property under the Public Private Alliance (PPA) arrangement, with special interest in developing the tourism industry of the Region.

Island-wide Tourism Development

The Puerto Rico Tourism Company (PRTC), founded in 1970, is a public corporation responsible for stimulating, promoting and regulating the development of Puerto Rico's tourism industry. This

[11] Quoted from the Puerto Rico Land Use Plan approved November 19, 2015.

industry is a relatively clean one when compared with other types of industry, and possess the potential for a greater contribution to the Island's economic activity as a result of the presence of unique natural resources available in Puerto Rico.

Tourism must be promoted beyond the San Juan areas and should consider the offerings of the other regions which have diverse natural and culturally offering to visitors. By improving the transportation infrastructure in the Island including information strategies, the tourism industry will result benefitted as well as the entire population.

Environmental Resources

Although Puerto Rico covers a small land area, it possesses a diversity of natural resources and ecosystems, which are the result of its geological evolution across the ages. These features are a direct consequence of the sharp differences in ground elevations observed between the coastal plains and the central mountainous part of the Island. This variability in the topography, establishes the conditions for a variable rainfall patterns observed between the different Regions, which in turn provides adequate conditions for biodiversity and different landscapes. The location of Puerto Rico within a tropical zone of the Caribbean Sea, in conjunction with its geologic characteristics, has resulted in the development and evolution of environmental resources of its own. In terms of physiography, the Island can be divided into three distinct physiographic provinces[12], which are:

- The Upland province;
- The Northern Karst province; and
- The Coastal Plains province.

Each, exhibits a combination of tropical marine climate, temperature, topography and rainfall conditions that have resulted in the development of biological and natural resources that are unique for each Region, as can be noted in Figure 2.7.

This diversity is impressive, considering the relatively small size of the Island. The fact that there are environmental resources ranging from wet to dry forests coexisting in this space is a function of the orographic nature of the rainfall distribution; where the humidity carried by the trade winds incoming from the northeast as well as storm systems that generally move in a westbound direction are intercepted in the northern parts of the Island. This causes the noticeable dryer condition of the south and southwest part of the Island. In fact, the north side of the central mountainous divide known as Cordillera Central shows an annual rainfall intensity close to 100 inches while the southwest Region (which is the driest one) corresponding intensity is of approximately 30 inches. The higher rainfall intensity areas are associated with higher ground

[12] USGS, Monroe, 1980.

elevations of the central mountainous system, while the driest ones are located within coastal zones that exhibit lower elevations in the south part of the Island.

The combination of the mentioned environmental conditions has resulted in the establishment of flora and fauna ecosystems with special characteristics, some of them endemic to Puerto Rico. Examples of these species are the Cedro macho, coqui frog, Green mango, Maga flower, Monito gecko, Palo de Jazmin, Puerto Rican nightjar, Puerto Rican emerald, Puerto Rican parrot, Puerto Rican screech owl, Tortugo Prieto, and Yellow-shouldered blackbird, among others. The confluence of the mentioned conditions, including the presence of colonial historic structures in Old San Juan, has resulted in the development of a healthy tourism industry.

Coastal Plains

The second most common physiographic province of Puerto Rico is composed by the alluvial coastal plains that formed from the erosion of the interior mountainous. Therefore, it shows mostly low elevations and are made up by sediments. The north plains extend from the northwestern corner of the Island up to the Rio Grande de Loíza, in the northeastern corner, while the south plans extend from Ponce to Guayama. The north coastal plains band has a maximum width of 14 miles[13], while the south band extends to a maximum of approximately 8 miles. Across these areas is possible to find environmental resources such as agricultural valleys, beaches, dry forest reserves, lagoons, mangrove forests, and wetlands.

Close to the coastal plains band, a significant and protected karts system is found, as shown in Figure 2.8. This area is formed by limestone rocks, and is characterized by large-scale processes of breaking down and dissolution of rock. Due to this characteristic, waters enter rapidly to the aquifers, and therefore are susceptible to groundwater contamination, which constitutes a reason for its sensitivity and protection. A second broad karstic Region is observed in the southwestern area, between Ponce and Cabo Rojo. However, this area is not as developed as the previous one in terms of karstic features.

Outcroppings (“mogotes”) of limestone are scattered through the mountainous volcanic Region in the center of the island. Cave systems (like the Camuy Caves) as well as river valleys are common features of this area. The erosion of the limestone often leaves large sinkholes in the surface. One of these sinkholes contains one of the world’s largest telescopes used by the Arecibo Observatory, to assist in the ongoing research regarding global climate and the effects of climatic changes on the environment.

[13] Atlas of Groundwater Resources in Puerto Rico and the U.S. Virgin Islands, Report 94-4198, U.S. Geological Survey, 1996.

A review of the land uses map in Figure 2.6 shows that most of the major population centers of the Island are located within these areas, which is the result of the availability of water resources and suitable conditions for the development of lands.

Mountains

The mountainous interior of Puerto Rico and its offshore islands are composed mainly of a mixture of volcanic and sedimentary rocks. It covers approximately a 60% of its entire surface. The Central Mountains range (Cordillera Central), is the main mountain range in Puerto Rico and crosses the island from west to east and divides the island into northern and southern coastal plains. It runs eastward from Maricao, in the west to Aibonito, in the central eastern Puerto Rico Region and on to the outskirts of the Sierra de Cayey. Sierra de Cayey is an extension of Cordillera Central that begins in the town of Cayey and runs eastwardly to Humacao. The Sierra de Cayey "extension" ends in a fork with two lower ranges: Sierra Guardarraya and Cuchillas de Panduras which run eastward to Yabucoa and Patillas respectively.

There is an additional Cordillera Central eastern branch, Sierra de Luquillo, which runs northeastwardly from Gurabo to Fajardo and includes several high peaks, including Toro Hill, at 3,524 ft. (1,074 m), El Yunque at 3,494 ft. (1,065 m) and El Pico Oeste at 3,446 ft. (1,056 m). El Yunque forest is the only Tropical Forest Reserve under the jurisdiction of the U.S. Forest Service system.

Important environmental resources located within this Region are: agricultural lands, caves, extensive forestland, landslide prone slope areas, and springs. Extensive tropical vegetation and fauna are observed in most of the rural areas of this Region.

Agriculture

Historically, until the 1950’s, agriculture constituted the most significant source of economic activity of the Island. Bananas, coffee, oranges, roots, tobacco, and tubers constituted the main agricultural crops cultivated in the Island. However, the government geared the local economy toward a manufacturing and petrochemical industry based one, in an effort to improve the extreme poverty levels of the population. This resulted in a constant and prolonged reduction of the agricultural output while benefiting the establishment of new manufacturing facilities. This trend was adversely impacted as a result of global economic conditions, which has been resulting in a continuously reduced manufacturing labor force.

In response to this situation, a slow return of the agriculture industry is being observed, but this time with the advantage of modern agricultural practices, which help to maximize the use of available lands. Current most important agricultural products include bananas, coffee, plantains, mangos and other high value specialty products such as mushrooms, lettuce and tomatoes. In addition, dairy production and other livestock products provide other streams of agricultural income. The principal agricultural valleys are located in the southwest and south parts of the Island, but many small farms are scattered through the interior mountainous parts.

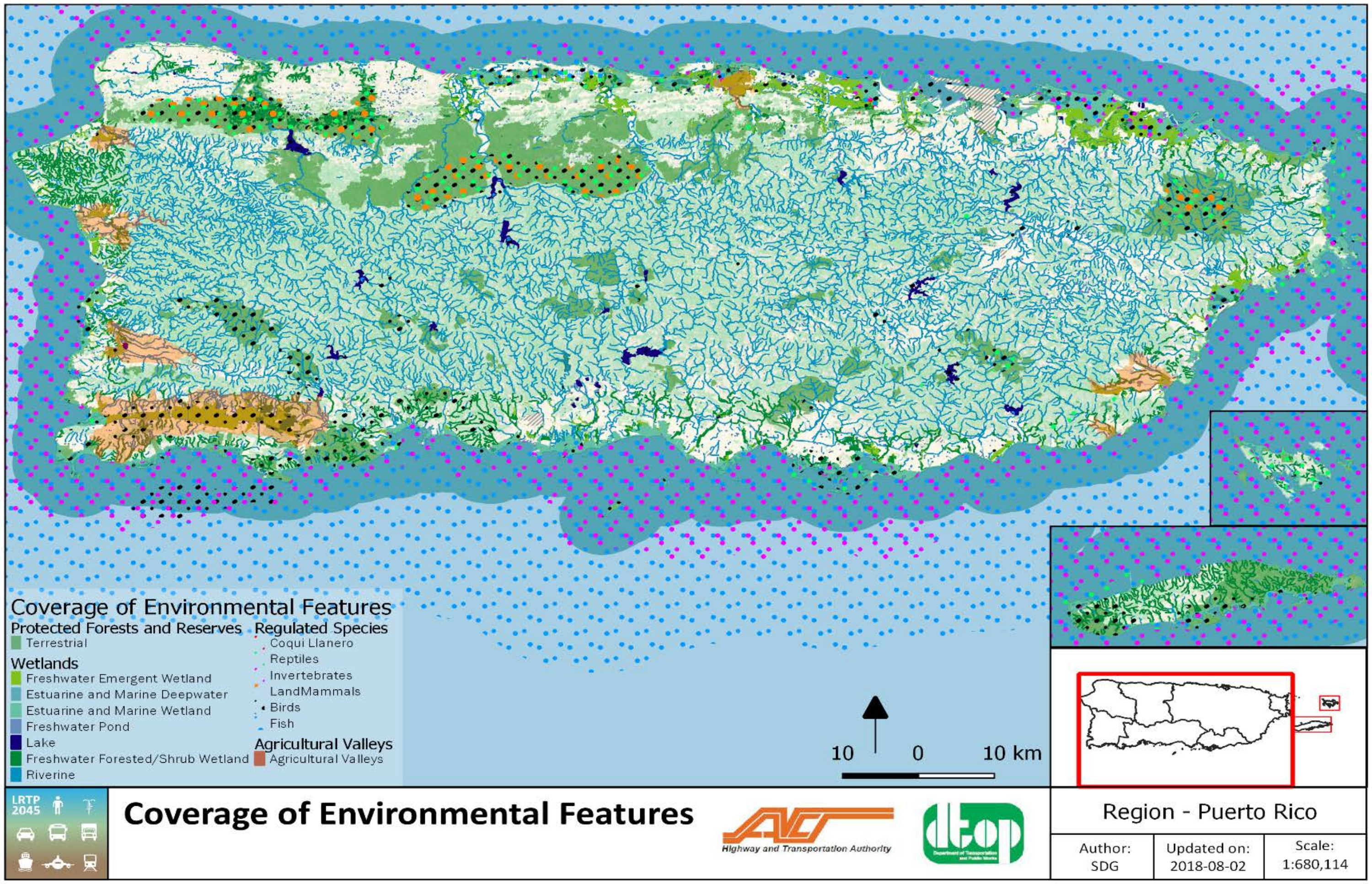
Forest and Wildlife Preserves

The mountainous ranges of Puerto Rico with their abundant rainfall and exuberant flora and fauna species host many state forest reserves. Perhaps, the most commonly known as El Yunque Caribbean National forest that comprises approximately 28,000 acres of land and is nested in the Sierra de Luquillo mountain range. It is the only tropical rainforest in US soil to be administered by the U.S. Forest Service. However, it is an area under preservation since 1876, when the Spanish crown set it aside for preservation. Even with this government protection, the area is being pressured in the past by attempts from private entities to develop nearby areas. These development efforts which may have resulted in negative impacts to the protected species that live within the forest efforts have been effectively controlled by both the local and federal government agencies with the establishment of special zoning and planning requirement applicable to projects in municipalities that surround this forest.

In contrast to the mountainous forest system, the Guánica Dry Forest and the Cabo Rojo Wildlife Refuge are examples of important reserves located in the southwest corner of the Island, in south coastal plains.

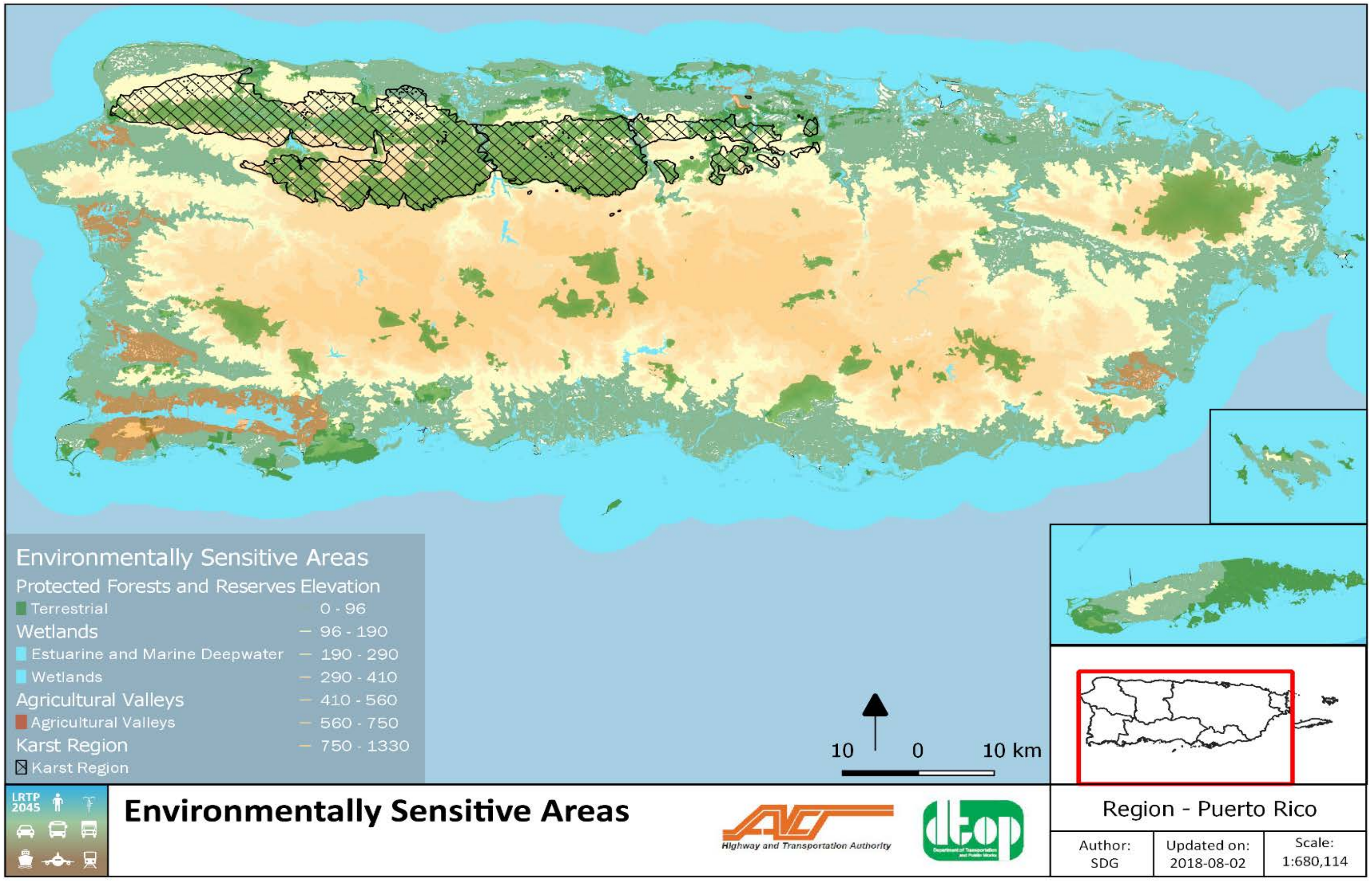
Future planned developments with the potential to negatively affect these preserved and unique natural resources shall be carefully analyzed to assess and eliminate them to the extent possible. Fortunately, there are numerous and established environmental regulations which are enforced locally by the Environmental Quality Board (EQB) and the Department of Natural and Environmental Resources (DNER). At a federal level agency such as the U.S. Fish and Wildlife Service (USFWS) and the U.S. Environmental Protection Agency (EPA) are vigilant of the protection of those environmental resources. Regarding to transportation improvement projects, new and future ones will be required to consider avoidance, minimization and mitigation of any identified environmental impact. The MPO, through the PRHTA, supports the coordination with federal and Commonwealth agencies to promote a consultation process.

Figure 2.7: Puerto Rico Environmental Features



Source: The Coverage of Environmental Features Map was created using information layers from various government agencies listed as follows: Wetlands https://www.fws.gov/wetlands/data/Mapper.html | Regulated Species: Puerto Rico Planning Board Web Feature Service: http://geoserver.gis.pr.gov:80/geoserver/wfs? | Agricultural Valleys: Puerto Rico Planning Board: http://www2.pr.gov/agencias/gis/descargaGeodatos/Desarrollo_Economico/Pages/Agricultura.aspx | Protected Forests and Reserves https://www.fs.usda.gov/detail/iitf/research/?cid=fseprd528757

Figure 2.8: Puerto Rico Environmentally Sensitive Areas



Source: The Environmentally Sensitive Areas Map was created using information layers from various government agencies listed as follows: Wetlands https://www.fws.gov/wetlands/data/Mapper.html | Elevation: Puerto Rico Planning Board Web Feature Service: http://geoserver.gis.pr.gov:80/geoserver/wfs? | Agricultural Valleys: Puerto Rico Planning Board: http://www2.pr.gov/agencias/gis/descargaGeodatos/Desarrollo_Economico/Pages/Agricultura.aspx | Protected Forests and Reserves https://www.fs.usda.gov/detail/iitf/research/?cid=fseprd528757

DEMOGRAPHICS

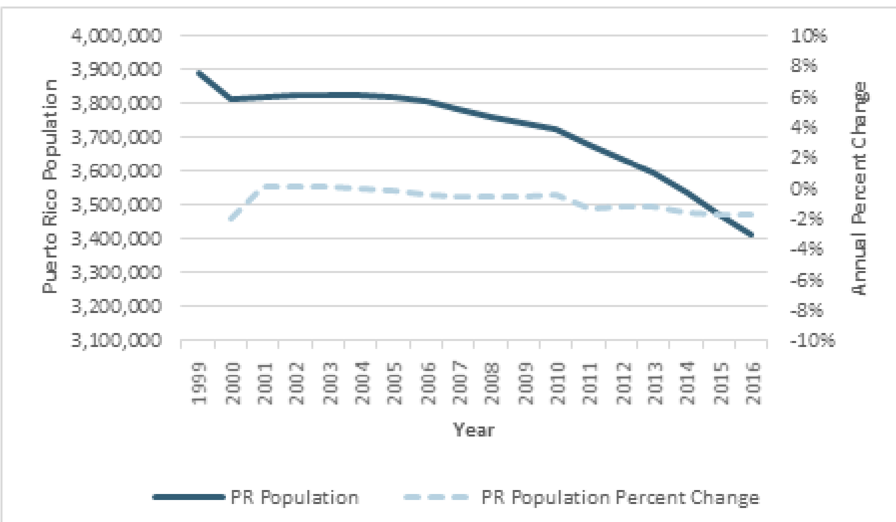
Population

The population growth trend is fundamental in estimating travel patterns and its impact on the operation performance in terms of congestion and reliability of the transportation system. The Population in Puerto Rico had experienced a decreasing trend since 2005 when the Island started to register an economic recession along with other countries and the United States. This trend on population had continued from an annual trend of 0.5% between 2005 and 2010 to over 1% after 2010 as shown in Figure 2.9.

According to the US Census Bureau and the Puerto Rico Statistic Institute, the population of Puerto Rico is projected to be less than three million people (2,980,532 people) by the year 2025. In its previous projection, this happened for the year 2050. For the year 2050, the new projection is only two million people (2,089,492 people) in Puerto Rico[14].

Between 2010 and 2016, the island population declined 8.4% from 3,725,789 to 3,411,307, a loss of 314,482 people, as can be seen in Figure 2.10.

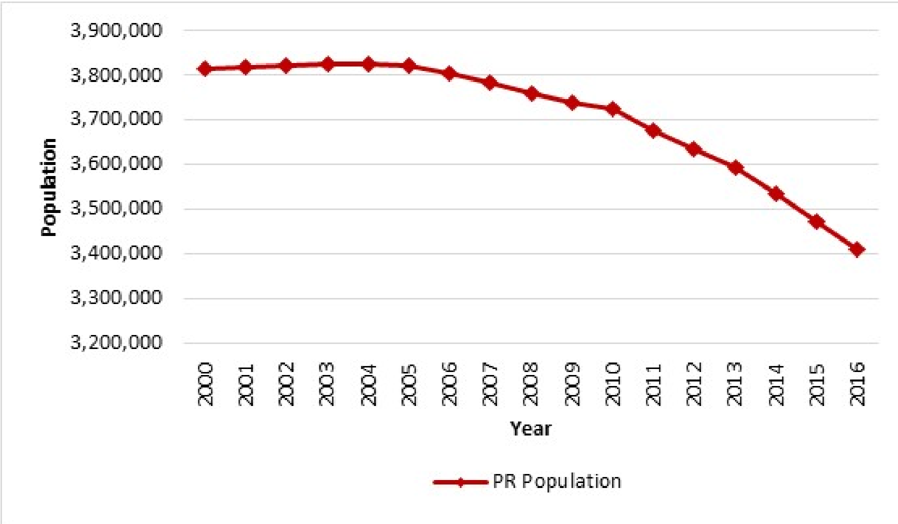
Figure 2.9: Puerto Rico Historic Population



Source: SDG analysis of US Census Data

[14] U.S. Census Bureau projects population in Puerto Rico will be below 3 million inhabitants in just 8 years (2025). (September 2017) Press Release. Red State Data Center of Puerto Rico (SDC-PR). https://censo.estadisticas.pr/Comunicado-de-prensa/2017-09-17t125335.

Figure 2.10: Puerto Rico Population



Source: SDG analysis of US Census Bureau Estimates

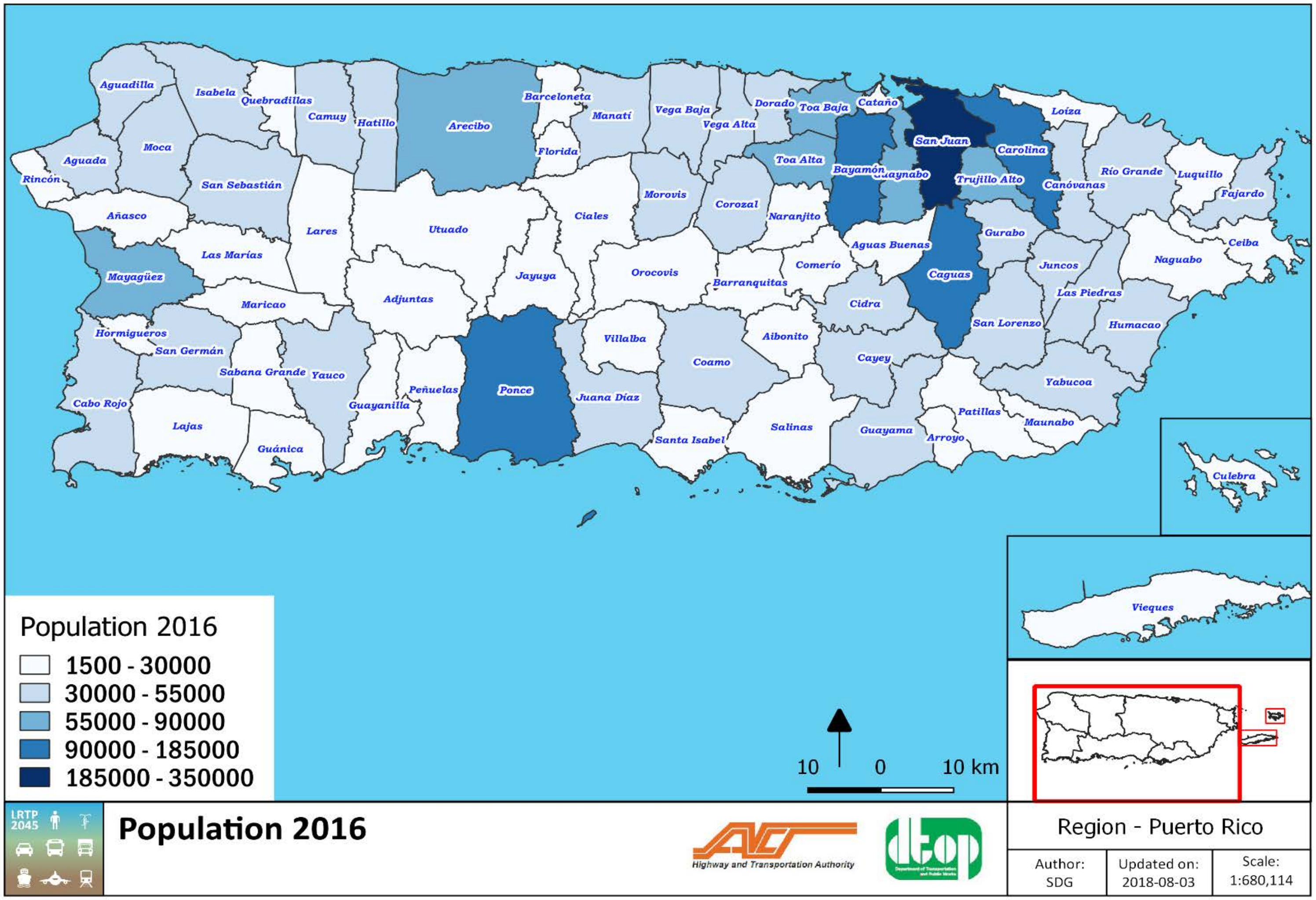
The population in the island has been decreasing since 2000 with an overall decrease of 2.3% from 2000 to 2010 and a more severe 8.4% from 2010 and 2016.

As shown in Figure 2.11, the most populated municipalities in the island are San Juan, Bayamón, Carolina, Caguas and Ponce.

From 2000 to 2010 there was a mix of population losses and gains within the island's municipalities with 43 of the 78 losing population between -0.01% in Salinas to -24.7% in Ceiba. Increases in population were observed in the remaining 18 municipalities from 0.04% in San Lorenzo to as high as 22.6% in Gurabo.

Between 2010 and 2016, Gurabo was the only municipality in the Puerto Rico where population growth occurred (4.2%); meanwhile, Lares exhibited the largest percent reduction in population (13.4%) followed by Peñuelas (13.0%). In levels, San Juan experienced the most significant population reduction (48,274), followed by Bayamón (23,747). Population changes are shown in Table 2.1.

Figure 2.11: Puerto Rico Population 2016



Source: Population Estimates from U.S. Census Bureau

Table 2.1: Puerto Rico Population 2000-2010-2016

Municipality	2000	2010	2000-2010 % Change	2016	2010-2016 % Change
Adjuntas	19,213	19,483	1.4%	18,314	(6.0%)
Aguada	42,262	41,959	(0.7%)	38,938	(7.2%)
Aguadilla	64,879	60,949	(6.1%)	54,582	(10.4%)
Aguas Buenas	29,199	28,659	(1.8%)	26,471	(7.6%)
Aibonito	26,600	25,900	(2.6%)	23,605	(8.9%)
Añasco	28,505	29,261	2.7%	27,540	(5.9%)
Arecibo	100,370	96,440	(3.9%)	87,939	(8.8%)
Arroyo	19,195	19,575	2.0%	18,236	(6.8%)
Barceloneta	22,432	24,816	10.6%	24,467	(1.4%)
Barranquitas	29,044	30,318	4.4%	28,977	(4.4%)
Bayamon	224,162	208,116	(7.2%)	184,374	(11.4%)
Cabo Rojo	47,211	50,917	7.8%	49,361	(3.1%)
Caguas	140,704	142,893	1.6%	132,164	(7.5%)
Camuy	35,471	35,159	(0.9%)	32,434	(7.8%)
Canóvanas	43,553	47,648	9.4%	46,477	(2.5%)
Carolina	185,765	176,762	(4.8%)	158,457	(10.4%)
Cataño	30,020	28,140	(6.3%)	24,968	(11.3%)
Cayey	47,416	48,119	1.5%	44,796	(6.9%)
Ceiba	18,093	13,631	(24.7%)	11,937	(12.4%)
Ciales	19,912	18,782	(5.7%)	17,021	(9.4%)
Cidra	43,012	43,480	1.1%	40,599	(6.6%)
Coamo	37,743	40,512	7.3%	39,558	(2.4%)
Comerío	20,057	20,778	3.6%	19,699	(5.2%)
Corozal	37,015	37,142	0.3%	34,408	(7.4%)
Culebra	1,944	1,818	(6.5%)	1,797	(1.2%)
Dorado	34,157	38,165	11.7%	37,536	(1.6%)
Fajardo	40,864	36,993	(9.5%)	32,219	(12.9%)
Florida	12,535	12,680	1.2%	11,988	(5.5%)
Guánica	21,993	19,427	(11.7%)	16,897	(13.0%)
Guayama	44,403	45,362	2.2%	42,063	(7.3%)
Guayanilla	23,161	21,581	(6.8%)	19,125	(11.4%)
Guaynabo	100,280	97,924	(2.3%)	89,307	(8.8%)
Gurabo	36,995	45,369	22.6%	47,269	4.2%
Hatillo	39,131	41,953	7.2%	40,676	(3.0%)
Hormigueros	16,705	17,250	3.3%	16,290	(5.6%)
Humacao	59,158	58,466	(1.2%)	53,895	(7.8%)
Isabela	44,604	45,631	2.3%	42,744	(6.3%)
Jayuya	17,377	16,642	(4.2%)	14,984	(10.0%)
Juana Diaz	50,635	50,747	0.2%	47,309	(6.8%)
Juncos	36,566	40,290	10.2%	39,477	(2.0%)
Lajas	26,308	25,753	(2.1%)	23,434	(9.0%)
Lares	34,493	30,753	(10.8%)	26,629	(13.4%)
Las Marías	11,051	9,881	(10.6%)	8,645	(12.5%)
Las Piedras	34,578	38,675	11.8%	38,049	(1.6%)
Loíza	32,522	30,060	(7.6%)	26,583	(11.6%)

Municipality	2000	2010	2000-2010 % Change	2016	2010-2016 % Change
Luquillo	19,780	20,068	1.5%	18,660	(7.0%)
Manatí	45,498	44,113	(3.0%)	39,941	(9.5%)
Maricao	6,383	6,276	(1.7%)	5,786	(7.8%)
Maunabo	12,682	12,225	(3.6%)	11,074	(9.4%)
Mayagüez	98,311	89,080	(9.4%)	77,748	(12.7%)
Moca	39,770	40,109	0.9%	37,117	(7.5%)
Morovis	29,988	32,610	8.7%	31,603	(3.1%)
Naguabo	23,708	26,720	12.7%	26,448	(1.0%)
Naranjito	29,658	30,402	2.5%	28,805	(5.3%)
Orocovis	23,815	23,423	(1.6%)	21,529	(8.1%)
Patillas	20,076	19,277	(4.0%)	17,472	(9.4%)
Peñuelas	26,730	24,282	(9.2%)	21,117	(13.0%)
Ponce	186,286	166,327	(10.7%)	145,278	(12.7%)
Quebradillas	25,465	25,919	1.8%	24,201	(6.6%)
Rincon	14,756	15,200	3.0%	14,380	(5.4%)
Rio Grande	52,429	54,304	3.6%	51,009	(6.1%)
Sabana Grande	25,928	25,265	(2.6%)	23,163	(8.3%)
Salinas	31,080	31,078	(0.0%)	28,846	(7.2%)
San German	37,077	35,527	(4.2%)	32,321	(9.0%)
San Juan	434,747	395,326	(9.1%)	347,052	(12.2%)
San Lorenzo	41,043	41,058	0.0%	38,174	(7.0%)
San Sebastian	44,243	42,430	(4.1%)	38,202	(10.0%)
Santa Isabel	21,625	23,274	7.6%	22,277	(4.3%)
Toa Alta	64,348	74,066	15.1%	73,980	(0.1%)
Toa Baja	94,066	89,609	(4.7%)	80,207	(10.5%)
Trujillo Alto	75,981	74,842	(1.5%)	68,242	(8.8%)
Utuado	35,252	33,149	(6.0%)	29,564	(10.8%)
Vega Alta	37,890	39,951	5.4%	38,230	(4.3%)
Vega Baja	61,962	59,662	(3.7%)	53,674	(10.0%)
Vieques	9,038	9,301	2.9%	8,825	(5.1%)
Villalba	27,915	26,073	(6.6%)	23,113	(11.4%)
Yabucoa	39,210	37,941	(3.2%)	34,358	(9.4%)
Yauco	46,380	42,043	(9.4%)	36,673	(12.8%)

Source: US Census Bureau Estimates 2000-2016

Employment[15]

In 2016, there were 986,151 jobs available on the island, with 61.9% of total formal and informal employment focused in the San Juan TMA.[16] The San Juan municipality, accounts for the largest single portion of employment, composing 12.4% of Puerto Rico employment; this is followed by Bayamon and Carolina at 6.4% and 5.3% respectively, as shown in Figure 2.13.

Puerto Rico lost 7.1% of its employment between 2010 and 2016, which amounts to 74,905 jobs and a Compound Annual Growth Rate (CAGR) of -1.2%. Figure 2.12, showing employment by place of residence, helps depict this trend.[17]

[15] Employment Data used to graph trends in this section showing intermediate years between 2010 to 2016 is by Place of Residence and covers all employment sectors including agricultural employment and the self-employed. In employment tables showing just the years 2010 and 2016, employment is by place of work, and covers all the employment sectors noted above. The sourcing under each table or graph, will note whether the data is by Place of Residence or Place of Work.

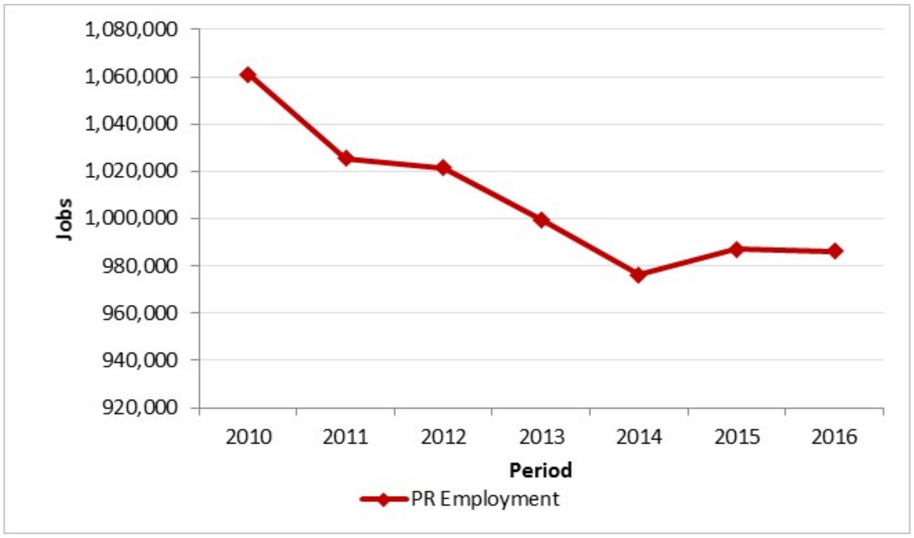
[16] This data is obtained from the Bureau of Labor Statistics Local Area Unemployment Statistics (LAUS) program. This program relies heavily on the Current Population Survey (CPS); a monthly survey consisting of in-person and telephone visits to a rotating sample of the population. Because the CPS occurs at individuals home locations, it is adept at capturing both formal and informal employment. The definition of employment by the BLS is:

> "All persons who, during the reference week, (a) did any work at all (at least 1 hour) as paid employees, worked in their own business, profession, or on their own farm, or worked 15 hours or more as unpaid workers in an enterprise operated by a member of the family, and (b) all those who were not working but who had jobs or businesses from which they were temporarily absent because of vacation, illness, bad weather, childcare problems, maternity or paternity leave, labor-management dispute, job training, or other family or personal reasons, whether or not they were paid for the time off or were seeking other jobs".

Quoted from Bureau of Labor Statistics, U.S. Department of Labor, Household Data, Current Population Survey, on the Internet at https://www.bls.gov/cps/eetech_methods.pdf (visited May 29, 2018).

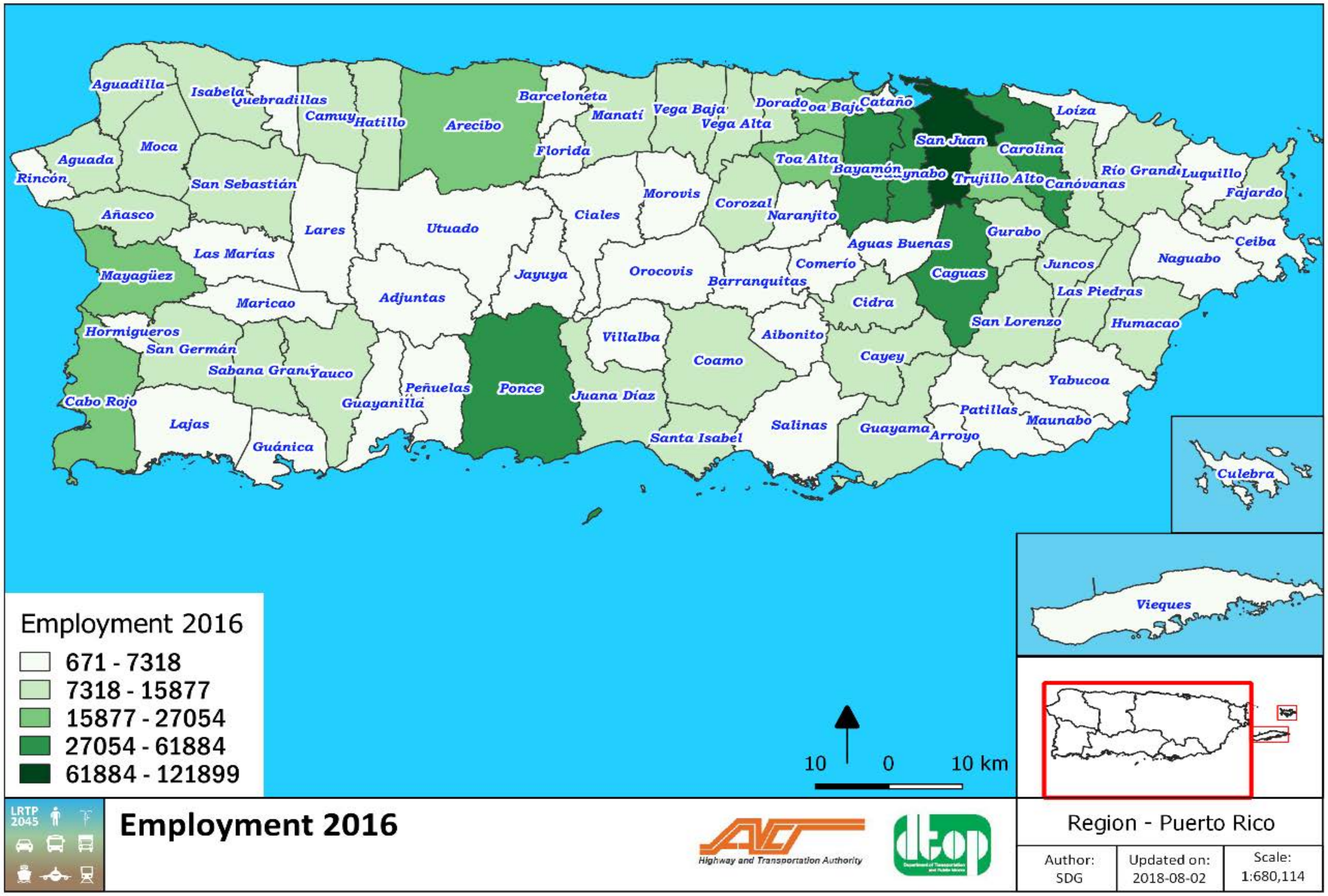
[17] As employment was only transformed from Place of Residence to Place of Work for the spot years 2010 and 2016. Employment data by Place of Residence has been utilized to depict historical trends over time.

Figure 2.12: Puerto Rico – Employment



Source: SDG analysis of Bureau of Labor Statistics (BLS) Local Area Unemployment Statistics (LAUS) by Place of Residence

Figure 2.13: Puerto Rico Employment 2016



Source: Employment Data from the BLS LAUS, transformed to present employment by place of work.

Puerto Rico's overall employment rate has decreased since 2010. There were 74,905 less employed citizens in 2016 than there were in 2010 (7.1%), as shown in Table 2.2.

Table 2.2: Puerto Rico Employment by Place of Work 2010-2016

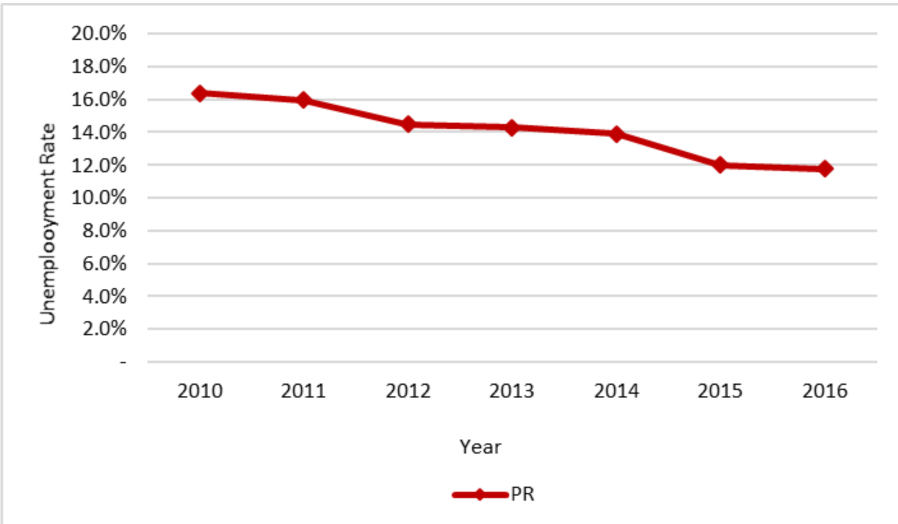
Municipality	2010	2016	2010 to 2016 Percent Change
Adjuntas	3,677	3,122	(15.1%)
Aguada	11,648	10,027	(13.9%)
Aguadilla	16,033	15,877	(1.0%)
Aguas Buenas	7,348	6,435	(12.4%)
Aibonito	5,918	5,733	(3.1%)
Añasco	7,957	7,641	(4.0%)
Arecibo	25,628	22,400	(12.6%)
Arroyo	4,274	4,150	(2.9%)
Barceloneta	5,438	5,413	(0.5%)
Barranquitas	6,672	5,665	(15.1%)
Bayamon	65,180	61,884	(5.1%)
Cabo Rojo	17,349	16,687	(3.8%)
Caguas	42,045	40,164	(4.5%)
Camuy	10,194	9,896	(2.9%)
Canóvanas	11,043	9,744	(11.8%)
Carolina	61,125	52,512	(14.1%)
Cataño	5,963	5,533	(7.2%)
Cayey	11,184	9,370	(16.2%)
Ceiba	4,375	3,260	(25.5%)
Ciales	3,812	3,283	(13.9%)
Cidra	12,994	11,661	(10.3%)
Coamo	8,457	8,025	(5.1%)
Comerío	2,730	2,770	1.5%
Corozal	8,155	7,991	(2.0%)
Culebra	557	671	20.6%
Dorado	10,208	11,566	13.3%
Fajardo	11,176	11,305	1.2%
Florida	3,301	2,909	(11.9%)
Guánica	4,955	5,015	1.2%
Guayama	11,267	9,275	(17.7%)
Guayanilla	5,300	3,951	(25.5%)
Guaynabo	36,458	41,042	12.6%
Gurabo	12,418	11,351	(8.6%)
Hatillo	10,002	10,473	4.7%
Hormigueros	5,335	5,296	(0.7%)
Humacao	15,549	14,272	(8.2%)
Isabela	11,690	11,648	(0.4%)
Jayuya	3,287	2,797	(14.9%)
Juana Diaz	13,884	13,431	(3.3%)

Municipality	2010	2016	2010 to 2016 Percent Change
Juncos	10,121	10,167	0.4%
Lajas	7,185	6,190	(13.9%)
Lares	8,743	7,077	(19.1%)
Las Marías	3,339	2,450	(26.6%)
Las Piedras	9,917	8,719	(12.1%)
Loíza	6,637	6,311	(4.9%)
Luquillo	5,155	3,953	(23.3%)
Manatí	11,176	11,962	7.0%
Maricao	1,308	1,136	(13.2%)
Maunabo	2,629	1,971	(25.0%)
Mayagüez	23,283	20,403	(12.4%)
Moca	11,257	11,191	(0.6%)
Morovis	6,959	5,762	(17.2%)
Naguabo	5,520	5,240	(5.1%)
Naranjito	6,647	5,417	(18.5%)
Orocovis	4,162	3,393	(18.5%)
Patillas	4,564	3,863	(15.4%)
Peñuelas	6,306	5,357	(15.1%)
Ponce	51,618	46,586	(9.7%)
Quebradillas	6,699	5,906	(11.8%)
Rincon	4,176	4,549	8.9%
Rio Grande	13,998	13,461	(3.8%)
Sabana Grande	7,477	7,972	6.6%
Salinas	6,415	5,278	(17.7%)
San German	10,416	9,155	(12.1%)
San Juan	135,295	121,899	(9.9%)
San Lorenzo	11,165	10,184	(8.8%)
San Sebastian	11,382	11,494	1.0%
Santa Isabel	8,872	10,619	19.7%
Toa Alta	24,443	22,776	(6.8%)
Toa Baja	28,237	27,054	(4.2%)
Trujillo Alto	28,666	25,671	(10.5%)
Utuado	6,684	6,528	(2.3%)
Vega Alta	9,592	8,510	(11.3%)
Vega Baja	15,834	14,233	(10.1%)
Vieques	2,446	3,139	28.4%
Villalba	7,374	7,318	(0.8%)
Yabucoa	7,950	6,475	(18.6%)
Yauco	12,820	12,546	(2.1%)

Source: 2010 2040 LRTP and 2016 SDG Analysis of Bureau of Labor Statistics Local Area Unemployment Statistics, adjusted to be by Place of Work

In 2016, Puerto Rico's unemployment rate, 11.8%, has decreased from 2010 to 2016, as shown in Figure 2.14 and Figure 2.15.

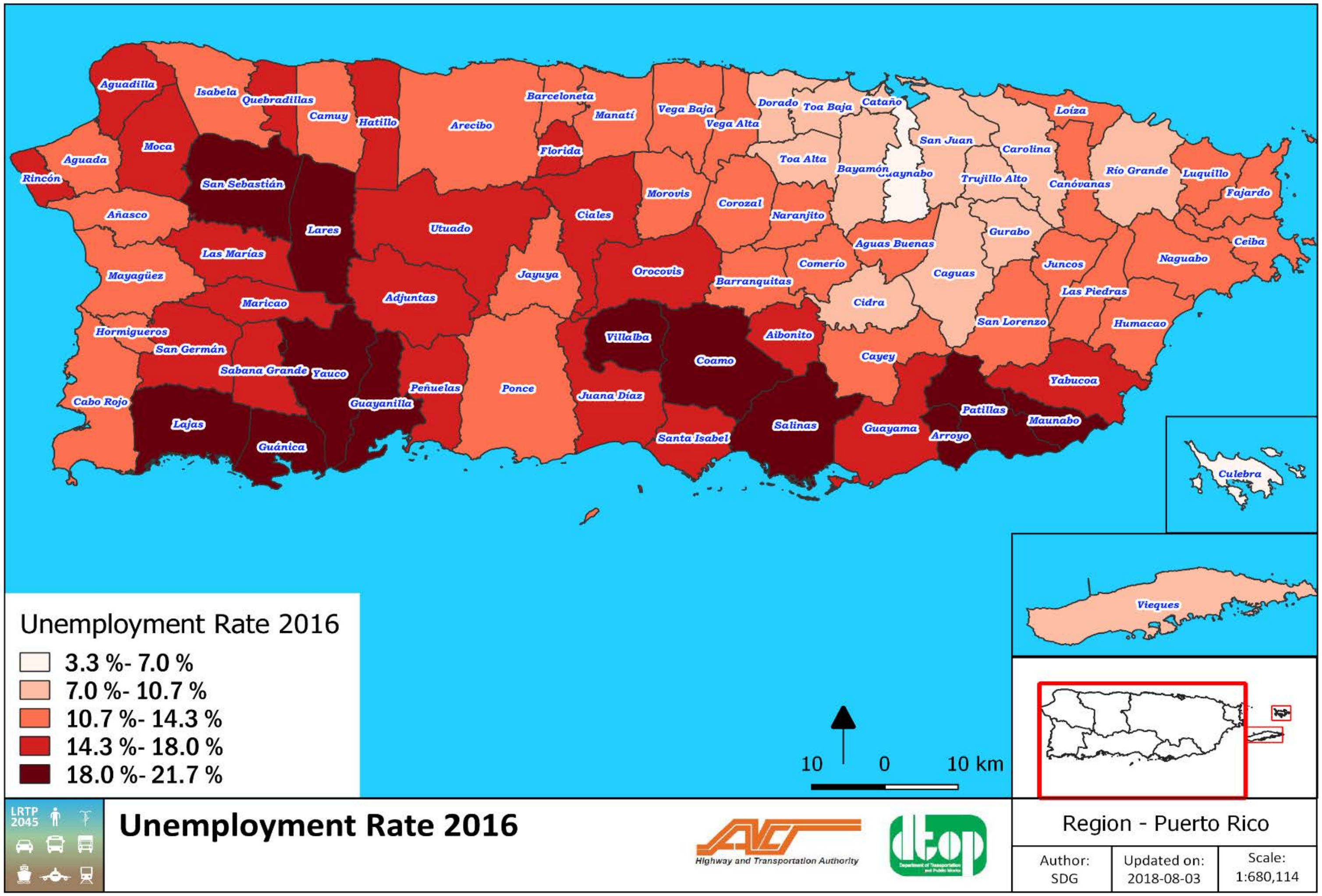
Figure 2.14: Puerto Rico– Unemployment Rate



Source: SDG analysis of Bureau of Labor Statistics Local Area Unemployment Statistics by Place of Residence

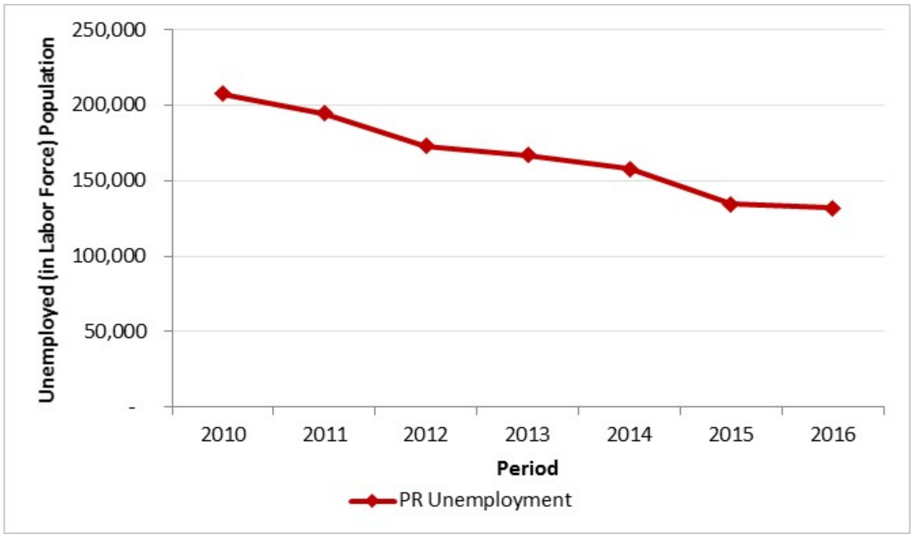
Table 2.3 and Figure 2.16 display the unemployed population in Puerto Rico per years. In Figure 2.23, Salinas, Patillas and Villalba have the highest unemployment rates at 22%, 21%, and 20% respectively, and all three have relatively small labor forces all under 10,000 in 2016. The three largest municipalities in terms of labor force, San Juan, Bayamon, and Carolina all have unemployment rates below 10%.

Figure 2.15: Puerto Rico Unemployment Rate 2016



Source: Bureau of Labor Statistics, Local Area Unemployment Statistics - https://www.bls.gov/lau/

Figure 2.16: Puerto Rico Unemployed (In Labor Force) Population

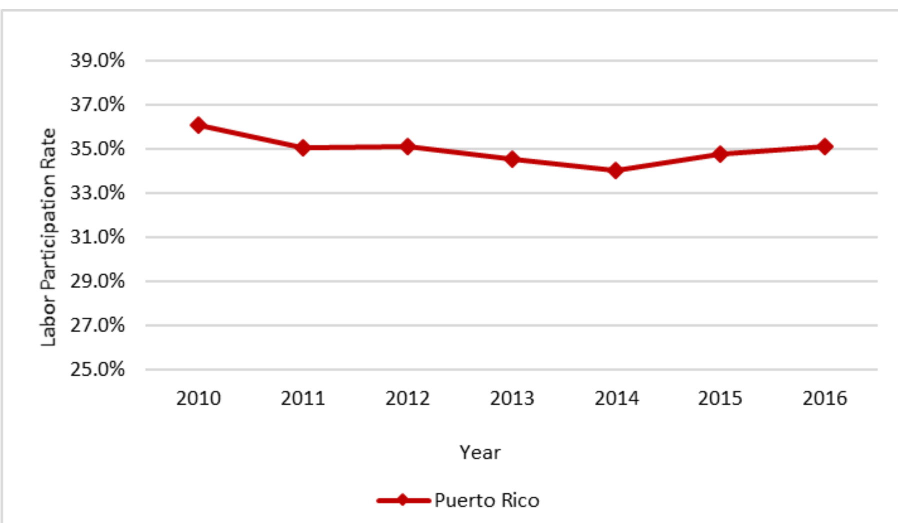


Source: SDG analysis of Bureau of Labor Statistics Local Area Unemployment Statistics by Place of Residence

The LAUS survey does not distinguish between informal and formal employment, as questions of taxation or method of payment do not determine whether someone is counted as employed.

Unemployment has declined as employment declined because population and the labor force decreased at a faster rate than employment losses. This is highly related to the migration of individuals in the labor force out of the Island and the effect of low birth rates over the past 20 years starting to affect the workforce. Puerto Rico's participation rate, calculated as labor force as a portion of population over 16 years old, and shown in Figure 2.17, has remained in the range of 34% to 36%.

Figure 2.17: Puerto Rico Participation Rate in Labor Force



Source: SDG analysis of ACS population estimates and BLS LAUS employment data

Table 2.3: Puerto Rico Unemployed (In Labor Force) Population by Municipality

Municipality	2010	2011	2012	2013	2014	2015	2016
Adjuntas	1,016	1,075	1,078	1,112	989	780	755
Aguada	2,626	2,602	2,329	2,284	2,070	1,659	1,667
Aguadilla	3,556	3,310	3,013	2,689	2,470	2,081	2,223
Aguas Buenas	1,767	1,579	1,368	1,196	1,147	1,002	975
Aibonito	1,467	1,466	1,376	1,196	1,202	973	996
Añasco	1,933	1,780	1,590	1,705	1,475	1,159	1,147
Arecibo	5,016	4,725	4,050	3,943	3,801	3,338	3,173
Arroyo	1,423	1,384	1,296	1,434	1,235	981	956
Barceloneta	1,625	1,429	1,198	1,357	1,226	901	831
Barranquitas	1,443	1,378	1,274	1,198	1,187	986	962
Bayamon	9,922	9,318	7,943	7,040	6,999	6,283	5,973
Cabo Rojo	2,564	2,476	2,249	3,000	2,473	1,734	1,768
Caguas	8,525	7,956	7,059	6,024	5,751	5,036	4,996
Camuy	1,791	1,650	1,429	1,504	1,437	1,216	1,178
Canóvanas	3,156	2,794	2,324	2,151	2,119	1,918	1,875
Carolina	9,272	8,251	7,034	6,128	6,215	5,567	5,388
Cataño	1,408	1,351	1,174	1,104	1,009	844	796
Cayey	2,882	2,795	2,594	2,296	2,081	1,750	1,745
Ceiba	970	931	829	758	686	537	498
Ciales	1,292	1,090	929	1,148	967	682	621
Cidra	2,745	2,639	2,448	2,070	1,894	1,550	1,599
Coamo	2,668	2,709	2,477	2,308	2,328	2,088	1,970
Comerío	1,303	1,190	1,134	1,097	1,000	788	685
Corozal	1,762	1,780	1,572	1,463	1,447	1,271	1,139
Culebra	83	62	48	57	49	31	30
Dorado	1,624	1,414	1,181	1,137	1,111	1,005	1,045
Fajardo	2,744	2,674	2,290	2,101	2,102	1,710	1,562
Florida	851	762	703	772	667	510	489
Guánica	1,308	1,258	1,182	1,273	1,122	827	750
Guayama	3,521	3,175	2,790	2,823	2,524	2,126	1,981
Guayanilla	1,530	1,342	1,234	1,253	1,202	1,039	993
Guaynabo	3,506	3,159	2,586	2,294	2,314	2,174	2,221
Gurabo	2,475	2,276	1,954	1,841	1,809	1,508	1,491
Hatillo	2,298	2,312	2,183	2,159	2,138	2,047	2,076
Hormigueros	1,023	930	880	996	828	651	690
Humacao	4,272	4,200	3,789	3,399	3,116	2,611	2,470
Isabela	2,679	2,532	2,295	2,104	1,886	1,559	1,783
Jayuya	996	913	770	800	737	617	547
Juana Diaz	3,099	2,978	2,691	2,512	2,573	2,397	2,265
Juncos	2,508	2,402	2,103	1,974	1,926	1,741	1,649
Lajas	1,501	1,461	1,418	1,704	1,411	1,009	1,054
Lares	1,606	1,642	1,511	2,004	1,774	1,503	1,435
Las Marías	673	659	601	749	736	487	427
Las Piedras	2,388	2,306	2,273	2,070	1,847	1,598	1,534
Loíza	1,717	1,456	1,206	1,141	1,187	1,036	982
Luquillo	1,489	1,472	1,372	1,283	1,285	1,007	902
Manatí	2,545	2,238	1,875	1,657	1,628	1,388	1,357

Municipality	2010	2011	2012	2013	2014	2015	2016
Maricao	426	407	400	450	411	307	299
Maunabo	875	867	765	697	670	562	556
Mayagüez	5,206	4,883	4,289	4,807	4,155	3,174	3,194
Moca	2,453	2,392	2,202	2,199	1,990	1,665	1,677
Morovis	2,119	1,841	1,589	1,676	1,561	1,148	1,095
Naguabo	1,947	1,676	1,461	1,392	1,266	1,068	1,000
Naranjito	1,669	1,520	1,314	1,267	1,249	1,003	944
Orocovis	1,361	1,197	1,138	1,036	1,027	860	809
Patillas	1,583	1,470	1,372	1,253	1,172	1,014	996
Peñuelas	1,819	1,612	1,399	1,373	1,375	1,095	1,024
Ponce	9,535	9,024	8,299	8,109	7,554	6,745	6,432
Quebradillas	1,341	1,275	1,178	1,206	1,134	1,016	973
Rincon	920	965	899	976	941	768	725
Rio Grande	2,876	2,633	2,223	2,077	2,049	1,770	1,797
Sabana Grande	1,624	1,572	1,469	1,425	1,224	944	1,024
Salinas	2,387	2,365	2,237	2,236	2,199	1,912	1,644
San German	2,207	2,134	2,043	2,164	1,907	1,463	1,586
San Juan	15,939	14,781	12,791	11,246	11,020	10,356	10,693
San Lorenzo	2,325	2,287	2,003	2,098	1,916	1,574	1,496
San Sebastian	2,637	2,670	2,504	2,709	2,566	2,129	2,033
Santa Isabel	2,152	2,150	1,978	1,890	1,961	1,748	1,658
Toa Alta	3,286	3,105	2,685	2,452	2,386	2,203	2,214
Toa Baja	4,304	4,016	3,375	3,288	3,103	2,724	2,689
Trujillo Alto	3,176	2,876	2,395	2,101	2,108	1,911	1,958
Utuado	1,691	1,561	1,463	1,439	1,312	1,111	1,071
Vega Alta	1,859	1,753	1,456	1,437	1,379	1,157	1,141
Vega Baja	3,372	2,863	2,361	2,403	2,296	1,906	1,909
Vieques	634	503	392	491	443	363	346
Villalba	1,949	1,804	1,724	1,768	1,730	1,545	1,584
Yabucoa	2,793	2,706	2,399	2,427	2,104	1,611	1,540
Yauco	2,584	2,497	2,391	2,391	2,374	2,038	2,021

Source: Bureau of Labor Statistics Local Area Unemployment Statistics by Place of Residence

In Puerto Rico, in recent history, the number of people employed has decreased while employment rates have increased, as shown in Table 2.4. This is due to population losses, which occur at a faster rate than employment. The island has lost over 10% of their labor force between 2010 and 2016.

Table 2.4: Puerto Rico Employment (2010 and 2016)

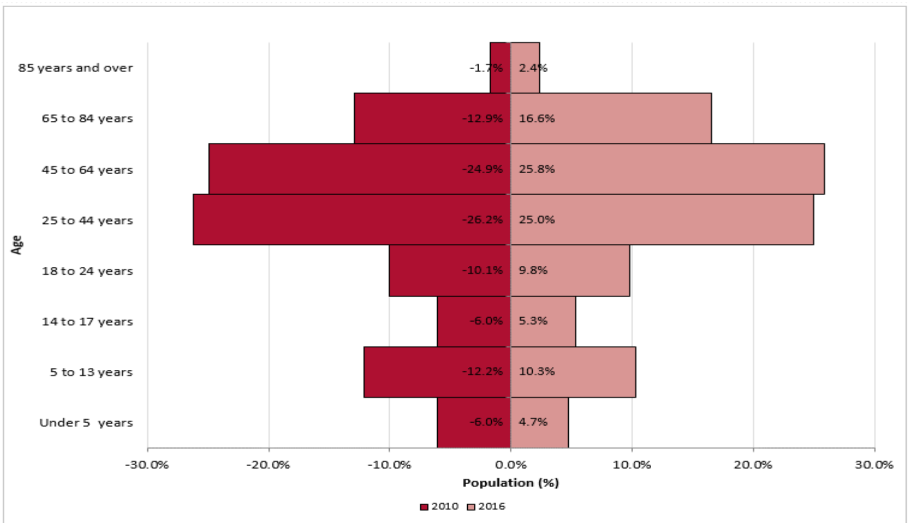
Region Name	2010 - Labor Force	2010 - Employment	2010 - Employment Rate	2016 - Labor Force	2016 - Employment	2016 Employment Rate	% Change in Labor Force	% Change in Employment
Puerto Rico	1,268,673	1,061,056	84%	1,117,928	986,151	88%	(11.9%)	(7.1%)

Source: Bureau of Labor Statistics (BLS) Local Area Unemployment Statistics (LAUS) by Place of Residence

Age

In 2010 Puerto Rico had an elderly population, individuals 65 years and older, of 541,998 people, representing the 14.6% of the Island inhabitants. By the year 2016, the population of individuals 65 years and over was estimated at 645,887 people, which represents 18.9% of the total residents. Puerto Rico's elderly population holds a more significant share of total population, 18.9%, compared to the young segment (under 15 years) who made up 16.3% of the population in 2016, as shown in Figure 2.18.

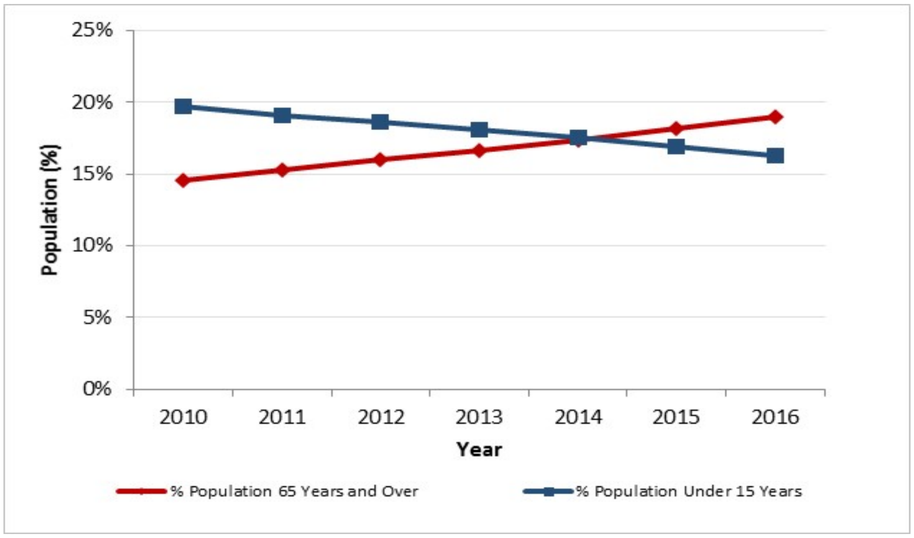
Figure 2.18: Age Distribution for Puerto Rico



Source: SDG analysis of US Census Bureau Estimates 2010-2016

Figure 2.19 shows that the share of the elderly population grew larger than the share of youths starting in 2015, with the gap continuing to widen. The proportion of the population aged between 20 and 59 years has been maintained, changing slightly from 52.3% to 51.7% during the period 2010-2016.

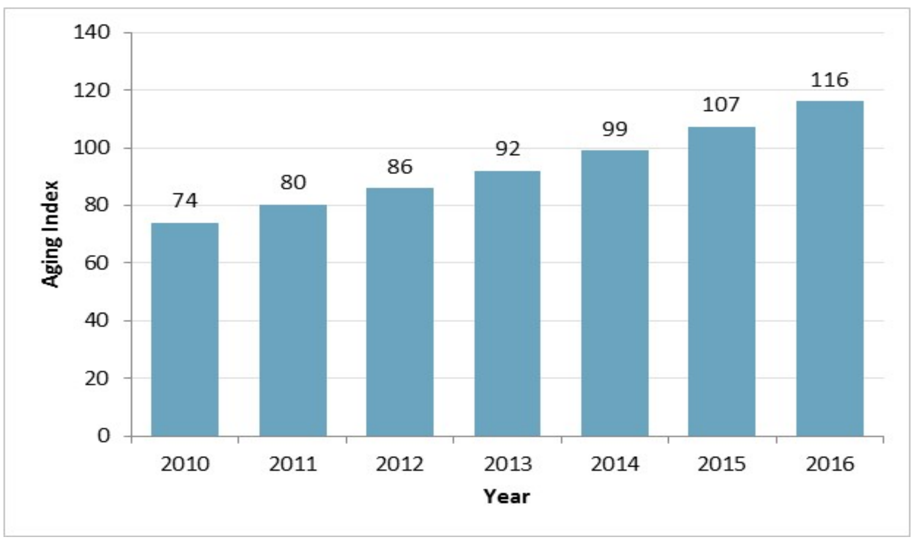
Figure 2.19: Comparison Puerto Rico Population Older vs. Younger



Source: SDG analysis of US Census Bureau Estimates 2010-2016

Figure 2.20 shows the trend of the Puerto Rico Aging Index[18] since 2010. In July 2016, the island's index was above 100 representing more senior than youth inhabitants in 20 of 35 municipalities as seen in Figure 2.21 .

Figure 2.20: Puerto Rico Aging Index 2010-2016



Source: SDG analysis of US Census Bureau Estimates 2010-2016

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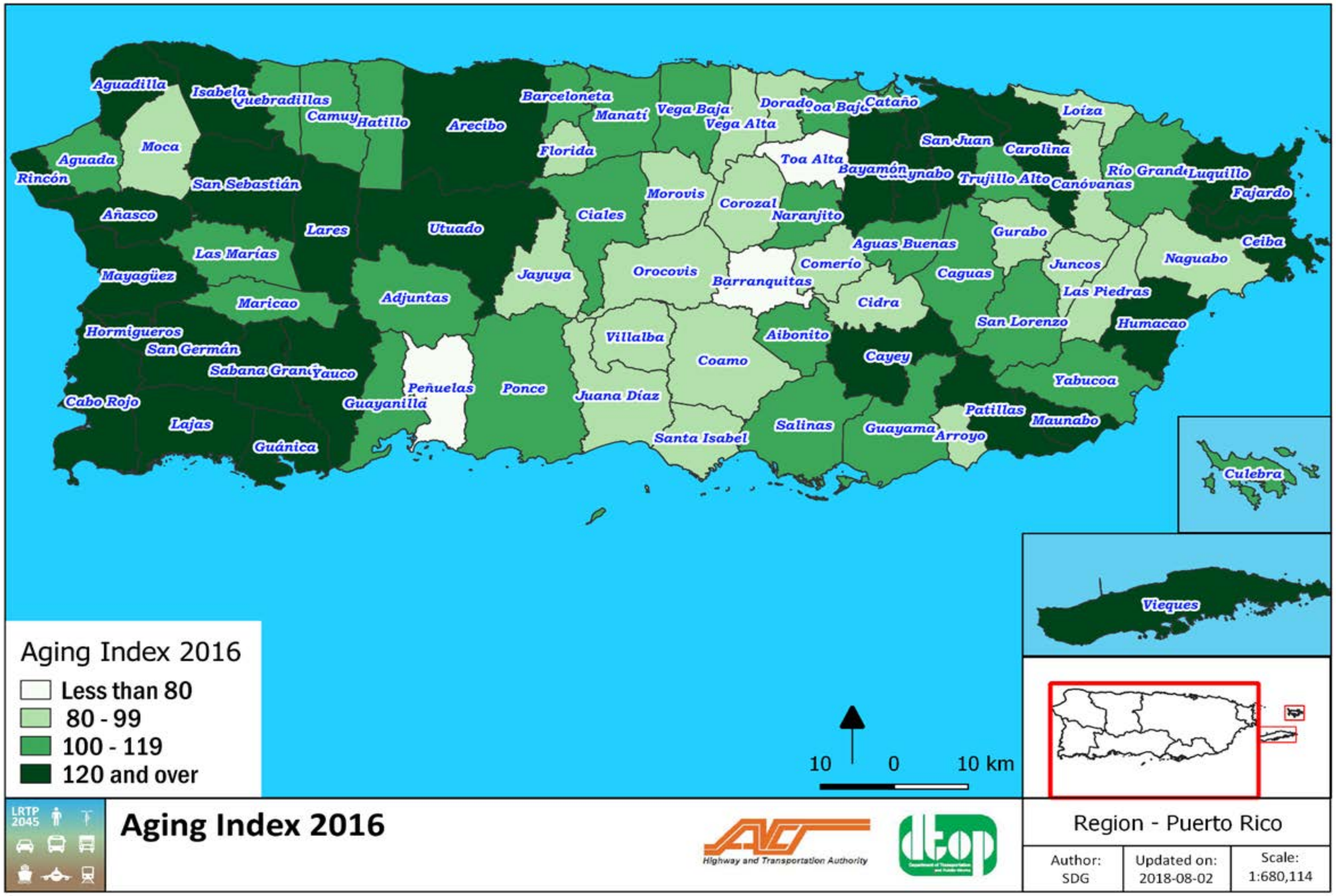
[18] Aging Index: "relates the most dynamic groups of population and that most influence the structure and evolution of a population. This index relates the old population, which can be 60 years or more (P_{60+}) or 65 years or more (P_{65+}) with the population of minors that is generally below the age of 15 years (P_{0-14}) in order to see if the oldest population of a particular place is more, equal or less than the youngest population. The utility of the Aging Index is to observe the amount of old population per 100 young, that is, try to measure the weight that one sector falls on another sector". http://demografia.rcm.upr.edu/index.php/indicadores-en-demografia/i-composicion/i-viejos.

Figure 2.21: Puerto Rico Aging Index by Municipality: 2016



Source: Age Statistics obtained from the U.S. Census Bureau

The highest-ranking municipalities in terms of aging index in Puerto Rico are shown in Table 2.5.

Table 2.5: Highest Aging Index in Puerto Rico: 2016

Municipality	Aging Index
Hormigueros	187
Rincón	159
Mayagüez	156
Lajas	153
Guaynabo	146

Source: SDG analysis of US Census Bureau Estimates 2010-2016

The lowest ranking municipalities in terms of aging index in Puerto Rico are shown in Table 2.6.

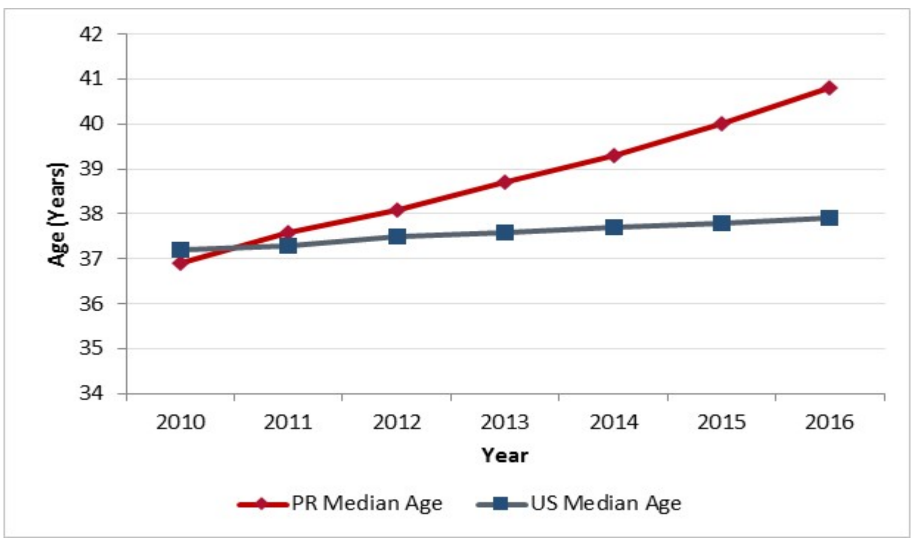
Table 2.6: Lowest Aging Index in Puerto Rico: 2016

Municipality	Aging Index
Toa Alta	74
Barranquitas	76
Peñuelas	78
Santa Isabel	82
Morovis	82

Source: SDG analysis of US Census Bureau Estimates 2010-2016

Regarding the median age, island-wide data revealed a median age of just under 41 in 2016, as shown in Figure 2.22.

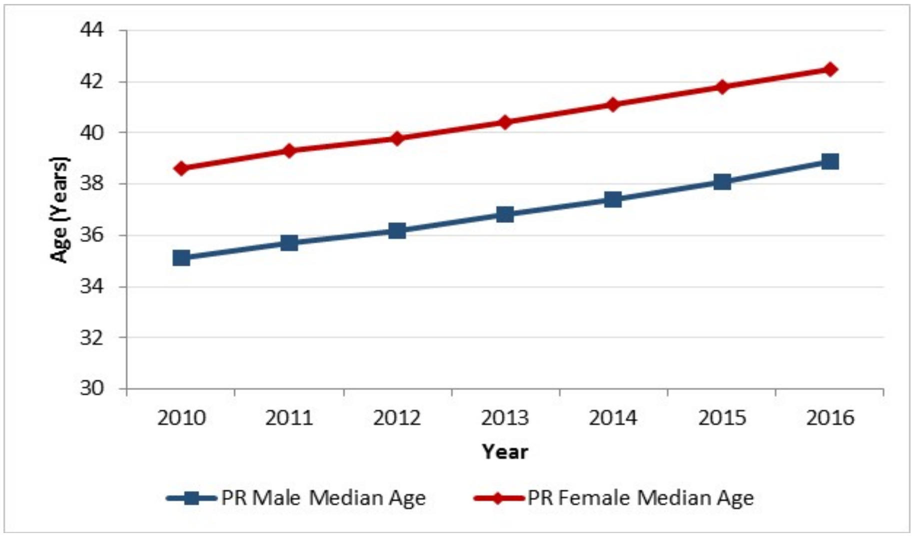
Figure 2.22: Median Age in Puerto Rico



Source: SDG analysis of US Census Bureau Estimates 2010-2016

Regarding the median age by gender, Puerto Rico's female population continued to have a median age higher than the male population. The 2016 median age for females was 43 years while the median age for males was 39, as shown in Figure 2.23.

Figure 2.23: Median Age by Gender in Puerto Rico



Source: SDG analysis of US Census Bureau Estimates 2010-2016

Within Puerto Rico, 48 Municipalities out of 78, showed a median age of 40 years and over in their population highlighted in Figure 2.24. Table 2.7 and Table 2.8 show the top municipalities within Puerto Rico with the highest and lowest median age populations in 2016 respectively.

Table 2.7: Highest Median Age in Puerto Rico - 2016

Municipality	Median Age
Hormigueros	45.9
Rincón	45.5
Vieques	44.6
Lajas	44.2
Patillas	43.9

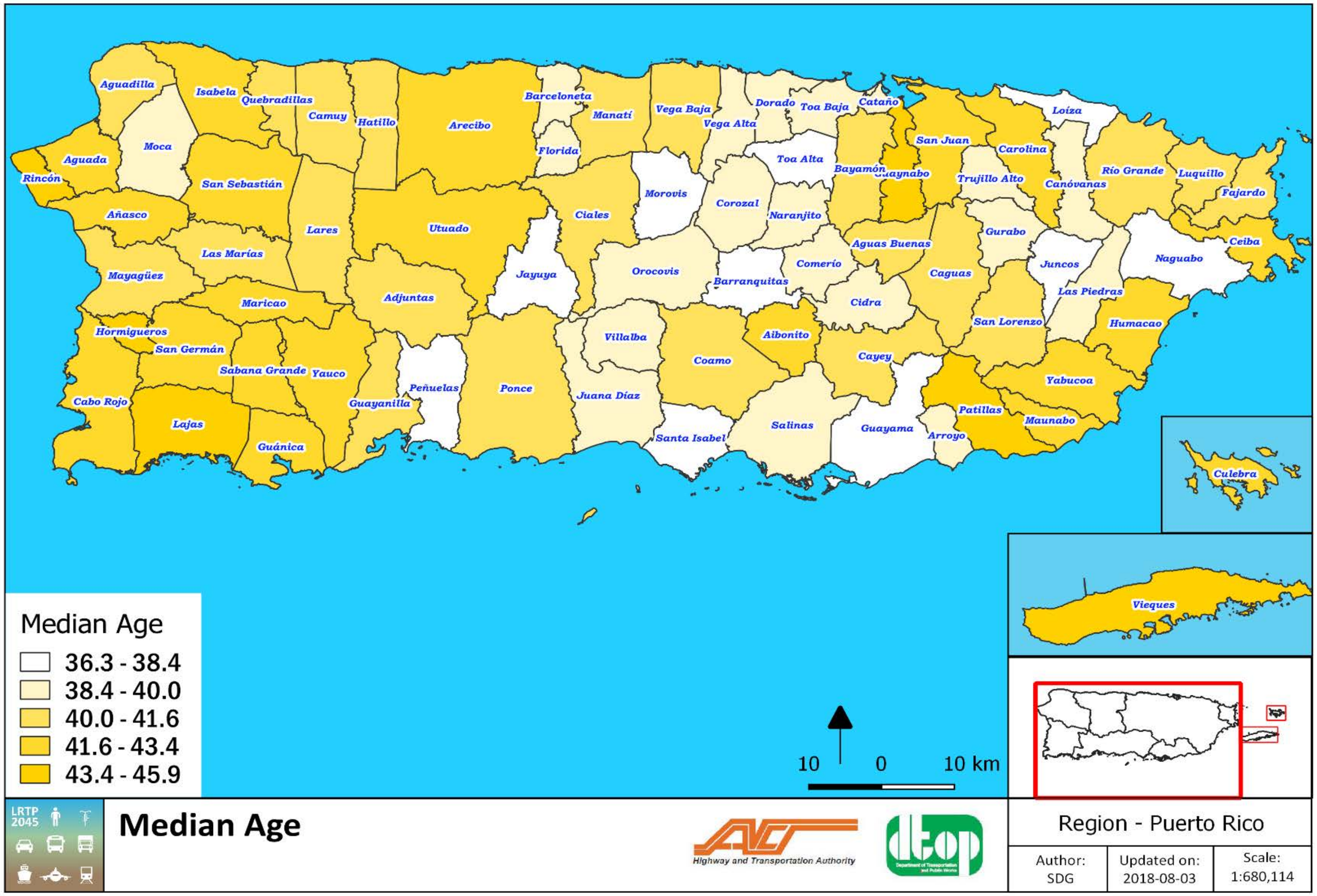
Source: SDG analysis of US Census Bureau Estimates 2010-2016

Table 2.8: Lowest Median Age in Puerto Rico - 2016

Municipality	Median Age
Barranquitas	36.3
Peñuelas	37.5
Jayuya	37.6
Naguabo	37.6
Morovis	37.7

Source: SDG analysis of US Census Bureau Estimates 2010-2016

Figure 2.24: Puerto Rico Median Age 2016

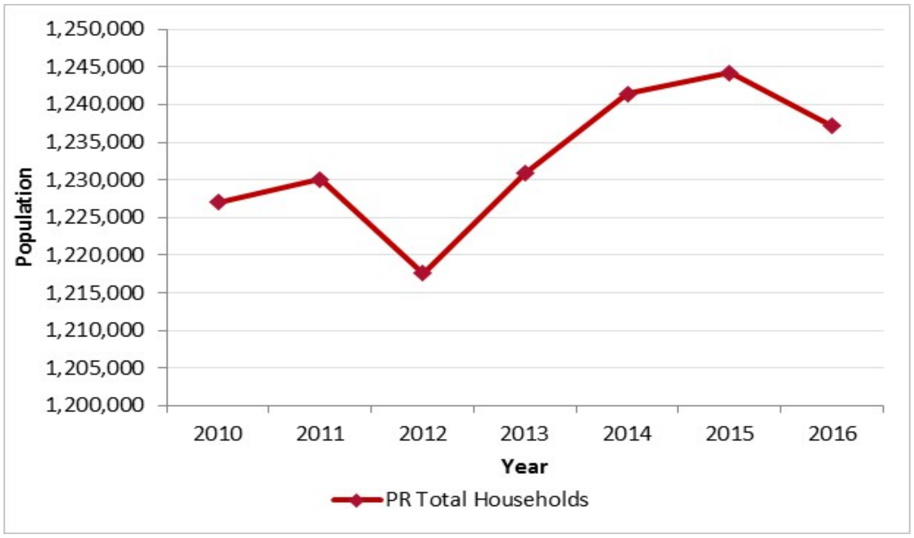


Source: Median Age Statistics obtained from the U.S. Census Bureau

Housing Type and Household Size

For the analysis of household type and size, U.S. Census estimates from 2016 indicated there were 1,237,180 households in Puerto Rico, as shown in Figure 2.25.

Figure 2.25: Puerto Rico – Total Households by year



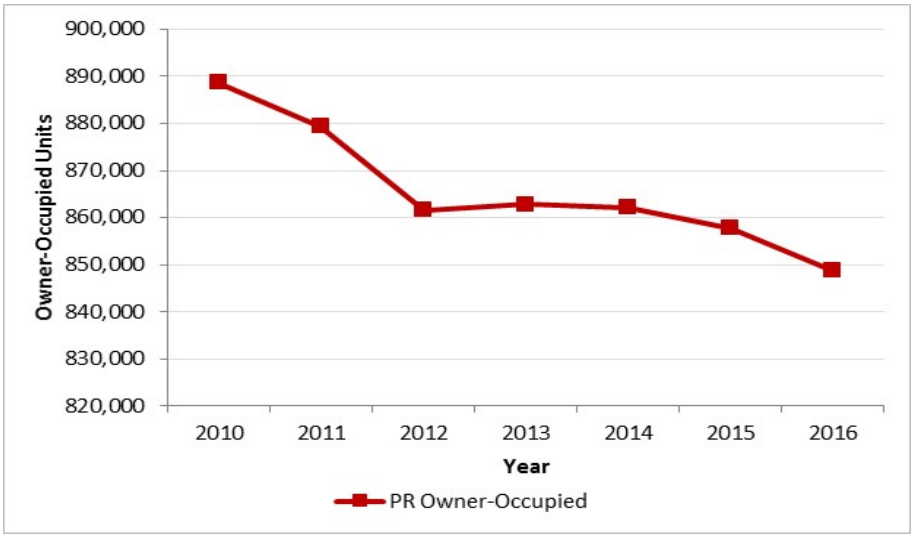
Source: SDG analysis of ACS 5-Year Estimates (2012-2016)

In 2016, Puerto Rico had 932,744 housing units. Of these, 68.6% (848,735) owned their homes, 31.4% (388,445) were renters and mostly (67.4%) are 1-unit detached structures[19] This information is shown in Figure 2.26 to Figure 2.28.

Island-wide, the percentage of household owners (homeownership rate) decreased from 72.4% to 68.6% between 2010 and 2016 and an increase in the corresponding rate for the households that are rented, 27.6% to 31.4%, was observed. Within these 6-years, the number of housing units increased by 6.6%.

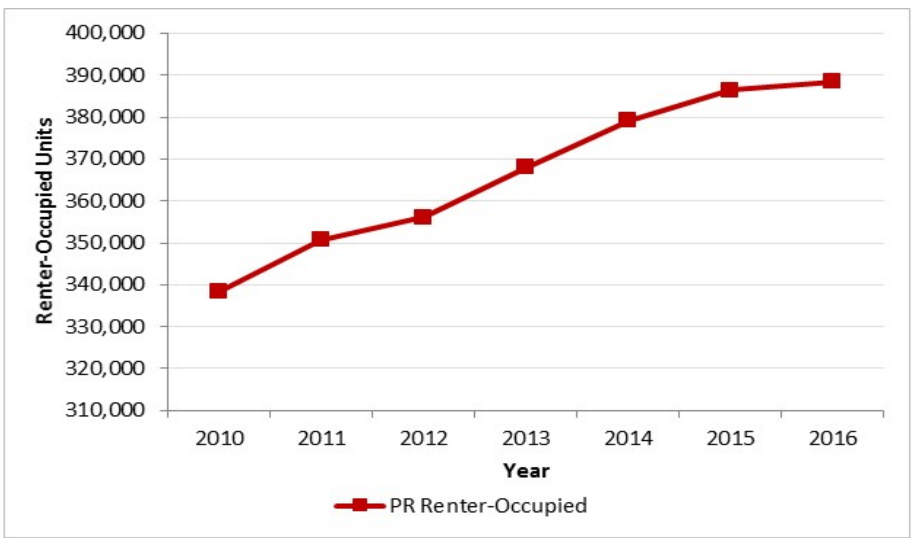
[19] Definition by U.S. Census Bureau: "This is a 1-unit structure detached from any other house; that is, with open space on all four sides".

Figure 2.26: Puerto Rico – Owner-Occupied Homes



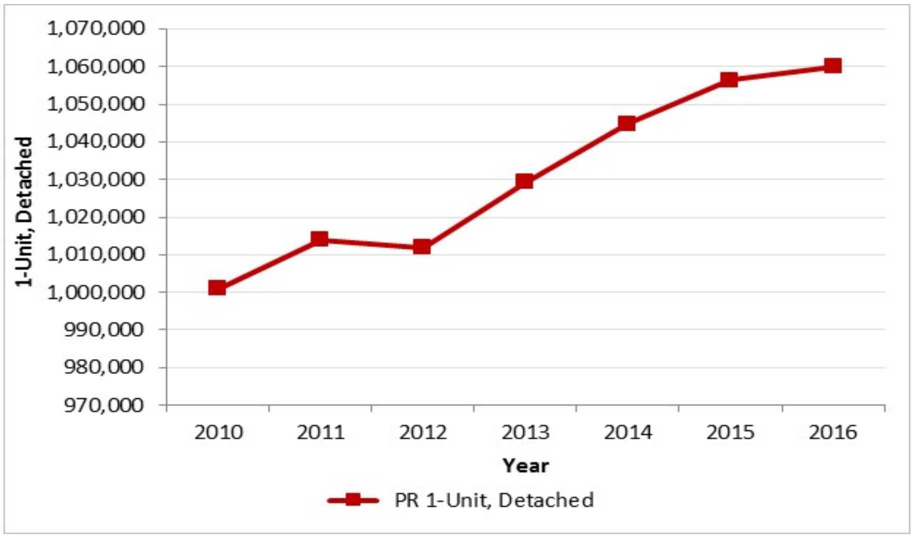
Source: SDG analysis of ACS 5-Year Estimates (2012-2016)

Figure 2.27: Puerto Rico – Renter-Occupied Homes



Source: SDG analysis of ACS 5-Year Estimates (2012-2016)

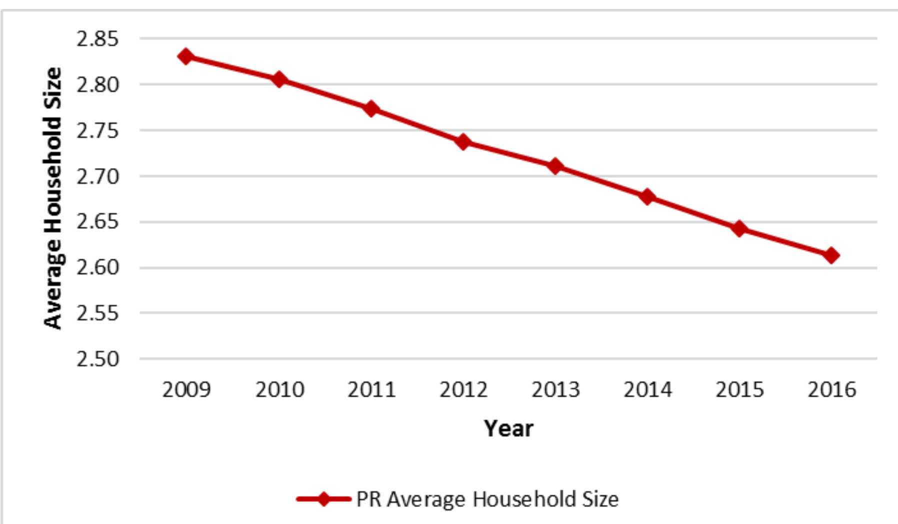
Figure 2.28: Puerto Rico – 1-Unit, Detached Structures



Source: SDG analysis of ACS 5-Year Estimates (2012-2016)

In 2016, Puerto Rico's average household size was approximately 2.6 people, as shown in Table 2.29. However, there is a decreasing trend showing in the island, with the average falling from 2.8 in 2010 to 2.6 in 2016. Toa Alta and Naranjito have the largest average household sizes in the Region with averages of 3.1 and 3.0 people per household respectively.

Figure 2.29: Puerto Rico – Average Household Size



Source: SDG analysis of ACS 5 Year Estimates (2012-2016)

Table 2.9 shows the household characteristics for each municipality in Puerto Rico.

Table 2.9: Puerto Rico – 2016 Total and Occupied Housing Units and Average Household Size

Municipality	Total Housing Units	Occupied Housing Units	Average Household Size
Adjuntas	7,673	6,305	2.64
Aguada	17,508	12,934	2.65
Aguadilla	27,365	20,999	2.56
Aguas Buenas	10,790	8,675	2.67
Aibonito	9,961	8,569	2.67
Añasco	12,448	9,373	2.70
Arecibo	41,400	32,121	2.55
Arroyo	8,556	6,203	2.74
Barceloneta	9,892	8,330	2.66
Barranquitas	11,034	9,376	2.79
Bayamón	83,785	70,950	2.64
Cabo Rojo	29,625	17,130	2.51
Caguas	58,356	50,327	2.65
Camuy	14,051	11,816	2.82
Canóvanas	18,012	14,664	2.81
Carolina	77,771	64,408	2.60
Cataño	10,849	9,190	2.72
Cayey	20,106	16,629	2.58
Ceiba	7,456	4,585	2.57
Ciales	7,322	5,883	2.72
Cidra	16,213	13,519	2.80
Coamo	16,380	13,609	2.68
Comerío	7,625	6,249	2.60
Corozal	13,063	11,011	2.89
Culebra	1,519	509	2.41
Dorado	15,803	12,036	2.91
Fajardo	18,627	12,691	2.67
Florida	4,919	4,305	2.88
Guánica	9,346	5,526	2.57
Guayama	18,819	14,879	2.54
Guayanilla	8,364	6,659	2.73
Guaynabo	40,303	34,724	2.56
Gurabo	17,568	15,473	2.75
Hatillo	16,855	14,339	2.65
Hormigueros	7,555	6,233	2.38
Humacao	26,899	18,763	2.60
Isabela	20,417	15,084	2.63
Jayuya	6,231	4,720	2.83
Juana Díaz	18,930	16,143	2.88
Juncos	15,723	12,746	2.70
Lajas	12,107	8,375	2.61
Lares	12,263	10,148	2.68

Municipality	Total Housing Units	Occupied Housing Units	Average Household Size
Las Marías	3,932	3,104	2.61
Las Piedras	15,634	12,876	2.79
Loíza	11,588	8,810	2.74
Luquillo	10,529	6,691	2.69
Manatí	18,799	15,946	2.64
Maricao	2,634	1,952	2.67
Maunabo	5,353	4,035	2.75
Mayagüez	41,274	30,099	2.40
Moca	15,632	12,473	2.73
Morovis	11,661	9,827	2.85
Naguabo	11,555	8,586	2.63
Naranjito	10,605	8,645	2.96
Orocovis	8,514	6,858	2.70
Patillas	8,943	6,458	2.50
Peñuelas	8,828	7,398	3.03
Ponce	66,906	54,722	2.58
Quebradillas	10,348	8,773	2.61
Rincón	9,462	5,210	2.55
Río Grande	23,191	16,292	2.70
Sabana Grande	10,806	7,413	2.47
Salinas	13,873	10,809	2.66
San Germán	15,652	12,263	2.42
San Juan	192,766	147,790	2.31
San Lorenzo	16,434	13,716	2.62
San Sebastián	17,695	13,870	2.63
Santa Isabel	9,380	7,757	2.68
Toa Alta	25,726	22,375	3.05
Toa Baja	34,592	28,261	2.62
Trujillo Alto	29,505	24,660	2.73
Utuado	13,368	10,058	2.68
Vega Alta	16,128	12,677	2.74
Vega Baja	24,739	17,356	2.62
Vieques	5,036	2,673	2.12
Villalba	9,144	7,870	2.88
Yabucoa	14,771	12,011	2.59
Yauco	17,252	10,658	2.52

Source: SDG analysis of ACS 5-Year Estimates (2012-2016)[20]

[20] ACS household data provides percentage of households that are 1-person, 2-person, 3-person, and 4-person plus. Using an assumed average value of 5 people for the 4-person plus households. SDG Team produced Weighted averages of household size by municipality. were produced. Because household data comes from the 5-year estimated dataset while population is from 2016 data only along with the weighted

Puerto Rico Household Travel Survey (PRHTS)

Household surveys were completed as part of the 2045 PRLRTP (please, see details in Appendix L). Overall sample size was 2,784 households participating in the survey.

Weighted survey results from the PRHTS are displayed with real 2016 data, but are not meant for direct comparison, as the survey results were weighted to 2015 household and population levels; this provides a check, looking for general proximity, to support the claim that the survey sampling distribution was representative of the population.

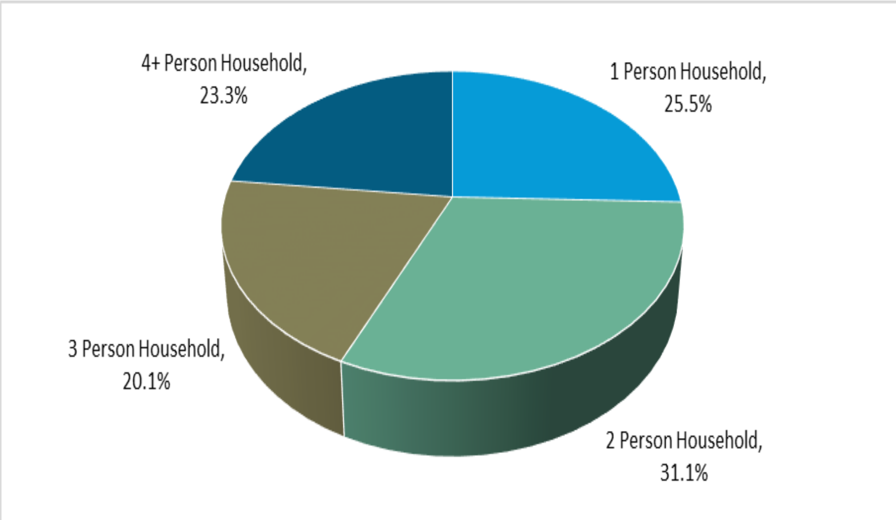
Household Level Demographic Data

Household demographic data was captured for the 2,784 households who participated in the survey. Results are shown in Table 2.10 to Table 2.14 and Figure 2.30 to Figure 2.34.

- Household Occupants: Seen in Table 5.1, just over 23% of Puerto Rico's households have 4 or more occupants. Overall, the distribution of household sizes for Puerto Rico holds across regions. In all regions, 2-person households make up over 30% of total households, more than any other household size strata in their respective regions.
- Vehicles per Household: At the Puerto Rico level close to 60% of households have 1 or less available vehicles, with just under 15% of households without access to a private vehicle.
- Housing Structure: In Puerto Rico, just over 80% of households live in single-family homes, with close to 15% living in multi-family homes.
- Income: With just under 60% of the population's income unknown due to survey respondent's choice to not disclose, this is unable to provide as much information as would be desired. Of those who disclosed income the majority of household incomes fall under $25,000.
- Home Ownership: At the Puerto Rico level, shown in, over 70% of all households own and have either paid in full or are currently paying, as over 50% of all household own and have paid off their home.

average calculation, multiplying number of households by the household size in table 3.11 will not be exactly equal to municipality population.

Figure 2.30: Puerto Rico Household Distribution by Household Size



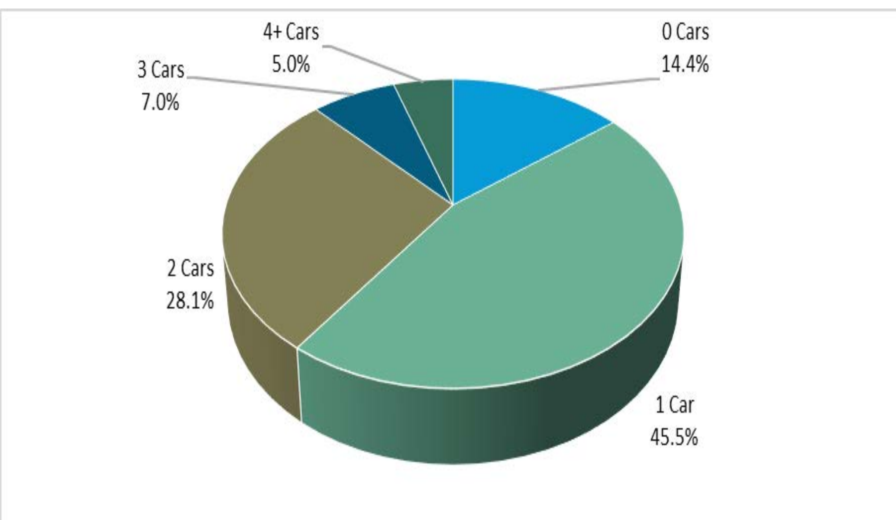
Source: SDG – Using Weighted Survey Results

Table 2.10: Household Distribution by Household Size and by Region

Household Size	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
1	195,196 (25.8%)	24,555 (23.7%)	97,863 (25.5%)	317,614 (25.5%)
2	233,836 (30.9%)	33,686 (32.6%)	119,913 (31.3%)	387,435 (31.1%)
3	152,192 (20.1%)	21,147 (20.4%)	76,513 (20.0%)	249,852 (20.1%)
4+	176,208 (23.3%)	24,058 (23.3%)	89,035 (23.2%)	289,301 (23.3%)
Total	**757,432 (60.9%)**	**103,446 (8.3%)**	**383,324 (30.8%)**	**1,244,202 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.31: Puerto Rico Household Distribution by Vehicle Ownership



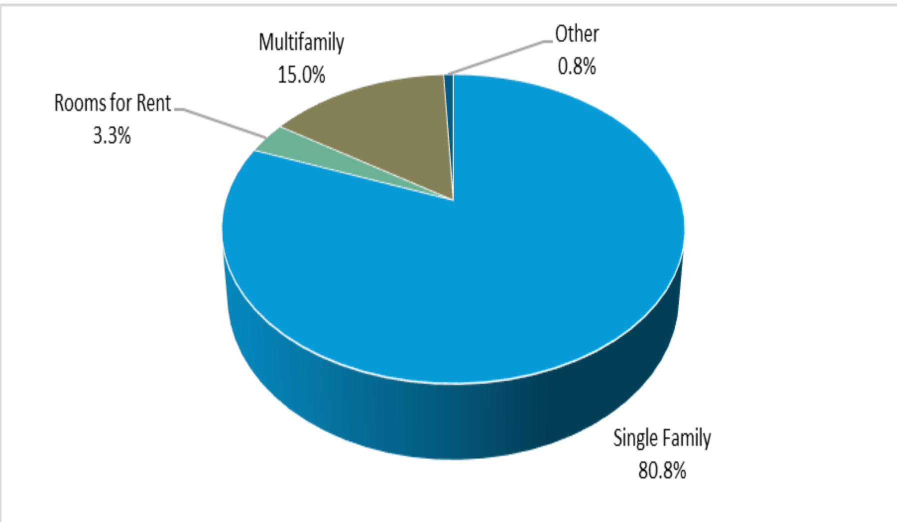
Source: SDG – Using Weighted Survey Results

Table 2.11: Household Distribution by Vehicle Ownership and by Region

Number of Vehicles	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
0	102,510 (13.5%)	15,407 (14.9%)	61,499 (16.0%)	179,416 (14.4%)
1	357,305 (47.2%)	42,785 (41.4%)	165,761 (43.2%)	565,851 (45.5%)
2	202,098 (26.7%)	33,184 (32.1%)	114,059 (29.8%)	349,341 (28.1%)
3	55,057 (7.3%)	6,536 (6.3%)	25,944 (6.8%)	87,536 (7.0%)
4+	40,463 (5.3%)	5,534 (5.4%)	16,061 (4.2%)	62,059 (5.0%)
Total	**757,432 (60.9%)**	**103,446 (8.3%)**	**383,324 (30.8%)**	**1,244,202 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.32: Puerto Rico Household Distribution by Household Type



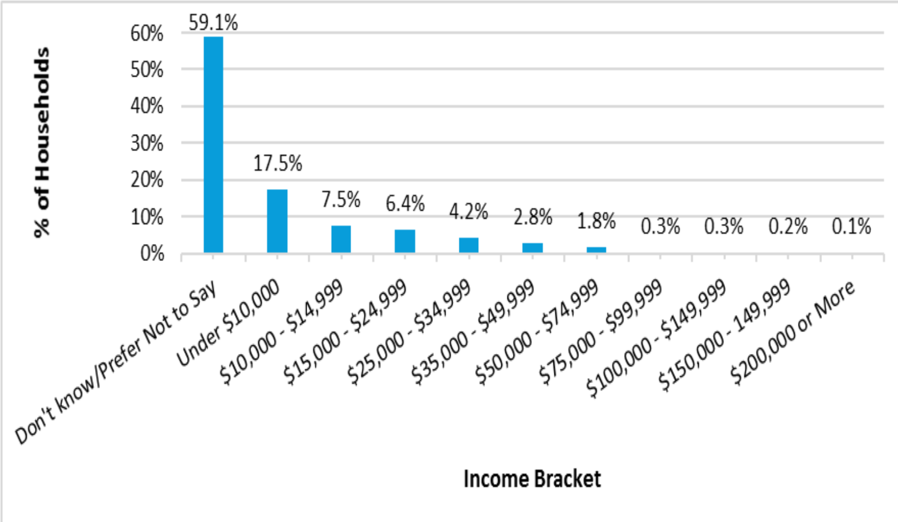
Source: SDG – Using Weighted Survey Results

Table 2.12: Household Distribution by Housing Type and Region

Housing Type	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Single Family	589,381 (77.8%)	91,300 (88.3%)	324,859 (84.7%)	1,005,541 (80.8%)
Rooms for Rent	27,069 (3.6%)	3,816 (3.7%)	10,672 (2.8%)	41,557 (3.3%)
Multifamily	132,137 (17.4%)	8,330 (8.1%)	46,631 (12.2%)	187,098 (15.0%)
Other	8,844 (1.2%)	0 (0.0%)	1,162 (0.3%)	10,006 (0.8%)
Total	**757,432 (60.9%)**	**103,446 (8.3%)**	**383,324 (30.8%)**	**1,244,202 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.33: Household Distribution by Household Income Brackets



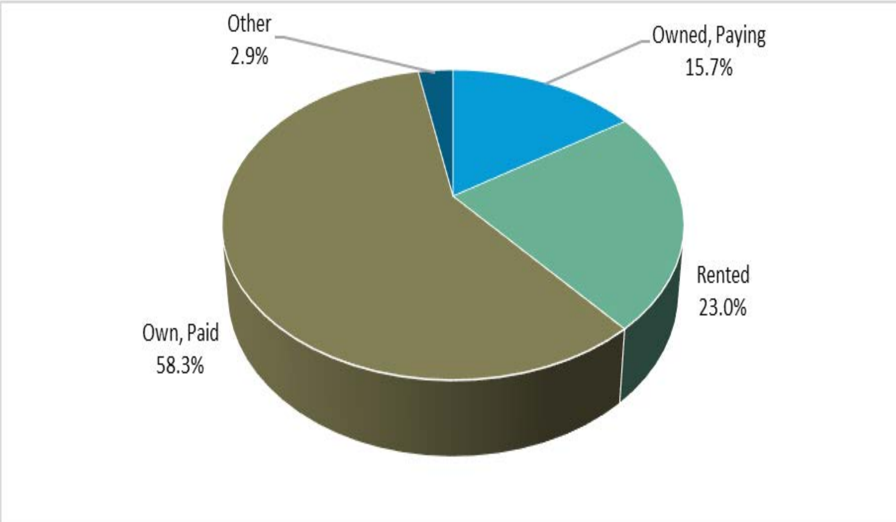
Source: SDG – Using Weighted Survey Results

Table 2.13: Household Distribution by Household Income Brackets and Region

HH Income	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Totals
Don't know/Prefer Not to Say	443,061 (58.5%)	66,547 (64.3%)	225,336 (58.8%)	734,944 (59.1%)
Under $10,000	129,287 (17.1%)	14,276 (13.8%)	73,628 (19.2%)	217,192 (17.5%)
$10,000 - $14,999	56,391 (7.4%)	7,472 (7.2%)	28,930 (7.5%)	92,792 (7.5%)
$15,000 - $24,999	51,388 (6.8%)	4,714 (4.6%)	23,013 (6.0%)	79,115 (6.4%)
$25,000 - $34,999	35,093 (4.6%)	3,590 (3.5%)	13,085 (3.4%)	51,769 (4.2%)
$35,000 - $49,999	18,504 (2.4%)	3,527 (3.4%)	12,297 (3.2%)	34,327 (2.8%)
$50,000 - $74,999	16,205 (2.1%)	2,652 (2.6%)	4,096 (1.1%)	22,953 (1.8%)
$75,000 - $99,999	2,931 (0.4%)	0 (0.0%)	1,276 (0.3%)	4,207 (0.3%)
$100,000 - $149,999	1,790 (0.2%)	410 (0.4%)	1,491 (0.4%)	3,691 (0.3%)
$150,000 - 199,999	1,885 (0.2%)	0 (0.0%)	171 (0.0%)	2,056 (0.2%)
$200,000 or More	898 (0.1%)	258 (0.2%)	0 (0.0%)	1,156 (0.1%)
Total	**757,432 (60.9%)**	**103,446 (8.3%)**	**383,324 (30.8%)**	**1,244,202 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.34: Puerto Rico Household Distribution by Home Ownership Status



Source: SDG – Using Weighted Survey Results

Table 2.14: Household Distribution by Home Ownership Status and Region

Housing Status	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Totals
Owned, Paying	135,954 (17.9%)	12,255 (11.8%)	47,451 (12.4%)	195,660 (15.7%)
Rented	180,746 (23.9%)	22,764 (22.0%)	83,254 (21.7%)	286,763 (23.0%)
Own, Paid	421,764 (55.7%)	65,015 (62.8%)	238,850 (62.3%)	725,629 (58.3%)
Other	18,967 (2.5%)	3,413 (3.3%)	13,769 (3.6%)	36,149 (2.9%)
Total	**757,432 (60.9%)**	**103,446 (8.3%)**	**383,324 (30.8%)**	**1,244,202 (100.0%)**

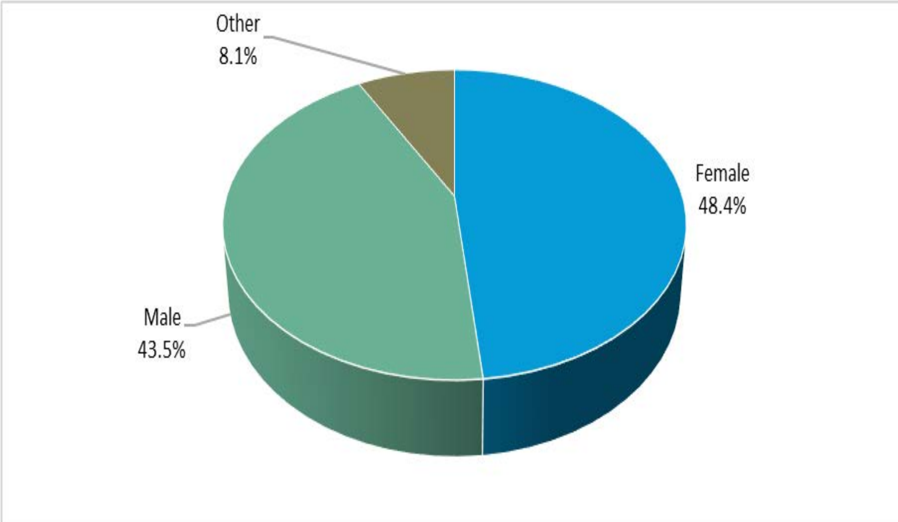
Source: SDG – Using Weighted Survey Results

Person Level Demographic Data

Person level demographic data was captured for the 6,861 people who participated in the survey.

- Gender: In Puerto Rico, just over 48% and close to 44% of people identify as Female and Male respectively. Aguadilla TMA is the one region where there is a higher percentage of males than females.
- Age: In Puerto Rico, just over 25% of the population falls under the age of 20, just over 36% falls between 20 and 49 years of age, and 34% are older than 50.
- Education Level: Just over 65% of the Puerto Rico Population have achieved High School completion or above.
- Occupants Living Status: In Puerto Rico, 4.5% of individuals are temporary household residents, led by the San Juan TMA where close to 7% of household occupants state their residence as temporary.

Figure 2.35: Puerto Rico Population Distribution by Gender



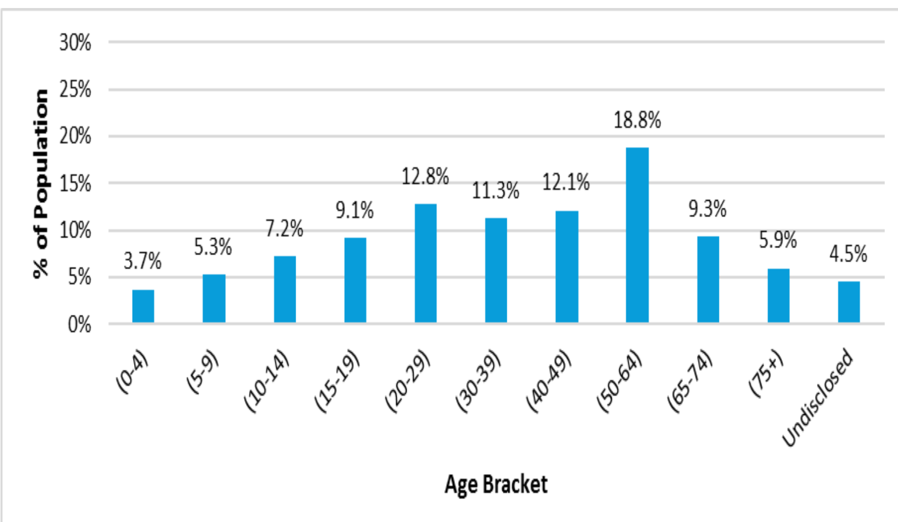
Source: SDG – Using Weighted Survey Results

Table 2.15: Population Distribution by Gender and Region

Gender	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Female	1,050,831 (48.8%)	128,279 (46.3%)	514,921 (48.0%)	1,694,031 (48.4%)
Male	885,176 (41.1%)	141,556 (51.1%)	497,689 (46.4%)	1,524,420 (43.5%)
Other	216,625 (10.1%)	7,389 (2.7%)	60,430 (5.6%)	284,444 (8.1%)
Total	**2,152,632 (61.5%)**	**277,224 (7.9%)**	**1,073,040 (30.6%)**	**3,502,895 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.36: Puerto Rico Population Distribution by Age Brackets



Source: SDG – Using Weighted Survey Results

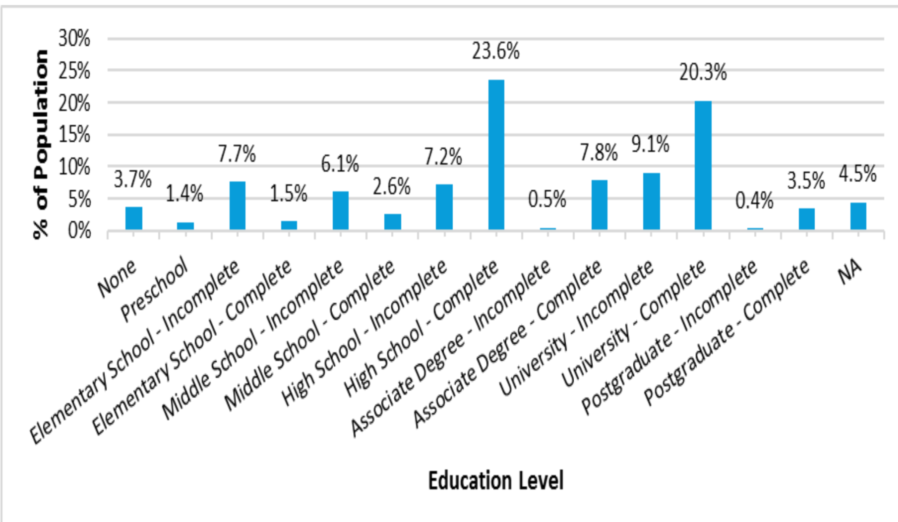
Table 2.16: Population Distribution by Age Bracket and Region

Age Bracket	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
(0-4)	71,633 (3.3%)	6,893 (2.5%)	50,051 (4.7%)	128,577 (3.7%)

Age Bracket	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
(5-9)	122,514 (5.7%)	6,322 (2.3%)	56,558 (5.3%)	185,394 (5.3%)
(10-14)	116,673 (5.4%)	32,320 (11.7%)	104,195 (9.7%)	253,188 (7.2%)
(15-19)	201,311 (9.4%)	16,738 (6.0%)	101,785 (9.5%)	319,834 (9.1%)
(20-29)	280,861 (13.0%)	39,716 (14.3%)	128,179 (11.9%)	448,756 (12.8%)
(30-39)	224,949 (10.4%)	37,277 (13.4%)	133,864 (12.5%)	396,090 (11.3%)
(40-49)	241,784 (11.2%)	42,916 (15.5%)	138,788 (12.9%)	423,488 (12.1%)
(50-64)	417,983 (19.4%)	51,290 (18.5%)	188,523 (17.6%)	657,796 (18.8%)
(65-74)	194,289 (9.0%)	24,752 (8.9%)	107,023 (10.0%)	326,064 (9.3%)
(75+)	135,574 (6.3%)	12,892 (4.7%)	58,909 (5.5%)	207,375 (5.9%)
Undisclosed	145,061 (6.7%)	6,108 (2.2%)	5,164 (0.5%)	156,333 (4.5%)
Total	**2,152,632 (61.5%)**	**277,224 (7.9%)**	**1,073,040 (30.6%)**	**3,502,895 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.37: Puerto Rico Population Distribution by Education Level



Source: SDG – Using Weighted Survey Results

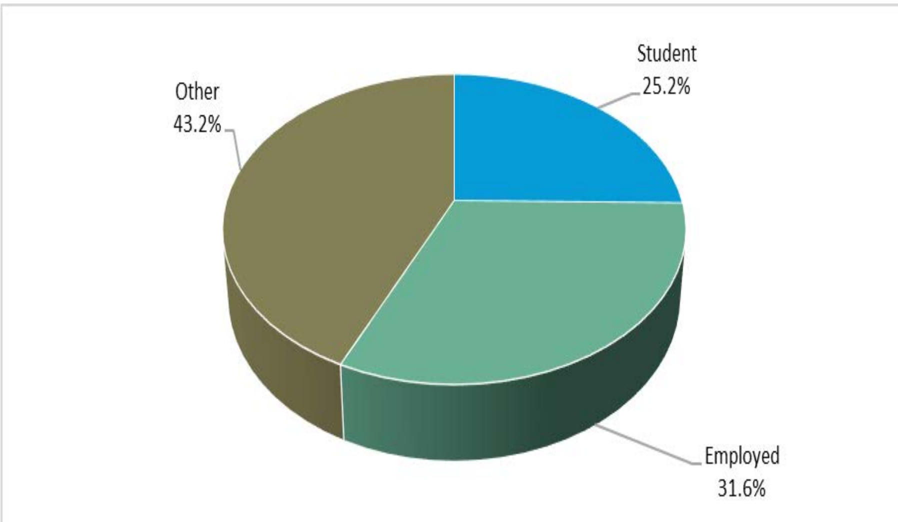
Table 2.17: Population Distribution by Education Level and Region

Education	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
None	72,726 (3.4%)	9,655 (3.5%)	45,748 (4.3%)	128,129 (3.7%)
Preschool	37,952 (1.8%)	1,333 (0.5%)	8,527 (0.8%)	47,812 (1.4%)
Elementary School - Incomplete	154,162 (7.2%)	12,396 (4.5%)	103,646 (9.7%)	270,204 (7.7%)
Elementary School - Complete	29,852 (1.4%)	3,520 (1.3%)	20,795 (1.9%)	54,167 (1.5%)
Middle School - Incomplete	96,581 (4.5%)	21,686 (7.8%)	96,978 (9.0%)	215,245 (6.1%)
Middle School - Complete	52,375 (2.4%)	10,833 (3.9%)	29,373 (2.7%)	92,581 (2.6%)
High School - Incomplete	161,820 (7.5%)	21,105 (7.6%)	69,914 (6.5%)	252,840 (7.2%)
High School - Complete	486,889 (22.6%)	69,833 (25.2%)	270,040 (25.2%)	826,762 (23.6%)
Associate Degree - Incomplete	10,930 (0.5%)	2,328 (0.8%)	5,187 (0.5%)	18,445 (0.5%)
Associate Degree - Complete	183,826 (8.5%)	19,984 (7.2%)	70,441 (6.6%)	274,251 (7.8%)
University - Incomplete	184,379 (8.6%)	21,928 (7.9%)	111,395 (10.4%)	317,703 (9.1%)

Education	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
University - Complete	446,836 (20.8%)	69,868 (25.2%)	195,046 (18.2%)	711,750 (20.3%)
Postgraduate - Incomplete	9,701 (0.5%)	224 (0.1%)	2,690 (0.3%)	12,615 (0.4%)
Postgraduate - Complete	79,540 (3.7%)	6,423 (2.3%)	38,095 (3.6%)	124,058 (3.5%)
NA	145,061 (6.7%)	6,108 (2.2%)	5,164 (0.5%)	156,333 (4.5%)
Total	**2,152,632 (61.5%)**	**277,224 (7.9%)**	**1,073,040 (30.6%)**	**3,502,895 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.38: Population Distribution by Employment/Student Status



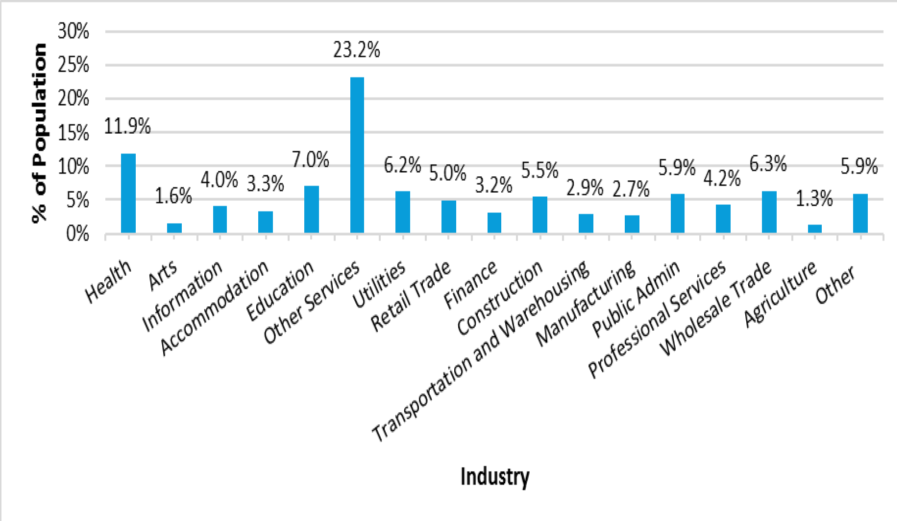
Source: SDG – Using Weighted Survey Results

Table 2.18: Population Distribution by Employment/Student Status and Region

Employment	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Other	953,519 (44.3%)	115,035 (41.5%)	454,590 (42.4%)	1,523,144 (43.5%)
Student	527,679 (24.5%)	63,728 (23.0%)	313,246 (29.2%)	904,653 (25.8%)
Employed	671,433 (31.2%)	98,461 (35.5%)	305,204 (28.4%)	1,075,098 (30.7%)
Total	**2,152,632 (61.5%)**	**277,224 (7.9%)**	**1,073,040 (30.6%)**	**3,502,895 (100.0%)**

Source: SDG– Using Weighted Survey Results

Figure 2.39: Puerto Rico Employed Population Distribution by Industry



Source: SDG – Using Weighted Survey Results

Table 2.19: Employed Population Distribution by Industry and Region

Industry	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Health Care and Social Assistance	74,945 (11.2%)	5,905 (6.0%)	47,118 (15.4%)	127,968 (11.9%)
Arts, Entertainment, and Recreation	16,696 (2.5%)	0 (0.0%)	0 (0.0%)	16,696 (1.6%)
Information	24,771 (3.7%)	5,849 (5.9%)	12,461 (4.1%)	43,082 (4.0%)
Accommodation and Food Service	24,535 (3.7%)	1,921 (2.0%)	9,471 (3.1%)	35,927 (3.3%)
Educational Services	44,550 (6.6%)	3,513 (3.6%)	27,482 (9.0%)	75,545 (7.0%)
Other Services (Except Public Administration)	172,778 (25.7%)	18,912 (19.2%)	57,966 (19.0%)	249,656 (23.2%)
Utilities	33,093 (4.9%)	9,403 (9.6%)	24,217 (7.9%)	66,712 (6.2%)
Retail Trade	39,599 (5.9%)	4,420 (4.5%)	9,308 (3.0%)	53,326 (5.0%)
Finance and Insurance	25,396 (3.8%)	1,513 (1.5%)	7,060 (2.3%)	33,970 (3.2%)
Construction	35,678 (5.3%)	6,560 (6.7%)	16,517 (5.4%)	58,754 (5.5%)
Transportation and Warehousing	23,343 (3.5%)	2,886 (2.9%)	4,420 (1.4%)	30,650 (2.9%)
Manufacturing	12,568 (1.9%)	970 (1.0%)	15,146 (5.0%)	28,684 (2.7%)
Public Administration	25,563 (3.8%)	10,579 (10.7%)	26,786 (8.8%)	62,928 (5.9%)
Professional, Scientific, and Technical Services	33,374 (5.0%)	5,476 (5.6%)	6,414 (2.1%)	45,265 (4.2%)
Wholesale Trade	37,655 (5.6%)	5,328 (5.4%)	25,106 (8.2%)	68,088 (6.3%)
Agriculture, Forestry, Fishing, and Hunting	7,527 (1.1%)	2,713 (2.8%)	3,839 (1.3%)	14,079 (1.3%)
Other	39,365 (5.9%)	12,510 (12.7%)	11,894 (3.9%)	63,768 (5.9%)
Total	**671,433 (62.5%)**	**98,461 (9.2%)**	**305,204 (28.4%)**	**1,075,098 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.40: Puerto Rico Population Distribution by Occupants Living Status

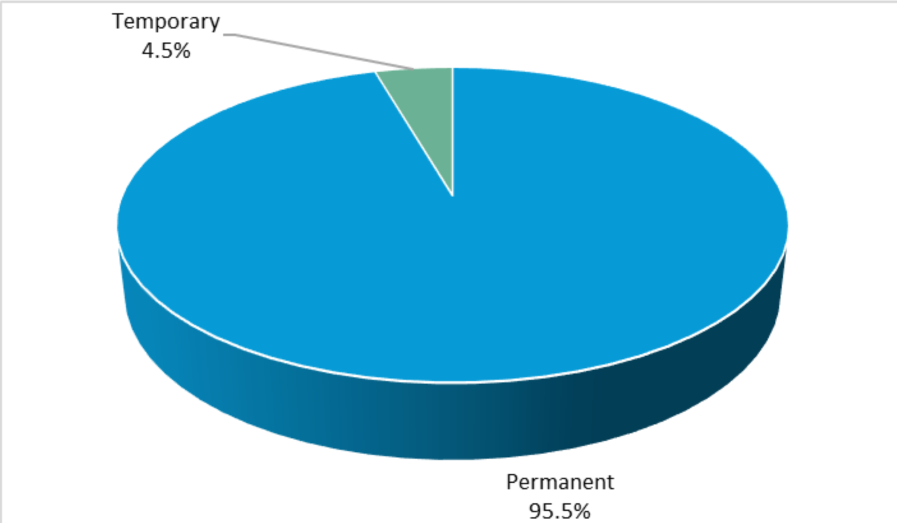


Table 2.20: Population Distribution by Occupants Living Status and by Region

Resident Type	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Area	Puerto Rico
Permanent	2,007,571 (93.3%)	271,116 (97.8%)	1,067,875 (99.5%)	3,346,562 (95.5%)
Temporary	145,061 (6.7%)	6,108 (2.2%)	5,164 (0.5%)	156,333 (4.5%)
Total	**2,152,632 (61.5%)**	**277,224 (7.9%)**	**1,073,040 (30.6%)**	**3,502,895 (100.0%)**

Source: SDG – Using Weighted Survey Results

Analysis of Trip Purpose and Frequency

The trip level data for participants with completed travel diaries is analyzed in this section, there were 10,557 trips and their respective details captured by the survey.

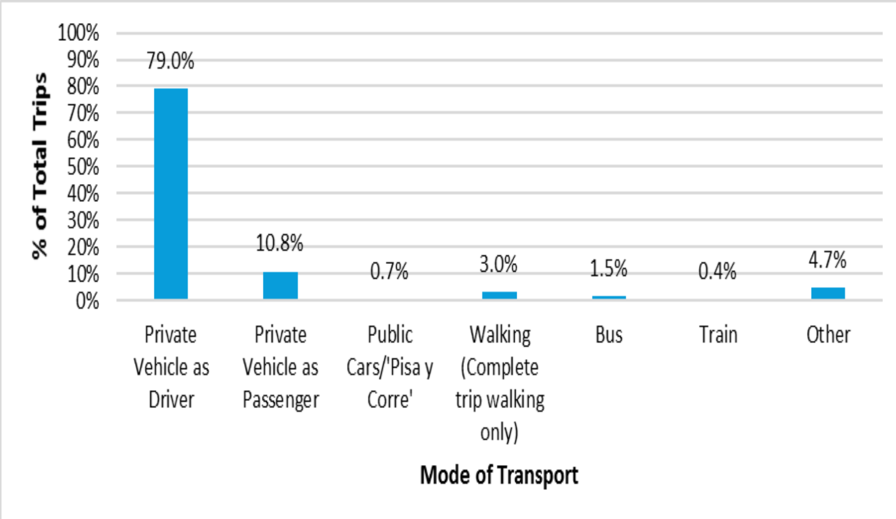
- Trips Per Household: As seen in Table 2.21, the mean trips generally increase with growth in household size and/or vehicle ownership. The greatest portion of households are 2-person and 1-vehicle households and their mean daily trips are 3.47.
- Transportation Mode: Close to 90% of trips in Puerto Rico are made in private vehicles as either the driver or as a passenger. San Juan has the highest portion of trips on public transit with 2.6% of trips on either bus or train.
- Trip Frequency: In Puerto Rico, just over 60% of all specific trips are recurring and completed 5 times or more a week.

Table 2.21: Household Travel Survey – Trips Per Household Per Typical Day – Sample Size (N=2,784)

HS	N HH	n HH survey	Mean Trips	SE	MOE	Total Trips
1	317,614	594	2.09	0.01	+/-0.02	662,412
2	387,435	1,024	3.48	0.04	+/-0.07	1,349,793
3	249,852	655	4.33	0.12	+/-0.2	1,082,629
4	289,301	511	6.19	0.48	+/-0.78	1,791,470
Total	**1,244,202**	**2,784**	**3.93**	**0.11**	**+/-0.18**	**4,886,304**

Source: SDG – Using Weighted Survey Results

Figure 2.41: Puerto Rico Trip Distribution by Transportation Mode



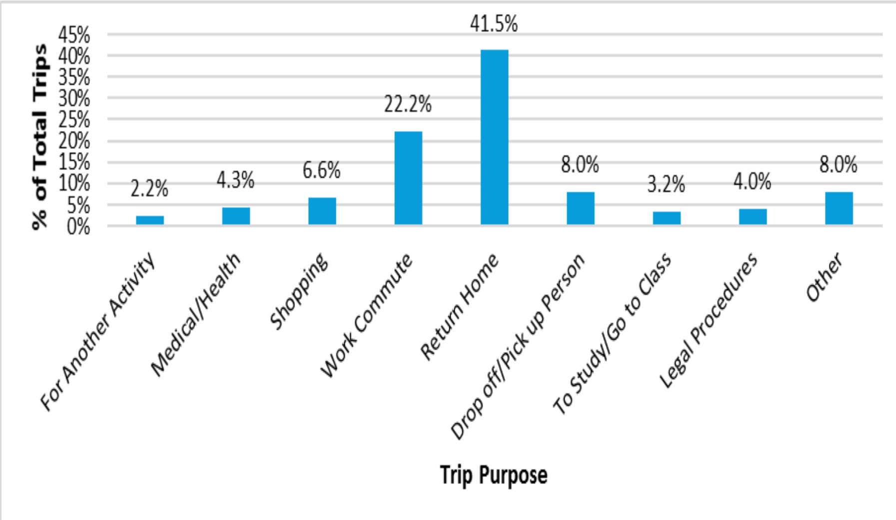
Source: SDG – Using Weighted Survey Results

Table 2.22: Trip Distribution by Transportation Mode and Region

Mode of Transport	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Totals
Private Vehicle as Driver	2,317,946 (76.8%)	319,415 (79.6%)	1,221,349 (83.2%)	3,858,709 (79.0%)
Private Vehicle as Passenger	368,383 (12.2%)	33,830 (8.4%)	125,033 (8.5%)	527,246 (10.8%)
Public Cars/'Pisa y Corre'	22,672 (0.8%)	990 (0.2%)	9,456 (0.6%)	33,118 (0.7%)
Walking (Complete Trip Walking Only)	69,476 (2.3%)	25,954 (6.5%)	52,326 (3.6%)	147,757 (3.0%)
Bus	58,020 (1.9%)	1,466 (0.4%)	13,126 (0.9%)	72,613 (1.5%)
Train	19,392 (0.6%)	0 (0.0%)	0 (0.0%)	19,392 (0.4%)
Other	160,715 (5.3%)	19,836 (4.9%)	46,916 (3.2%)	227,468 (4.7%)
Total	**3,016,605 (61.7%)**	**401,491 (8.2%)**	**1,468,207 (30.0%)**	**4,886,304 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.42: Puerto Rico Trip Distribution by Trip Purpose



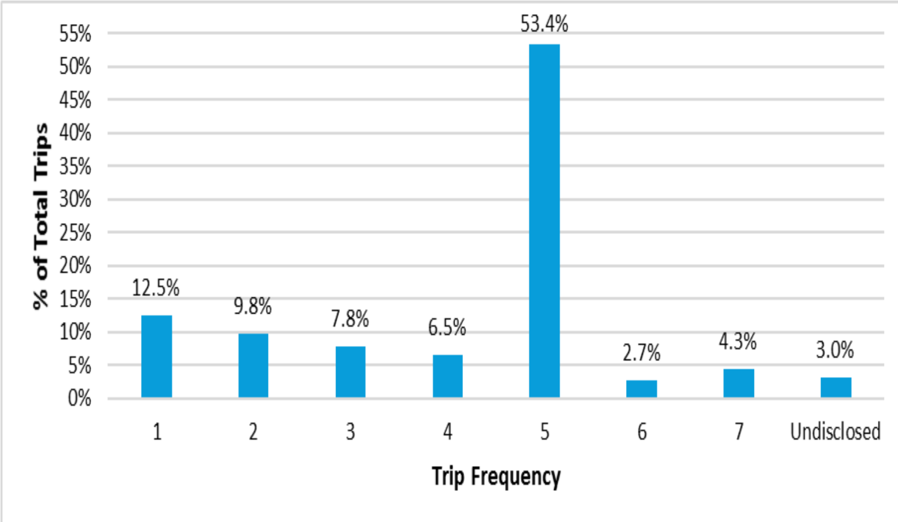
Source: SDG – Using Weighted Survey Results

Table 2.23: Trip Distribution by Trip Purpose and Region

Trip Purpose	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
For Another Activity	74,692 (2.5%)	6,860 (1.7%)	26,206 (1.8%)	107,759 (2.2%)
For Medical/Health Related Purposes	134,327 (4.5%)	12,665 (3.2%)	61,279 (4.2%)	208,271 (4.3%)
To Go Shopping	210,991 (7.0%)	18,901 (4.7%)	94,519 (6.4%)	324,411 (6.6%)
To Commute to Work	644,142 (21.4%)	103,865 (25.9%)	335,946 (22.9%)	1,083,954 (22.2%)
To Return Home	1,233,002 (40.9%)	171,616 (42.7%)	624,039 (42.5%)	2,028,657 (41.5%)
To Drop Off/Pick Up Someone	264,483 (8.8%)	18,877 (4.7%)	107,249 (7.3%)	390,610 (8.0%)
To Study/Go to Class	95,547 (3.2%)	17,070 (4.3%)	43,773 (3.0%)	156,390 (3.2%)
For Legal Procedures	118,416 (3.9%)	10,850 (2.7%)	67,350 (4.6%)	196,616 (4.0%)
Other	241,005 (8.0%)	40,786 (10.2%)	107,845 (7.3%)	389,636 (8.0%)
Total	**3,016,605 (61.7%)**	**401,491 (8.2%)**	**1,468,207 (30.0%)**	**4,886,304 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.43: Puerto Rico Trip Distribution by Trip Frequency Per Week



Source: SDG – Using Weighted Survey Results

Table 2.24: Trip Distribution by Trip Frequency and Region

Weekly Frequency of Trip	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
1	396,881 (13.2%)	33,244 (8.3%)	180,338 (12.3%)	610,463 (12.5%)
2	308,168 (10.2%)	36,357 (9.1%)	132,168 (9.0%)	476,694 (9.8%)
3	225,669 (7.5%)	25,984 (6.5%)	129,792 (8.8%)	381,446 (7.8%)
4	193,940 (6.4%)	37,709 (9.4%)	87,782 (6.0%)	319,430 (6.5%)
5	1,550,652 (51.4%)	221,453 (55.2%)	839,403 (57.2%)	2,611,508 (53.4%)
6	67,441 (2.2%)	17,361 (4.3%)	46,164 (3.1%)	130,966 (2.7%)
7	165,963 (5.5%)	16,298 (4.1%)	27,241 (1.9%)	209,502 (4.3%)
Undisclosed	107,891 (3.6%)	13,085 (3.3%)	25,319 (1.7%)	146,294 (3.0%)
Total	**3,016,605 (61.7%)**	**401,491 (8.2%)**	**1,468,207 (30.0%)**	**4,886,304 (100.0%)**

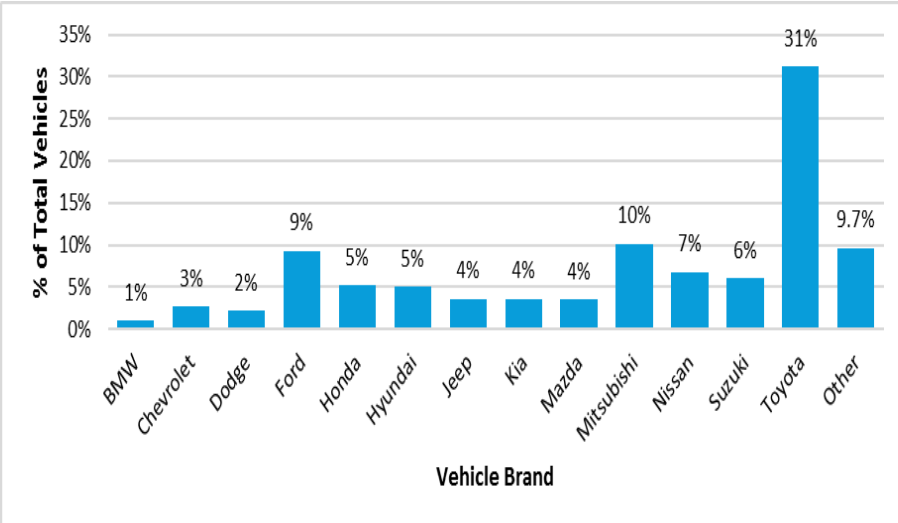
Source: SDG – Using Weighted Survey Results

Vehicle Type and Classifications

Vehicle data was logged by survey participants for 4,490 vehicles.

- Vehicle Brand: Over 31% of vehicles in Puerto Rico are manufactured by Toyota, with Mitsubishi in second place with 10% of total vehicles.
- Model Year: In Puerto Rico, over 25% of vehicles were manufactured prior to 2000. The largest portion of vehicles manufactured in any 5-year window in Puerto Rico were between 2001 and 2005, at close to 23% of total vehicles.
- Vehicle Type: In Puerto Rico, close to 60% of vehicles are standard cars/sedans, while over 30% are SUV's.
- Primary User: Over 80% of the time, the primary users of vehicles are the head of household or spouse/partner. With under 15% of vehicles being primarily used by children in a household.
- Parking Status: Close to 85% of all vehicles are stored in personal garages/driveways in Puerto Rico.

Figure 2.44: Puerto Rico Vehicle Distribution by Brand



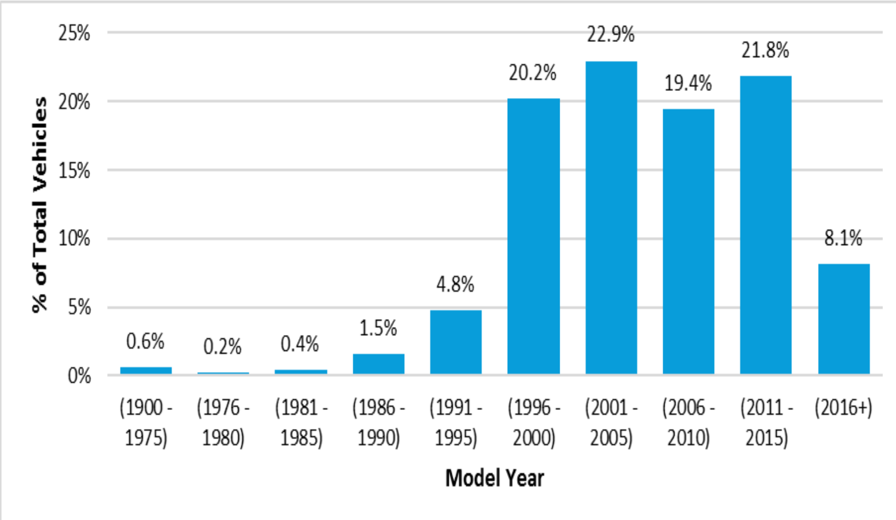
Source: SDG – Using Weighted Survey Results

Table 2.25: Vehicle Distribution by Brand and Region

Car Model	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
BMW	9,339 (0.8%)	516 (0.3%)	8,444 (1.5%)	18,299 (1.0%)
Chevrolet	31,377 (2.8%)	5,481 (3.6%)	12,468 (2.3%)	49,326 (2.7%)
Dodge	16,015 (1.4%)	2,336 (1.5%)	20,363 (3.7%)	38,713 (2.1%)
Ford	108,827 (9.8%)	9,361 (6.1%)	50,493 (9.2%)	168,682 (9.3%)
Honda	74,330 (6.7%)	4,185 (2.7%)	15,788 (2.9%)	94,303 (5.2%)
Hyundai	60,781 (5.5%)	10,367 (6.8%)	18,854 (3.4%)	90,003 (5.0%)
Jeep	35,441 (3.2%)	4,212 (2.8%)	25,732 (4.7%)	65,385 (3.6%)
Kia	41,876 (3.8%)	4,788 (3.1%)	18,824 (3.4%)	65,489 (3.6%)
Mazda	33,867 (3.1%)	4,460 (2.9%)	25,363 (4.6%)	63,690 (3.5%)
Mitsubishi	108,057 (9.7%)	11,960 (7.8%)	63,995 (11.7%)	184,011 (10.2%)
Nissan	82,845 (7.5%)	12,039 (7.9%)	28,433 (5.2%)	123,317 (6.8%)
Suzuki	56,851 (5.1%)	14,830 (9.7%)	36,828 (6.7%)	108,509 (6.0%)
Toyota	334,092 (30.1%)	59,138 (38.7%)	172,299 (31.5%)	565,529 (31.2%)
Other	116,138 (10.5%)	8,968 (5.9%)	49,641 (9.1%)	174,747 (9.7%)
Total	**1,109,838 (61.3%)**	**152,640 (8.4%)**	**547,525 (30.2%)**	**1,810,003 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.45: Puerto Rico Vehicle Distribution by Model Year



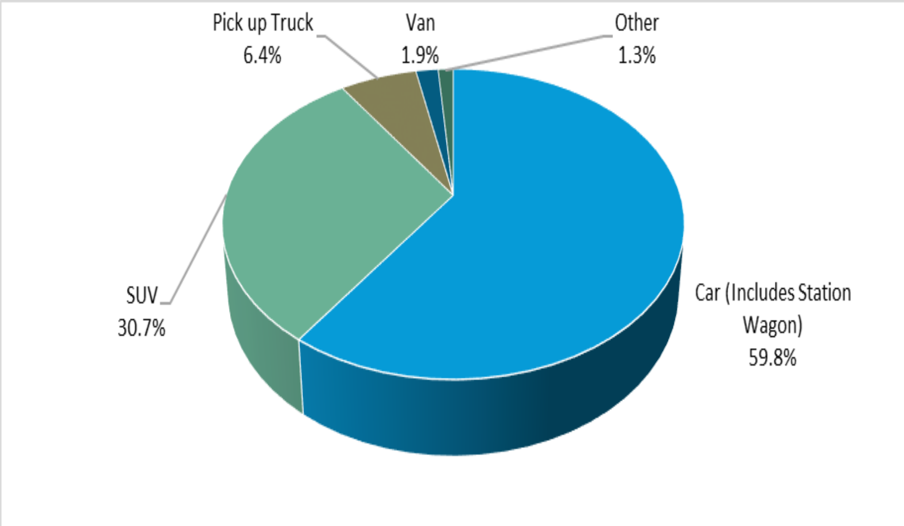
Source: SDG – Using Weighted Survey Results

Table 2.26: Vehicle Distribution by Model Year and Region

Year of Model	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
(1900 - 1975)	5,007 (0.5%)	2,286 (1.5%)	3,508 (0.6%)	10,800 (0.6%)
(1976 - 1980)	48 (0.0%)	258 (0.2%)	3,426 (0.6%)	3,732 (0.2%)
(1981 - 1985)	4,368 (0.4%)	475 (0.3%)	3,186 (0.6%)	8,028 (0.4%)
(1986 - 1990)	12,320 (1.1%)	4,840 (3.2%)	10,838 (2.0%)	27,998 (1.5%)
(1991 - 1995)	40,286 (3.6%)	5,866 (3.8%)	40,036 (7.3%)	86,188 (4.8%)
(1996 - 2000)	223,812 (20.2%)	27,779 (18.2%)	113,817 (20.8%)	365,408 (20.2%)
(2001 - 2005)	248,951 (22.4%)	37,972 (24.9%)	128,240 (23.5%)	415,163 (22.9%)
(2006 - 2010)	223,988 (20.2%)	34,150 (22.4%)	92,808 (17.0%)	350,947 (19.4%)
(2011 - 2015)	261,772 (23.6%)	29,917 (19.6%)	102,766 (18.8%)	394,455 (21.8%)
(2016+)	89,286 (8.0%)	9,098 (6.0%)	48,180 (8.8%)	146,564 (8.1%)
Total	**1,109,838 (61.3%)**	**152,640 (8.4%)**	**546,805 (30.2%)**	**1,809,283 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.46: Puerto Rico Vehicle Distribution by Vehicle Type



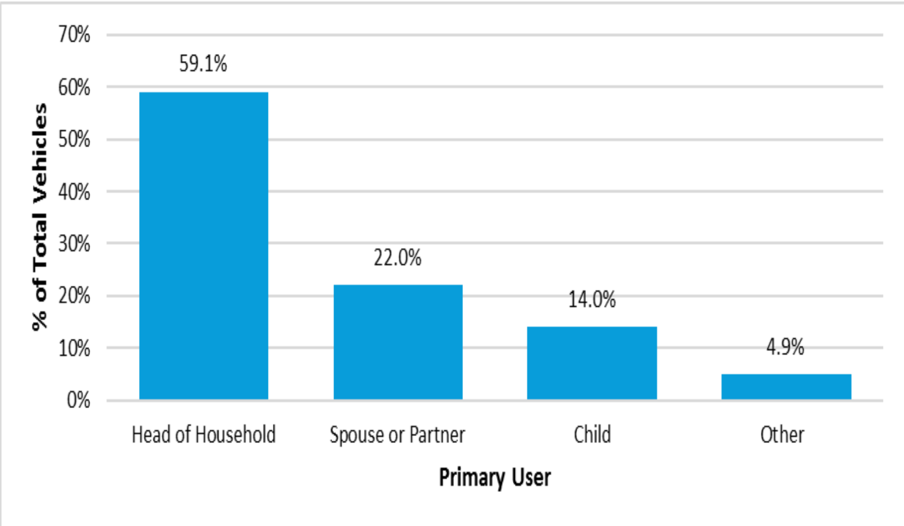
Source: SDG – Using Weighted Survey Results

Table 2.27: Vehicle Distribution by Vehicle Type and Region

Vehicle Type	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Car (Includes Station Wagon)	650,013 (58.6%)	95,899 (62.8%)	336,081 (61.4%)	1,081,993 (59.8%)
SUV	360,198 (32.5%)	44,426 (29.1%)	150,746 (27.5%)	555,370 (30.7%)
Pick-up Truck	57,186 (5.2%)	8,638 (5.7%)	50,244 (9.2%)	116,068 (6.4%)
Van	27,980 (2.5%)	1,787 (1.2%)	3,989 (0.7%)	33,756 (1.9%)
Other	14,460 (1.3%)	1,891 (1.2%)	6,466 (1.2%)	22,816 (1.3%)
Total	**1,109,838 (61.3%)**	**152,640 (8.4%)**	**547,525 (30.2%)**	**1,810,003 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.47: Puerto Rico Vehicle Distribution by Primary User



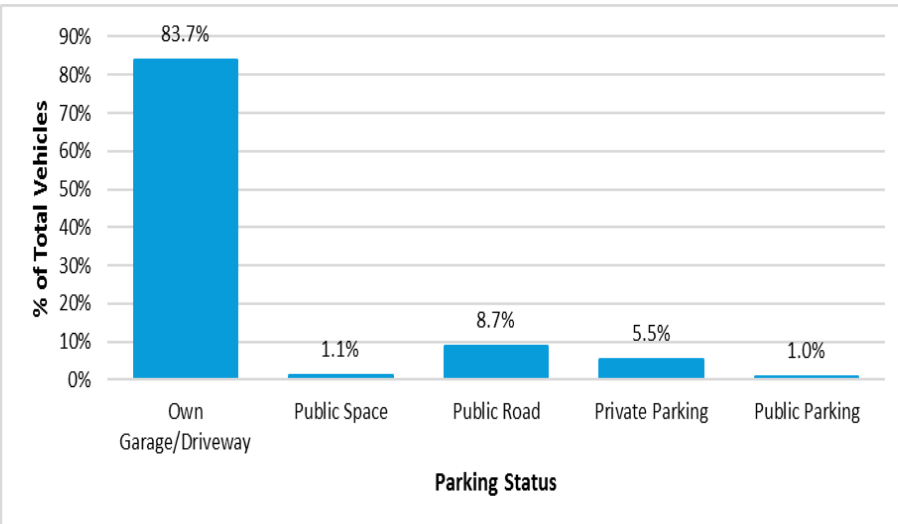
Source: SDG – Using Weighted Survey Results

Table 2.28: Vehicle Distribution by Primary User and Region

Primarily Used By	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Head of Household	665,318 (59.9%)	83,400 (54.6%)	321,352 (58.7%)	1,070,070 (59.1%)
Spouse or Partner	242,869 (21.9%)	37,263 (24.4%)	117,330 (21.4%)	397,462 (22.0%)
Child	150,526 (13.6%)	23,587 (15.5%)	78,942 (14.4%)	253,056 (14.0%)
Other	51,125 (4.6%)	8,390 (5.5%)	29,900 (5.5%)	89,415 (4.9%)
Total	**1,109,838 (61.3%)**	**152,640 (8.4%)**	**547,525 (30.2%)**	**1,810,003 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.48: Puerto Rico Vehicle Distribution by Parking Status



Source: SDG – Using Weighted Survey Results

Table 2.29: Vehicle Distribution by Parking Status and Region

Parking Status	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Own Garage/Driveway	902,410 (81.3%)	140,164 (91.8%)	472,664 (86.3%)	1,515,238 (83.7%)
Public Space	8,160 (0.7%)	0 (0.0%)	12,563 (2.3%)	20,722 (1.1%)
Public Road	117,295 (10.6%)	5,268 (3.5%)	35,446 (6.5%)	158,009 (8.7%)
Private Parking	70,474 (6.3%)	6,071 (4.0%)	22,291 (4.1%)	98,836 (5.5%)
Public Parking	11,499 (1.0%)	1,138 (0.7%)	4,562 (0.8%)	17,198 (1.0%)
Total	**1,109,838 (61.3%)**	**152,640 (8.4%)**	**547,525 (30.2%)**	**1,810,003 (100.0%)**

Source: SDG – Using Weighted Survey Results

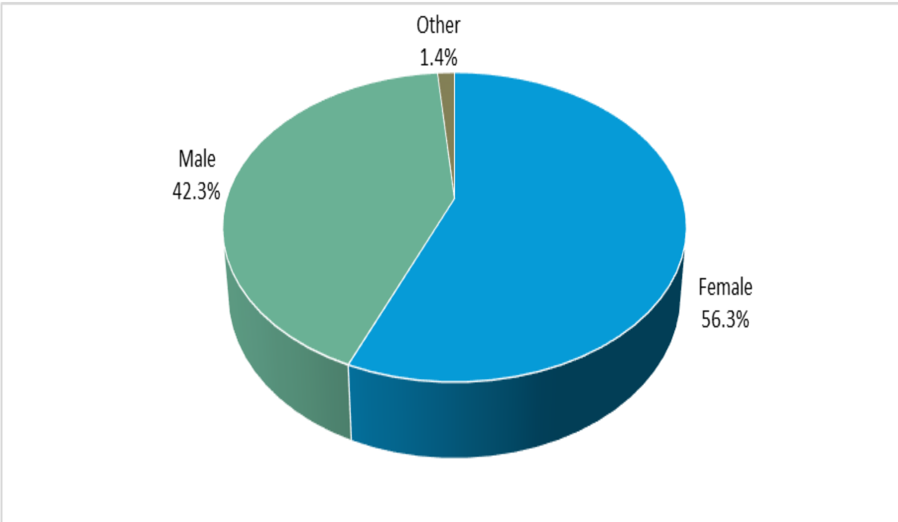
Focused Study – Households/People Without Access To Vehicles

Out of the participants in the household survey, 438 persons (15.7%) stated live in households with zero private vehicles. This section analyzes this group in further depth, specifically their demographics and trip patterns.

- Age: Over 50% of people who do not own a vehicle in Puerto Rico are over 50 years of age.
- Transportation Mode: Of trips taken by individuals who do not own a vehicle in Puerto Rico, just over 26% of trips are made via walking, while just over 26% of trips are

completed as the passenger in a private vehicle. In Aguadilla, over 45% of trips are completed via walking, the highest of the regions.

Figure 2.49: Puerto Rico Population Distribution, Persons Without Owned Vehicles, by Gender



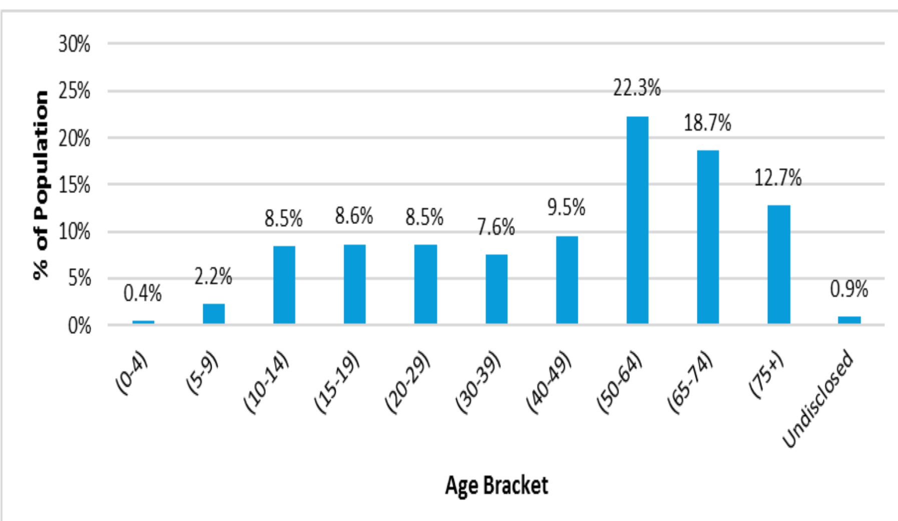
Source: SDG – Using Weighted Survey Results

Table 2.30: Population Distribution, Persons Without Owned Vehicles, by Gender and Region

Gender	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Female	97,480 (62.3%)	10,221 (42.6%)	64,831 (51.5%)	172,532 (56.3%)
Male	55,471 (35.5%)	12,979 (54.1%)	61,059 (48.5%)	129,509 (42.3%)
Other	3,517 (2.2%)	811 (3.4%)	0 (0.0%)	4,328 (1.4%)
Total	**156,469 (51.1%)**	**24,011 (7.8%)**	**125,890 (41.1%)**	**306,369 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.50: Puerto Rico Population Distribution, Persons Without Owned Vehicles, by Age Bracket



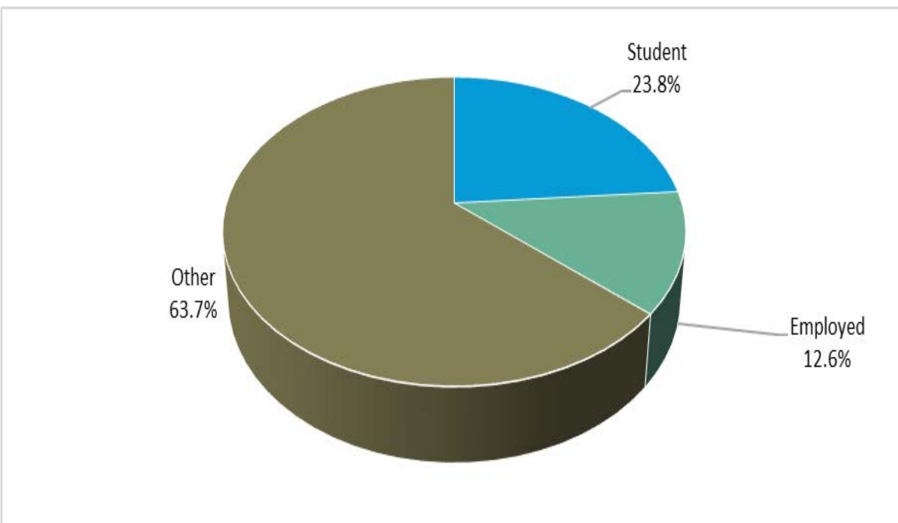
Source: SDG – Using Weighted Survey Results

Table 2.31: Population Distribution, Persons Without Owned Vehicles, by Age Bracket and Region

Age Bracket	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
(0-4)	1,213 (0.8%)	0 (0.0%)	0 (0.0%)	1,213 (0.4%)
(5-9)	5,572 (3.6%)	301 (1.3%)	935 (0.7%)	6,808 (2.2%)
(10-14)	8,389 (5.4%)	572 (2.4%)	16,956 (13.5%)	25,917 (8.5%)
(15-19)	6,483 (4.1%)	596 (2.5%)	19,372 (15.4%)	26,451 (8.6%)
(20-29)	17,816 (11.4%)	2,943 (12.3%)	5,406 (4.3%)	26,164 (8.5%)
(30-39)	9,313 (6.0%)	3,296 (13.7%)	10,578 (8.4%)	23,186 (7.6%)
(40-49)	9,970 (6.4%)	2,311 (9.6%)	16,970 (13.5%)	29,251 (9.5%)
(50-64)	36,882 (23.6%)	5,952 (24.8%)	25,518 (20.3%)	68,352 (22.3%)
(65-74)	36,240 (23.2%)	5,682 (23.7%)	15,279 (12.1%)	57,201 (18.7%)
(75+)	22,244 (14.2%)	1,848 (7.7%)	14,875 (11.8%)	38,967 (12.7%)
Undisclosed	2,347 (1.5%)	510 (2.1%)	0 (0.0%)	2,857 (0.9%)
Total	**156,469 (51.1%)**	**24,011 (7.8%)**	**125,890 (41.1%)**	**306,369 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.51: Puerto Rico Population Distribution, Persons Without Owned Vehicles, by Employment/Student Status



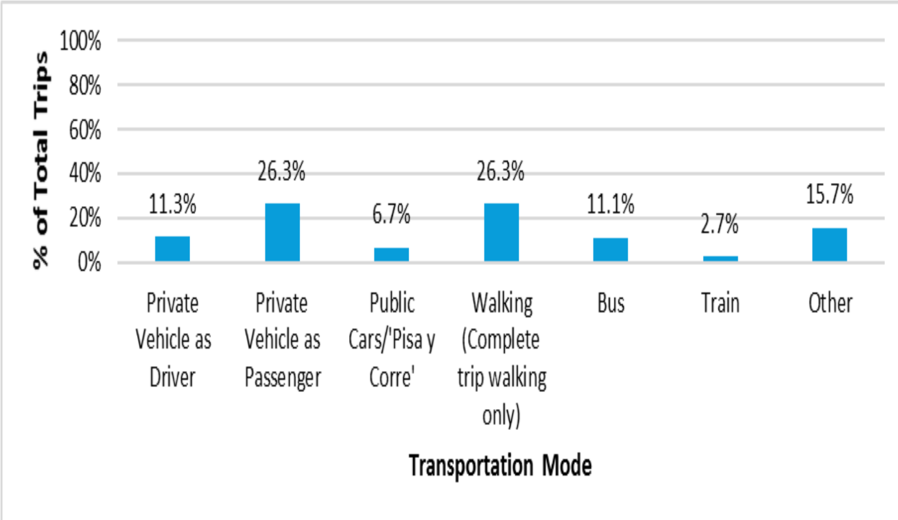
Source: SDG – Using Weighted Survey Results

Table 2.32: Population Distribution, Persons Without Owned Vehicles, by Employment/Student Status and Region

Employment	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Other	110,884 (70.9%)	16,101 (67.1%)	68,037 (54.0%)	195,022 (63.7%)
Student	23,906 (15.3%)	2,697 (11.2%)	46,245 (36.7%)	72,848 (23.8%)
Employed	21,680 (13.9%)	5,213 (21.7%)	11,607 (9.2%)	38,500 (12.6%)
Total	**156,469 (51.1%)**	**24,011 (7.8%)**	**125,890 (41.1%)**	**306,369 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.52: Puerto Rico Trip Distribution, Persons Without Owned Vehicles, by Transportation Mode



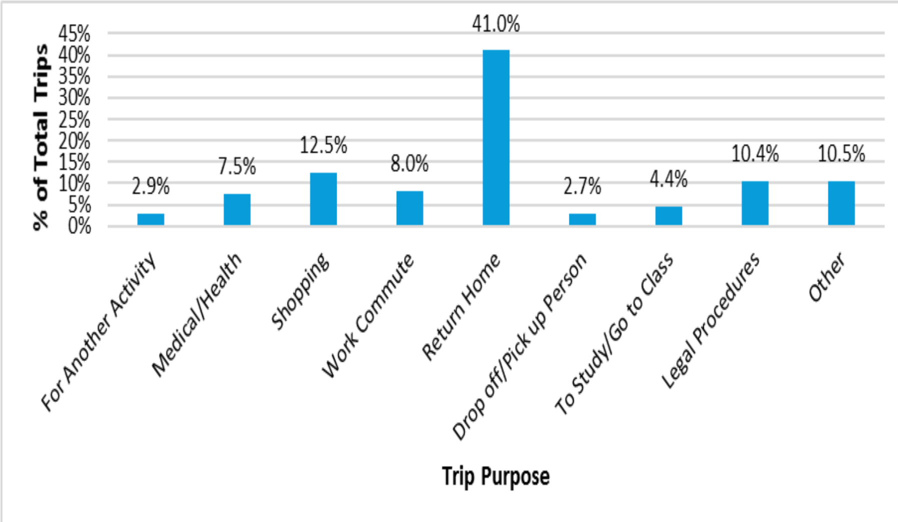
Source: SDG – Using Weighted Survey Results

Table 2.33: Trip Distribution, Persons Without Owned Vehicles, by Transportation Mode and Region

Mode of Transport	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Private Vehicle as Driver	22,826 (8.7%)	2,521 (6.9%)	25,355 (17.1%)	50,702 (11.3%)
Private Vehicle as Passenger	64,382 (24.4%)	8,477 (23.2%)	44,978 (30.3%)	117,837 (26.3%)
Public Cars/'Pisa y Corre'	20,479 (7.8%)	990 (2.7%)	8,672 (5.8%)	30,141 (6.7%)
Walking (Complete Trip Walking Only)	59,568 (22.6%)	16,868 (46.1%)	41,708 (28.1%)	118,144 (26.3%)
Bus	36,425 (13.8%)	1,466 (4.0%)	11,844 (8.0%)	49,735 (11.1%)
Train	11,997 (4.5%)	0 (0.0%)	0 (0.0%)	11,997 (2.7%)
Other	48,016 (18.2%)	6,286 (17.2%)	15,952 (10.7%)	70,254 (15.7%)
Total	**263,694 (58.8%)**	**36,608 (8.2%)**	**148,507 (33.1%)**	**448,809 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.53: Puerto Rico Trip Distribution, Persons Without Owned Vehicles, by Trip Purpose



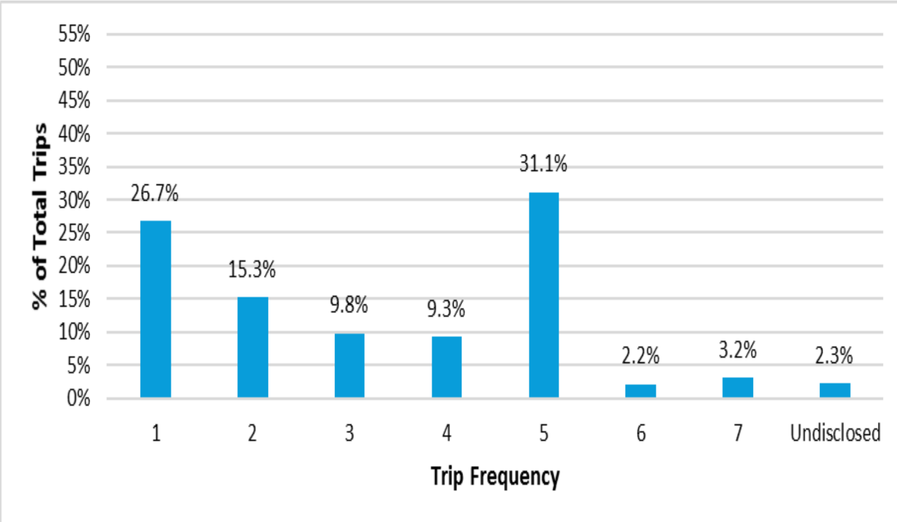
Source: SDG – Using Weighted Survey Results

Table 2.34: Trip Distribution, Persons Without Owned Vehicles, by Trip Purpose and Region

Trip Purpose	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
For Another Activity	8,349 (3.2%)	892 (2.4%)	3,829 (2.6%)	13,069 (2.9%)
For Medical/Health Related Purposes	22,466 (8.5%)	3,302 (9.0%)	7,947 (5.4%)	33,715 (7.5%)
To go Shopping	40,440 (15.3%)	2,964 (8.1%)	12,832 (8.6%)	56,235 (12.5%)
To Commute to Work	19,911 (7.6%)	3,474 (9.5%)	12,536 (8.4%)	35,922 (8.0%)
To Return Home	105,750 (40.1%)	13,084 (35.7%)	65,334 (44.0%)	184,168 (41.0%)
To Drop Off/Pick up Someone	8,492 (3.2%)	1,596 (4.4%)	2,073 (1.4%)	12,162 (2.7%)
To Study/Go to Class	7,438 (2.8%)	892 (2.4%)	11,341 (7.6%)	19,671 (4.4%)
For Legal Procedures	25,443 (9.6%)	3,570 (9.8%)	17,719 (11.9%)	46,731 (10.4%)
Other	25,405 (9.6%)	6,834 (18.7%)	14,897 (10.0%)	47,137 (10.5%)
Total	**263,694 (58.8%)**	**36,608 (8.2%)**	**148,507 (33.1%)**	**448,809 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.54: Puerto Rico Trip Distribution, Persons Without Owned Vehicles, by Trip Frequency Per Week



Source: SDG – Using Weighted Survey Results

Table 2.35: Trip Distribution, Persons Without Owned Vehicles, by Trip Frequency and Region

Weekly Frequency of Trip	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
1	80,802 (30.6%)	1,192 (3.3%)	37,951 (25.6%)	119,945 (26.7%)
2	40,379 (15.3%)	8,210 (22.4%)	20,192 (13.6%)	68,780 (15.3%)
3	28,854 (10.9%)	4,192 (11.5%)	11,078 (7.5%)	44,124 (9.8%)
4	25,071 (9.5%)	4,206 (11.5%)	12,646 (8.5%)	41,923 (9.3%)
5	64,558 (24.5%)	16,051 (43.8%)	59,099 (39.8%)	139,708 (31.1%)
6	5,103 (1.9%)	1,021 (2.8%)	3,655 (2.5%)	9,778 (2.2%)
7	10,254 (3.9%)	892 (2.4%)	3,013 (2.0%)	14,158 (3.2%)
Undisclosed	8,674 (3.3%)	844 (2.3%)	874 (0.6%)	10,392 (2.3%)
Total	**263,694 (58.8%)**	**36,608 (8.2%)**	**148,507 (33.1%)**	**448,809 (100.0%)**

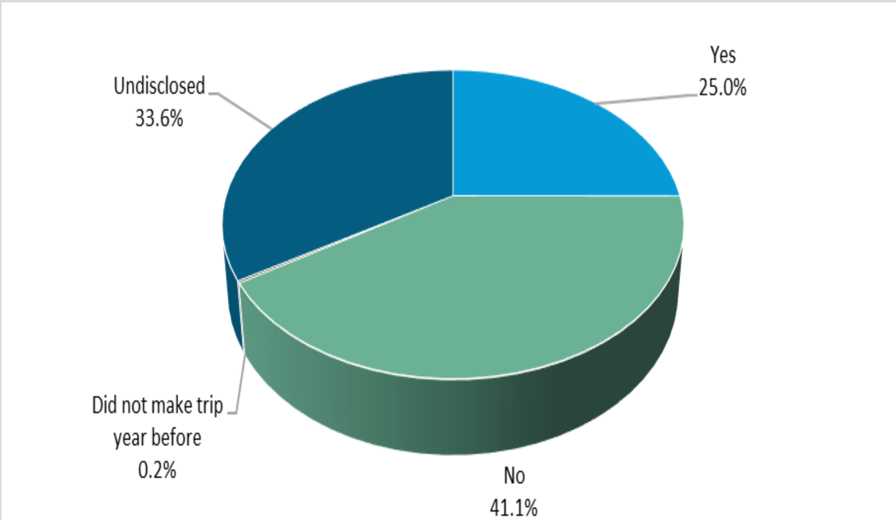
Source: SDG – Using Weighted Survey Results

Focused Study – Transportation Affected By Hurricane María

Out of the participants in the household survey, 438 persons (15.7%) stated live in households with zero private vehicles. This section analyzes this group in further depth, specifically their demographics and trip patterns.

- Age: Over 50% of individuals in Puerto Rico whose trips were affected by Hurricane María are over 50 years of age.
- Transportation Mode: Close to 90% of trips affected by Hurricane María were completed as either driver or passenger of a private vehicle.

Figure 2.55: Puerto Rico Trip Distribution by "Was Trip and/or Transportation Mode Affected by Hurricane María"



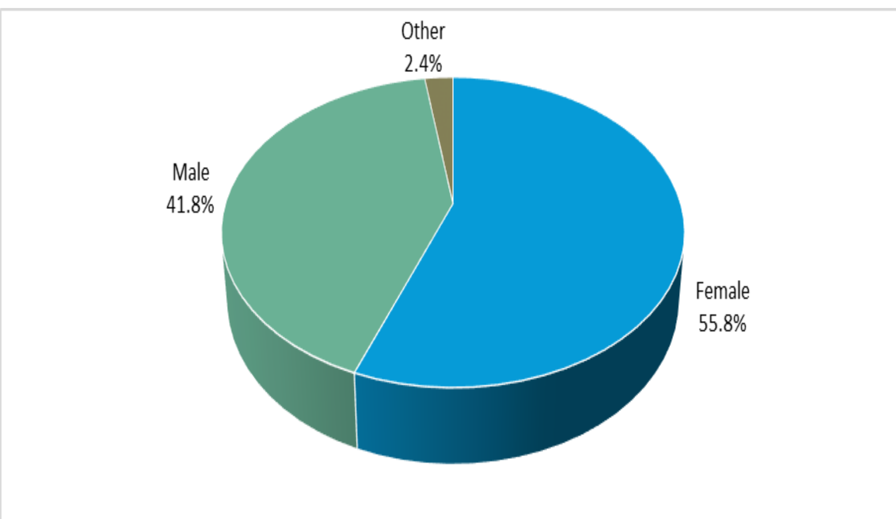
Source: SDG – Using Weighted Survey Results

Table 2.36: Trip Distribution by "Was Trip and/or Transportation Mode Affected by Hurricane María" and Region

Changed by Hurricane	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Yes	721,328 (23.9%)	94,660 (23.6%)	406,674 (27.7%)	1,222,662 (25.0%)
No	1,287,838 (42.7%)	143,392 (35.7%)	577,833 (39.4%)	2,009,063 (41.1%)
Did not make trip year before	7,744 (0.3%)	892 (0.2%)	2,580 (0.2%)	11,216 (0.2%)
Undisclosed	999,696 (33.1%)	162,547 (40.5%)	481,120 (32.8%)	1,643,363 (33.6%)
Total	**3,016,605 (61.7%)**	**401,491 (8.2%)**	**1,468,207 (30.0%)**	**4,886,304 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.56: Puerto Rico Population Distribution, People with Trips Affected by Hurricane María, by Gender



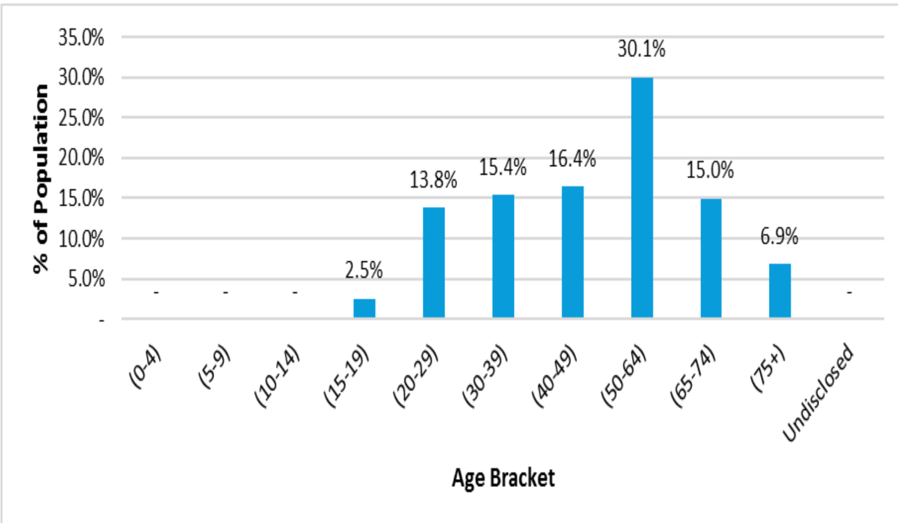
Source: SDG – Using Weighted Survey Results

Table 2.37: Population Distribution, People with Trips Affected by Hurricane María, By Gender and Region

Gender	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Female	213,497 (61.4%)	23,327 (44.1%)	97,825 (49.2%)	334,649 (55.8%)
Male	129,691 (37.3%)	29,550 (55.9%)	91,422 (46.0%)	250,662 (41.8%)
Other	4,554 (1.3%)	0 (0.0%)	9,556 (4.8%)	14,111 (2.4%)
Total	**347,741 (58.0%)**	**52,877 (8.8%)**	**198,803 (33.2%)**	**599,422 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.57: Puerto Rico Population Distribution, People with Trips Affected by Hurricane María, by Age Bracket



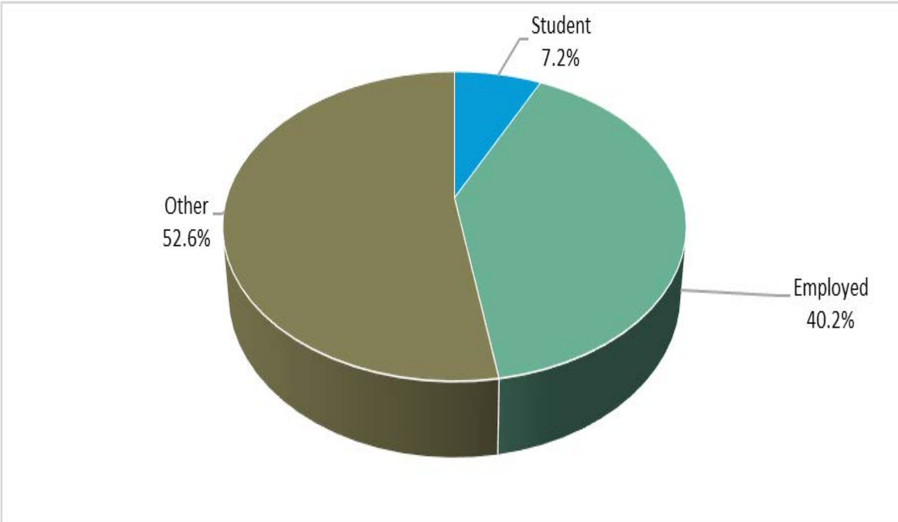
Source: SDG – Using Weighted Survey Results

Table 2.38: Population Distribution, People with Trips Affected by Hurricane María, by Age Bracket and Region

Age Bracket	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
(0-4)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
(5-9)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
(10-14)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
(15-19)	11,325 (3.3%)	304 (0.6%)	3,480 (1.8%)	15,109 (2.5%)
(20-29)	53,958 (15.5%)	9,849 (18.6%)	18,779 (9.4%)	82,586 (13.8%)
(30-39)	42,395 (12.2%)	9,378 (17.7%)	40,361 (20.3%)	92,135 (15.4%)
(40-49)	49,893 (14.3%)	9,370 (17.7%)	39,293 (19.8%)	98,557 (16.4%)
(50-64)	108,023 (31.1%)	14,667 (27.7%)	57,445 (28.9%)	180,136 (30.1%)
(65-74)	56,272 (16.2%)	6,537 (12.4%)	26,978 (13.6%)	89,788 (15.0%)
(75+)	25,875 (7.4%)	2,772 (5.2%)	12,464 (6.3%)	41,111 (6.9%)
Undisclosed	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	**347,741 (58.0%)**	**52,877 (8.8%)**	**198,803 (33.2%)**	**599,422 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.58: Puerto Rico Population Distribution, People with Trips Affected by Hurricane María, by Employment/Student Status



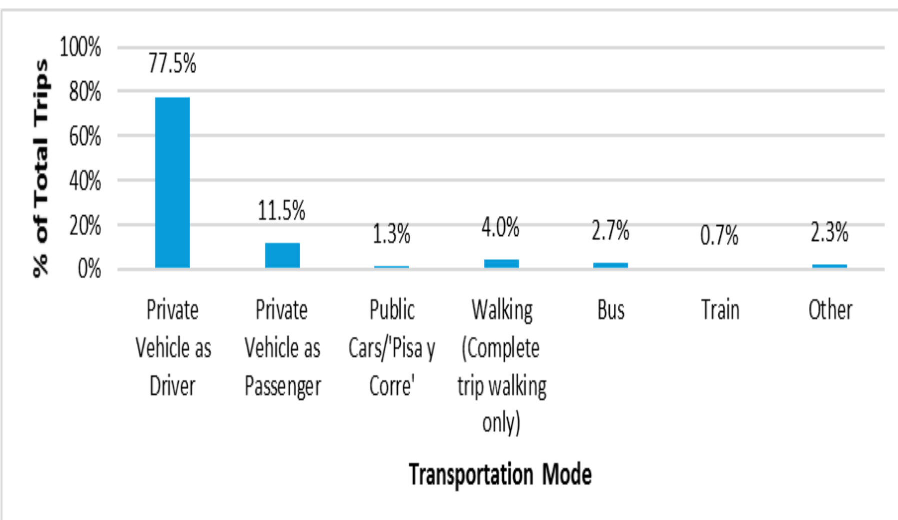
Source: SDG – Using Weighted Survey Results

Table 2.39: Population Distribution, People with Trips Affected by Hurricane María, by Employment/Student Status and Region

Employment	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
Other	186,380 (53.6%)	26,963 (51.0%)	101,678 (51.1%)	315,021 (52.6%)
Student	22,045 (6.3%)	3,339 (6.3%)	18,072 (9.1%)	43,456 (7.2%)
Employed	139,316 (40.1%)	22,575 (42.7%)	79,053 (39.8%)	240,944 (40.2%)
Total	**347,741 (58.0%)**	**52,877 (8.8%)**	**198,803 (33.2%)**	**599,422 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.59: Puerto Rico Trip Distribution, Trips Affected by Hurricane María, by Transportation Mode



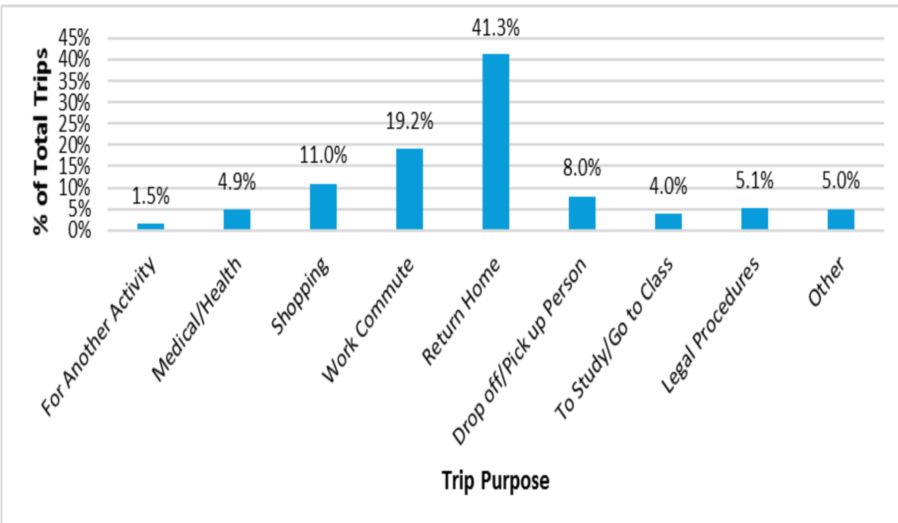
Source: SDG – Using Weighted Survey Results

Table 2.40: Trip Distribution, Trips Affected by Hurricane María, by Transportation Mode and Region

Mode of Transport	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Totals
Private Vehicle as Driver	532,748 (73.9%)	78,629 (83.1%)	336,608 (82.8%)	947,985 (77.5%)
Private Vehicle as Passenger	93,868 (13.0%)	5,816 (6.1%)	40,356 (9.9%)	140,040 (11.5%)
Public Cars/'Pisa y Corre'	11,430 (1.6%)	446 (0.5%)	3,408 (0.8%)	15,284 (1.3%)
Walking (Complete trip walking only)	21,742 (3.0%)	8,041 (8.5%)	19,235 (4.7%)	49,017 (4.0%)
Bus	31,753 (4.4%)	446 (0.5%)	1,283 (0.3%)	33,482 (2.7%)
Train	9,105 (1.3%)	0 (0.0%)	0 (0.0%)	9,105 (0.7%)
Other	20,682 (2.9%)	1,282 (1.4%)	5,785 (1.4%)	27,750 (2.3%)
Total	**721,328 (59.0%)**	**94,660 (7.7%)**	**406,674 (33.3%)**	**1,222,662 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.60: Puerto Rico Trip Distribution, Trips Affected by Hurricane María, by Trip Purpose



Source: SDG – Using Weighted Survey Results

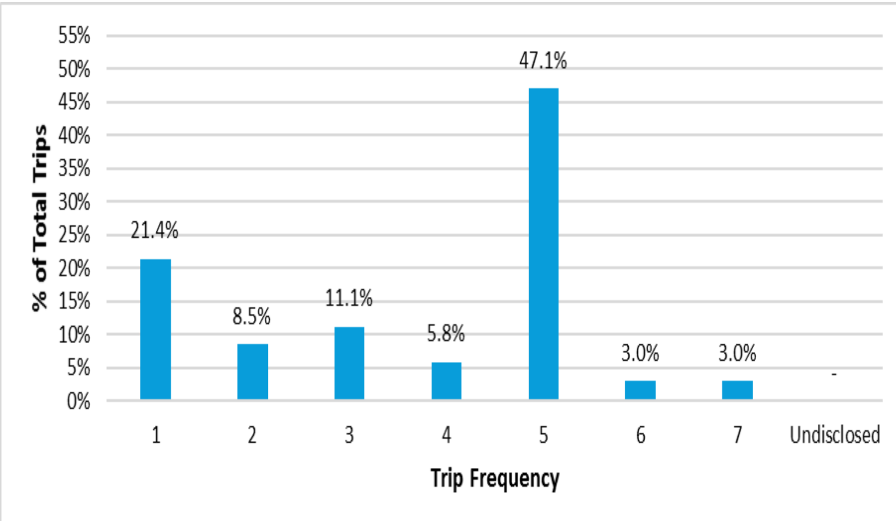
Table 2.41: Trip Distribution, Trips Affected by Hurricane María, by Trip Purpose and Region

Trip Purpose	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
For Another Activity	10,680 (1.5%)	801 (0.8%)	7,069 (1.7%)	18,550 (1.5%)
For Medical/Health Related Purposes	37,476 (5.2%)	5,325 (5.6%)	16,806 (4.1%)	59,608 (4.9%)
To go Shopping	89,839 (12.5%)	5,609 (5.9%)	38,801 (9.5%)	134,250 (11.0%)
To Commute to Work	137,619 (19.1%)	19,859 (21.0%)	77,377 (19.0%)	234,854 (19.2%)
To Return Home	294,163 (40.8%)	36,714 (38.8%)	173,910 (42.8%)	504,787 (41.3%)
To Drop Off/Pick up Someone	58,116 (8.1%)	6,341 (6.7%)	33,680 (8.3%)	98,137 (8.0%)
To Study/Go to Class	25,489 (3.5%)	5,545 (5.9%)	17,424 (4.3%)	48,458 (4.0%)
For Legal Procedures	39,076 (5.4%)	4,788 (5.1%)	18,885 (4.6%)	62,750 (5.1%)

Other	28,870 (4.0%)	9,678 (10.2%)	22,722 (5.6%)	61,269 (5.0%)
Total	**721,328 (59.0%)**	**94,660 (7.7%)**	**406,674 (33.3%)**	**1,222,662 (100.0%)**

Source: SDG – Using Weighted Survey Results

Figure 2.61: Puerto Rico Trip Distribution, Trips Affected by Hurricane María, by Trip Frequency Per Week



Source: SDG – Using Weighted Survey Results

Table 2.42: Trip Distribution, Trips Affected by Hurricane María, by Trip Frequency and Region

Weekly Frequency of Trip	San Juan (TMA)	Aguadilla (TMA)	Other Urbanized Areas	Puerto Rico
1	168,883 (23.4%)	12,780 (13.5%)	79,977 (19.7%)	261,640 (21.4%)
2	63,857 (8.9%)	8,698 (9.2%)	31,578 (7.8%)	104,132 (8.5%)
3	91,323 (12.7%)	8,218 (8.7%)	36,784 (9.0%)	136,325 (11.1%)
4	42,083 (5.8%)	6,875 (7.3%)	22,018 (5.4%)	70,976 (5.8%)
5	306,029 (42.4%)	52,166 (55.1%)	217,906 (53.6%)	576,102 (47.1%)
6	20,547 (2.8%)	4,453 (4.7%)	11,522 (2.8%)	36,522 (3.0%)
7	28,605 (4.0%)	1,470 (1.6%)	6,889 (1.7%)	36,964 (3.0%)
Undisclosed	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	**721,328 (59.0%)**	**94,660 (7.7%)**	**406,674 (33.3%)**	**1,222,662 (100.0%)**

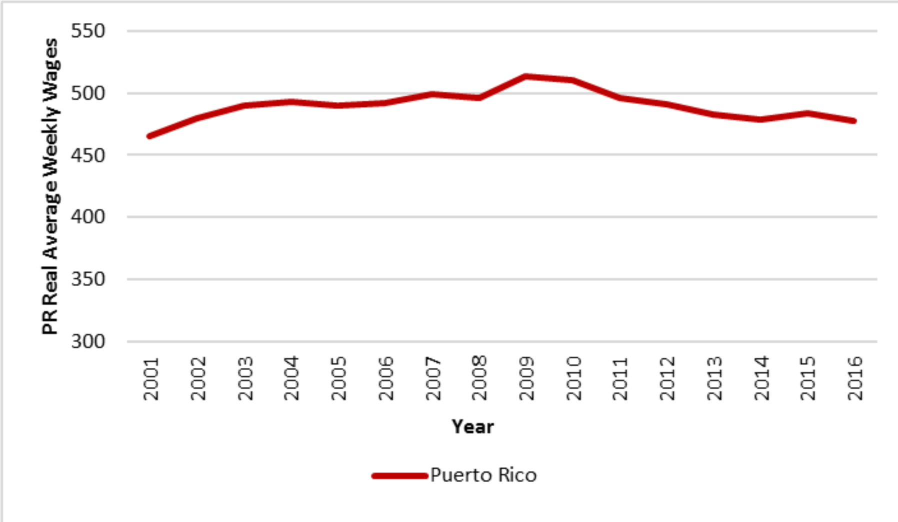
Source: SDG – Using Weighted Survey Results

Forecasting

This section outlines the 2045 LRTP forecasts for population and employment in Puerto Rico. The forecasts were produced using a combination of regional economic forecasting techniques and demographic analysis. For additional details on socio-economic forecasting see Appendix B.

The analysis follows standard practice in regional economic forecasting by focusing on the relationship between population growth (or decline) and economic growth (or decline). The approach focuses on the interplay between population, employment and the cost-of-doing business, as measured by regional wage rates. Wage costs are important to Puerto Rico, as they play a key role in attracting mainland US firms by providing a relatively competitive labor force. Figure 2.62 shows Puerto Rico's average weekly wages by region.

Figure 2.62: Puerto Rico Average Weekly Wages (Constant 2010 Prices)



Source: SDG analysis of Bureau of Labor Statistics Data

The process of forecasting population and employment growth in Puerto Rico needed to contend with the fact that the Island has been undergoing structural changes in its employment base. This change, coupled with several other events both discussed below and in previous sections, have led to a decrease in both employment and population within the last decade. This was shown above in Figure 2.9 and Figure 2.12.

It was found the reversal to be rooted in several factors, including:

- A significant decline in birth rates;
- A decline in manufacturing employment, tied to changes in federal taxation policy, international competition and the fact that manufacturing productivity growth with tend to decrease employment through automation; and
- An increase in the rate of out-migration to the rest of the United States.

This trend is likely to continue and, from initial estimates, has already been exacerbated by a series of impactful exogenous events, including:

- The recent Hurricane María (Sept. 2017) that gravely disrupted economic activity; and
- A long-running fiscal imbalance that culminated in the appointment of the federal oversight board in 2017. The financial crisis has exacerbated the economic challenges on several fronts, forcing cuts in public sector spending and employment and increasing the perceived risk of investing in Puerto Rico's economy.

The forecasts described below suggest that Puerto Rico will recover from recent events, most notably Hurricane María, but will continue to see employment levels declining but at a much slower rate. Population growth will continue to be negative (but at a much slower rate than recent experience), as lower Birth rates will tend to amplify the long-standing pattern for Puerto Rico of net out-migration, principally to the United States mainland.

Puerto Rico is expected to lose nearly 520,000 persons and over 90,000 jobs by 2045. This corresponds to a 15.2% decline in population and an 10.4% decline in employment from Puerto Rico's 2016 figures.

The forecasting approach, described below, does not include scenarios, in the sense that the forecasts **do not** consider various changes in policy given their uncertainty, such as:

- The possibility that debt restructuring for Puerto Rico could yield a relaxation of fiscal constraints for the government of the Island;
- The possibility that changes in the structure of Federal taxes affects Puerto Rico's competitive position negatively; or
- The possibility that Puerto Rico develops new sources of employment and growth, for example in high technology sectors.

Forecasting Methodology

The models developed for Puerto Rico build "bottom-up" from separate models for the seven Regions in Puerto Rico.

Description of Econometric Models

The econometric models used for this exercise consider population, employment, and wages. The models can be understood to be a representation of labor market conditions. These models use past values of related variables to predict future ones, while also incorporating the dynamics of regional economies and labor markets.

While growth tends to follow a general trend, high wages will, at the margin, act as a break on growth and investment. Similarly, lower wages will tend to attract investment. The model structure is therefore grounded in regional economic theory and is capable of predicting beyond trend growth.

Specifically, the models were used to estimate in the growth rates for each of the seven Regions in Puerto Rico. Forecasted growth rates are then applied to base historic levels of population and employment. The models also use manufacturing value added as an exogenous predictor.

The general system of equations takes the following form:

$$Population_t = \alpha_0 + \alpha_1 Population_{t-1} + \alpha_2 Employment_{t-1} + \alpha_3 Real\ Wages_{t-1} + \alpha_4 Manuf\ Value\ Added_{t-1} + u_{pt}$$

$$Employment_t = \beta_0 + \beta_1 Population_{t-1} + \beta_2 Employment_{t-1} + \beta_3 Real\ Wages_{t-1} + \beta_4 Manuf\ Value\ Added_{t-1} + u_{et}$$

$$Real\ Wages_t = \gamma_0 + \gamma_1 Population_{t-1} + \gamma_2 Employment_{t-1} + \gamma_3 Real\ Wages_{t-1} + \gamma_4 Manuf\ Value\ Added_{t-1} + u_{wt}$$

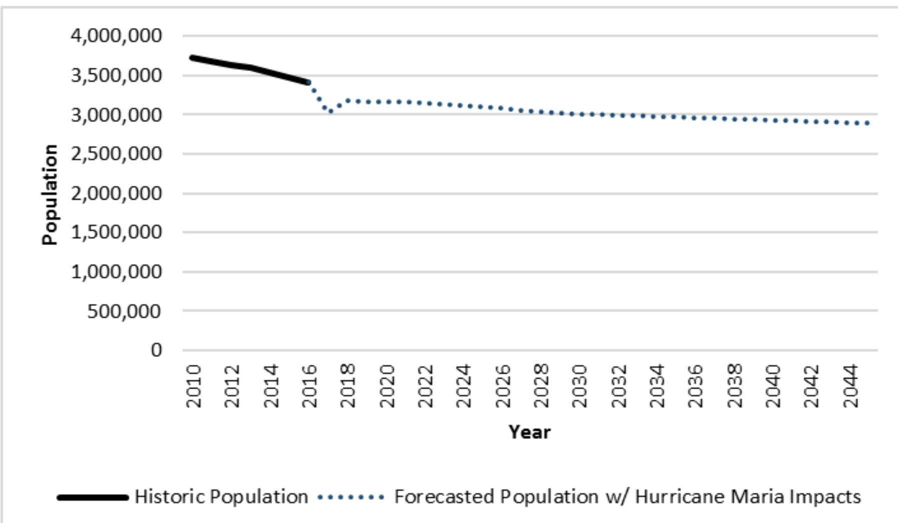
Estimation of Impact of Hurricane María

One advantage of using these models for this exercise is their ability to predict impacts of exogenous shocks. In addition to forecasting long-term growth, these models are used to estimate the persistent effects of an event such as Hurricane María. Studies of other regions suffering natural disasters show that post-disaster population can be slow to recover to pre-disaster trends. These models first estimate long-term population and employment forecasts based on pre-Hurricane levels, then separately estimate the impact of Hurricane María. What these models can do is tell us the trajectory of outmigration specifically due to the Hurricane, followed by the return of some residents. They determine how long population and employment levels should take to return to the trends forecasted without the impact of the Hurricane. Specifically, the model captures the persistence effect of the hurricane's impact (generally estimated to have been a 7.7% reduction population[21] in 2017).

Population

Figure 2.63 presents the formal population forecasts for Puerto Rico. This includes historical population trends, the impacts of Hurricane María and the subsequent return to a forecasted population trend of slower population decline[22].

Figure 2.63: Population Forecasts – Puerto Rico



Source: SDG Population Forecast

Table 2.43 breaks down the population forecast into temporal segments. Over the 29-year timespan, 2016-2045, population is forecasted to decline by 15.2% and analysis of CAGR points to focused population decline from 2016 to 2020. Population during this 4 year-period is forecasted to decline 1.8% annually, a reduction of close to 520,000 people. It is important to note that historically, employment in the region has not declined at the same rate as population.

[21] PR Fiscal Board.

[22] SDG developed its forecasting models using decennial and annual population estimates spanning 2001-2016 from the U.S. Census Bureau. Following the release of the decennial census, preceding annual population estimates are adjusted to produce intercensal estimates. SDG models do not use intercensal estimates, choosing to specify models on annual estimates, and are presented in graphics from 2010-2045.

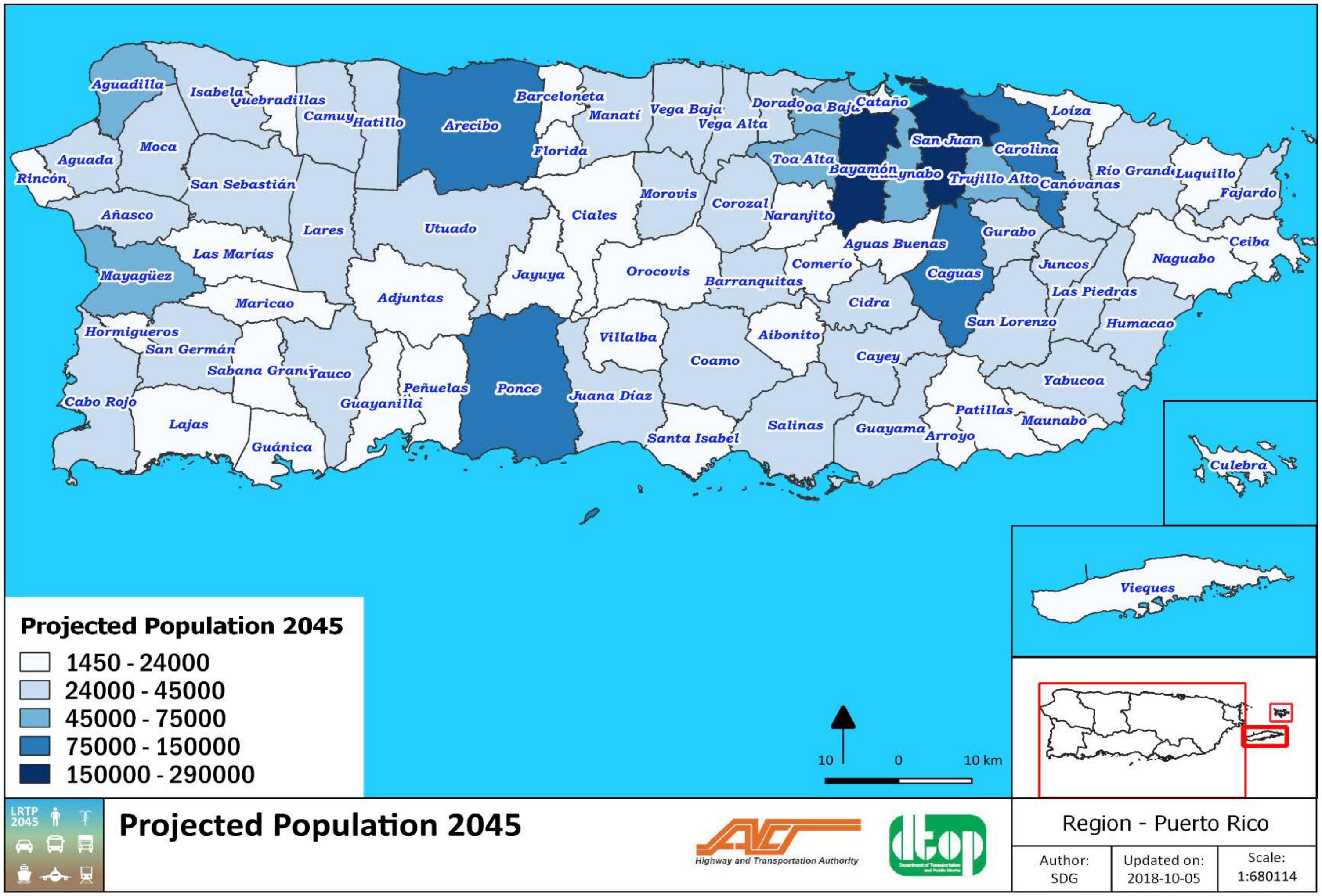
Over the time-scale, 2016-2045, the population CAGR is reduced to -0.6%. This slowing population decline results from the relationship between employment, population, and wages present in the forecast models and discussed in the model development section. Figure 2.64 shows the forecasted 2045 population and population changes respectively.

Table 2.43: Population Forecast Growth Rates – Puerto Rico

Year	PR Population	Percent Change from 2016	CAGR from 2016
2016	3,411,307	-	-
2020	3,168,498	(7.1%)	(1.8%)
2025	3,094,020	(9.3%)	(1.1%)
2040	2,929,693	(14.1%)	(0.6%)
2045	2,893,950	(15.2%)	(0.6%)

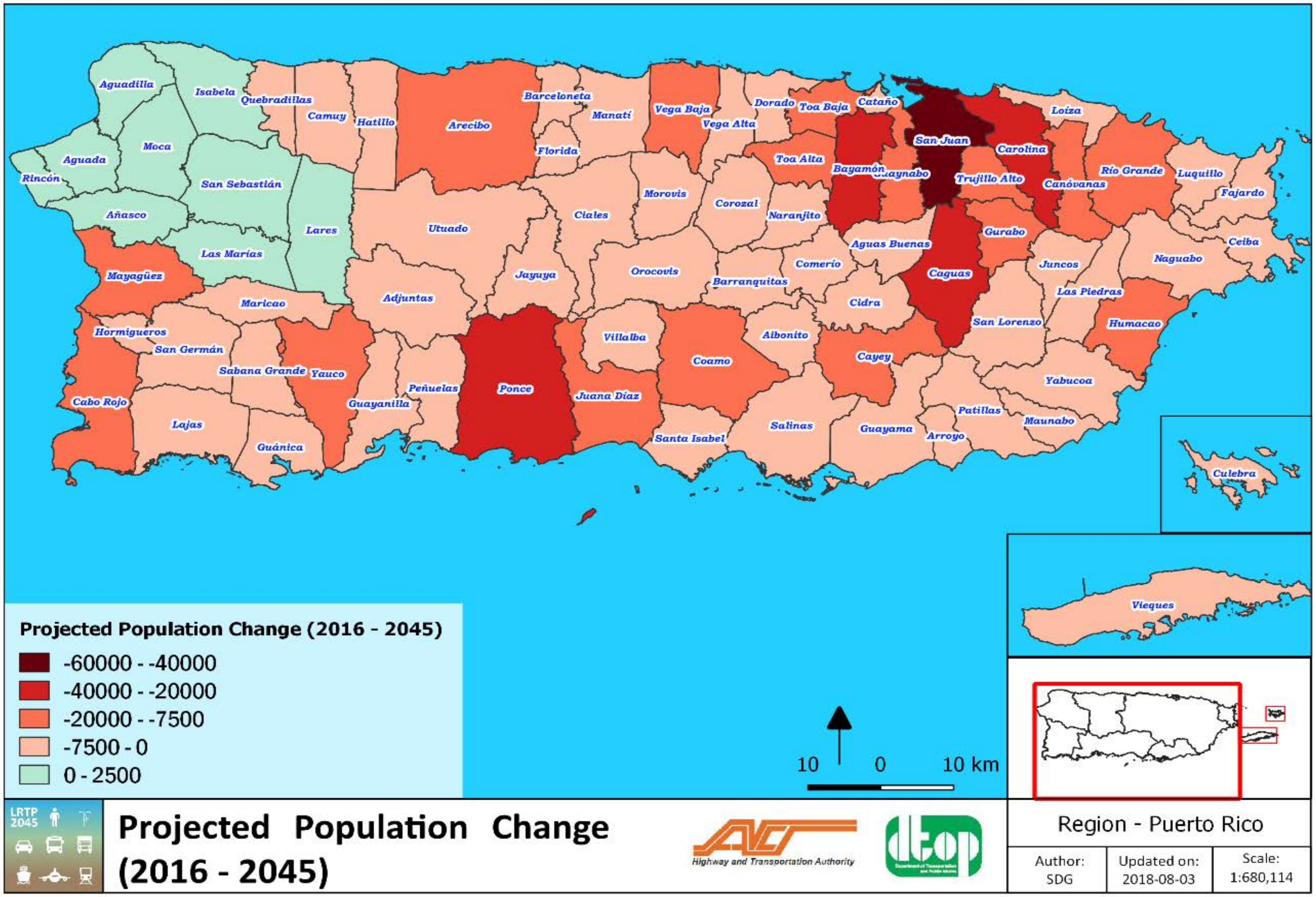
Source: SDG Population Forecast

Figure 2.64: Puerto Rico Population 2045



Source: Population Projections carried out by Steer Davies Gleave on U.S. Census Bureau Population Estimates.

Figure 2.65: Puerto Rico Population Change 2016-2045



Source: Population Projections carried out by Steer Davies Gleave on U.S. Census Bureau Population Estimates.

Employment

Two employment data sources were used to produce final forecasts of employment by municipality. The ultimate data source was the BLS -LAUS which encompasses all employment including agricultural employment and the self-employed. BLS LAUS displays employment by place of residence. While useful for many types of analyses, employment by home location was not ideal for much of the modelling, which required employment by place of work. For example, employment by place of work is required as inputs to the trip generation phase.

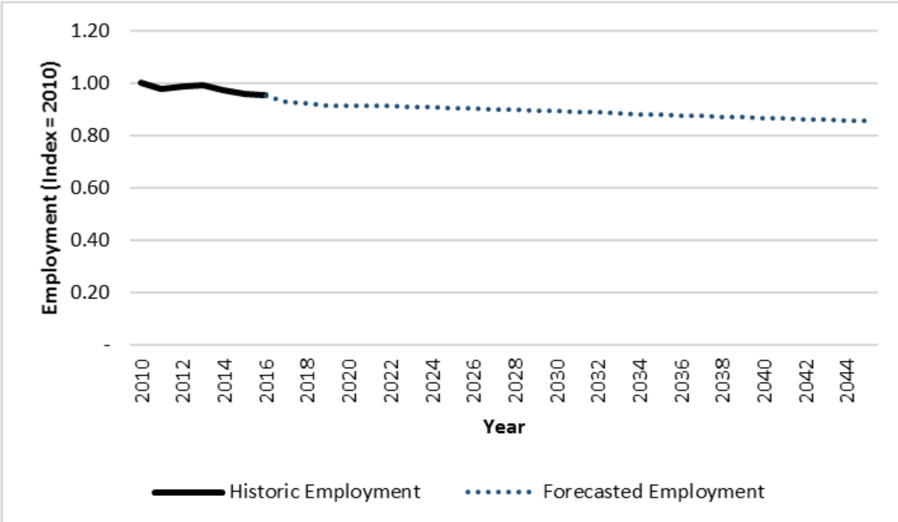
The LAUS data was the reference point in terms of total employment for Puerto Rico, as it includes the broadest coverage of employment categories. In the base 2010 dataset at the Traffic Analysis Zone (TAZ) level, the BLS LAUS employment was the reference data but it was transformed into employment by place of work using journey-to-work information. The approach is to base the analysis on this 2010 employment transformed from place of residence to place of work which matches the 2010 employment totals for Puerto Rico reported in the LAUS.

The BLS Quarterly Census of Employment and Wages (QCEW) was used to update the 2010 base data to 2016, however the dataset does not include agricultural employment or the self-employed. The BLS QCEW is reported by place of work and is available for historical years 2001-2016, which allowed for the generation of forecasting models to update the 2010 data by TAZ. The QCEW was not used for employment totals, as the coverage is more limited than the LAUS.

In short, while the QCEW is preferable to generate models of growth it is not preferable as an indicator of total employment (which is essential for trip generation). For this reason, the total employment numbers for 2016 used in the econometric models for forecasting are lower than the total 2016 employment numbers from the 2016 TAZ level employment dataset.

Figure 2.66 presents the Island-wide formal employment forecasts. This includes historical employment trends, the impacts of Hurricane María, and a slight forecasted employment decline into the future. The impacts of Hurricane María varied between the island's different Regions. Municipalities serving as economic hubs, and where initial efforts for hurricane recovery were focused, were more insulated to the economic shock of María than other regional areas.

Figure 2.66: Indexed Employment Forecasts – Puerto Rico – Indexed Growth (Index = 2010)



Source: SDG Employment Forecast

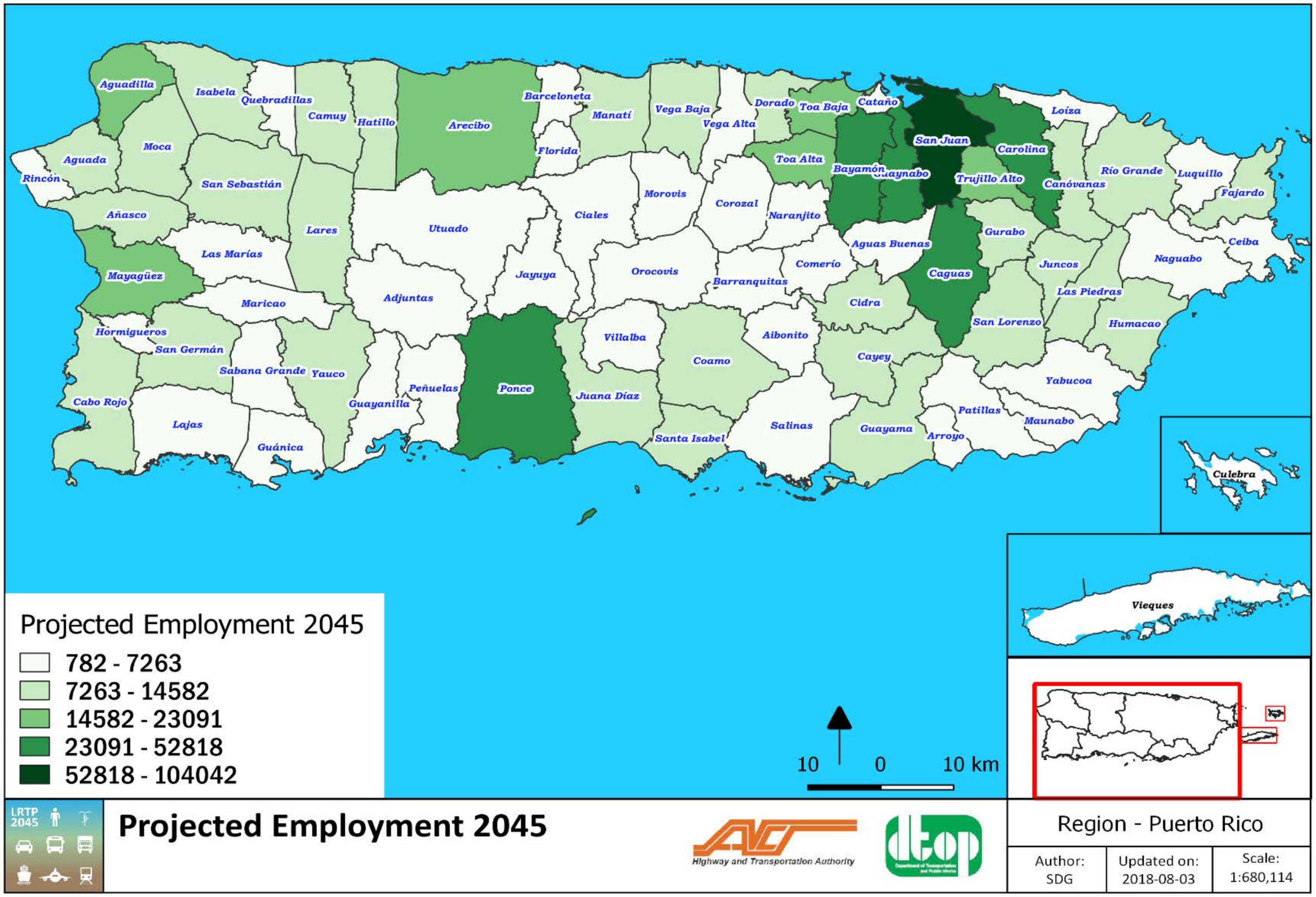
Table 2.44 breaks down the employment forecast dynamics of Puerto Rico into temporal segments. Over the timespan, 2016-2045, employment is forecasted to decline by 8.9%, with focused employment decline from 2016-2020, a reduction of just under 40,000 jobs. This is largely a result of Hurricane María impacts compounding upon existing trends. Over the time-scale, 2016-2045, the employment CAGR is reduced close to -0.3%, a display of slowing employment decline and the potential for eventual economic growth. Figure 2.67 shows forecasted employment totals.

Table 2.44: Employment Forecast Growth Rates – Puerto Rico

Year	Employment	Percent change from 2016	CAGR from 2016
2016	986,151	-	-
2020	948,832	(3.8%)	(1.0%)
2025	941,501	(4.5%)	(0.5%)
2040	908,252	(7.9%)	(0.3%)
2045	897,987	(8.9%)	(0.3%)

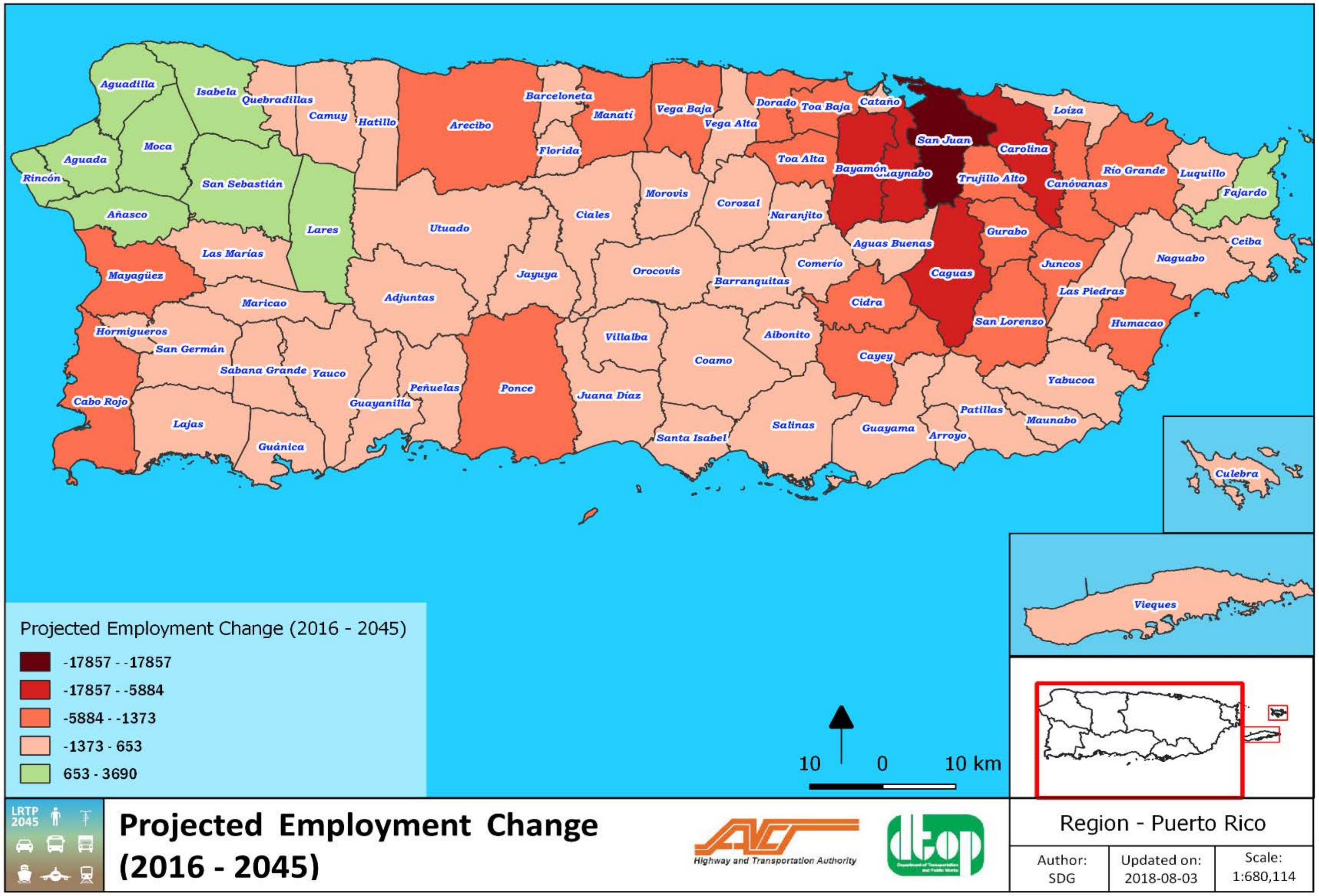
Source: SDG TAZ Level Employment Forecast

Figure 2.67: Puerto Rico Employment 2045



Source: Employment Projections carried out by Steer Davies Gleave on Buerau of Labor Statistics (BLS) datasets.

Figure 2.68: Puerto Rico Employment Change 2016-2045



Source: Employment Projections carried out by Steer Davies Gleave on Buerau of Labor Statistics (BLS) datasets.

TRANSPORTATION SYSTEM

Highways

Roadway System

Puerto Rico model network for 2016 has a total of 9,943 route miles (bi-directional), 11,838 lane miles and 54.3 million daily vehicle miles as extracted from the 2016 LRTP model calibration[23]. Figure 2.69 show the highway system as defined by the Transportation National Highway System (NHS) and non-NHS system.

For an additional level of detail; Table 2.45 and Figure 2.70 display the roadway network functional classifications according to the Puerto Rico Department of Transportation NHS information layer. The goal of this classification is to define the role of a roadway in the overall roadway network.

Table 2.45: Roadway System by Functional Classification – Puerto Rico

Functional Classification	Route Miles
Interstate	572.07
Freeways and Expressways	155.5
Principal Arterials	713.96
Local Principal Arterials	9.2
Minor Arterials	3.15

Source: 2045 LRTP Plan Development

FHWA defined each one of the functional classification categories as follows:

- **Interstate**: they are designed and built considering mobility and long-distance travel, and they are the highest classification of Arterials;
- **Other Freeways and Expressways**: They are designed and built to increase mobility function, and adjoining land uses are not directly served by them; access and egress points are limited to on- and off-ramp locations or a limited number of at-grade intersections; and they have directional travel lanes, usually separated by some type of physical barrier;
- **Principal Arterials**: serve main centers of metropolitan areas, offer both high mobility degree and mobility through rural areas; and adjoining land uses can be served directly;
- **Minor Arterial**: provide connectivity to the higher Arterial system and service for trips of moderate length; also serve geographic areas;
- **Major Collector**: provide more mobility, might have more travel lanes, have higher annual average traffic volumes and speed limits, have lower connecting driveway densities, are longer in length and are spaced at greater intervals than their Minor Collector counterparts; and
- **Minor Collector**: offer less mobility and more access than their Major Collector counterparts. Also, they serve both land access and traffic circulation in lower density

[23] These values include all classifications but connectors therefore minor road values are omitted in these numbers.

residential and commercial/industrial areas instead of the higher density service in Major Collectors.

There is a complex non-NHS system within the Island (local system) due to their provision of direct access to adjoining land, they are not intended for use in long distance travel, except at the origin or destination end of the trip[24].

The Puerto Rico Roadways map shown in Figure 2.72 illustrates the 2018 road network as it is described on the National Highway System 2018 layer. The map displays an extensive network of principal arterials and expressways interconnecting the three interstates that form the Eisenhower Interstate System on the island, a more detailed description of the roadway system can be found in the regional documents.

The three observable Interstates represented in color red are **PRI-1:** composed of PR-52 and PR-18; **PRI-2**: composed of PR-22 and PR-2; **PRI-3:** composed of PR-3, PR-26, PR-53 and PR-66 and they all originate within the San Juan metropolitan area and extend into the south, east and west municipalities of the island.

Interstates

- **PRI-1:**
    - **PR-18**: A north to south 6 km long expressway which runs through the heart of the San Juan municipality perpendicular to PR-23 and PR-17 and ending on PR-1 at km 6; it connects PR-22 to PR21, PR-1 and PR-52.
    - **PR-52**: Highway PR-52 (Luis A. Ferré Highway), commences at the intersection of PR-18 and PR-1 and runs south and then west for 108.3 km, it connects the municipality of San Juan with the municipalities of Trujillo Alto, Caguas, Cayey within the San Juan TMA and leading into Salinas, Santa Isabel, Juana Díaz and ends in Ponce in the South Region.
- **PRI-2:**
    - **PR-2**: The road travels the whole north and west of the Island starting in Santurce (San Juan) intersecting PR-22 at various points along the way. It connects the municipalities of Guaynabo, Bayamón, Toa Baja, Dorado, Vega Alta, Vega Baja and Manatí. The road extends beyond the San Juan Region to Hatillo in the North Region where it takes over PR-22 as Interstate and it keeps going west until it reaches Aguadilla then it turns south to Mayagüez and Hormigueros after which it turns east to Ponce and connects with PR-52, effectively connecting San Juan TMA, North TPR, Aguadilla TMA, Southwest TPR and South TPR.
    - **PR-22**: Also known as José De Diego Expressway, PR-22 is 83.7 km long highway that originates at PR-26 in San Juan and extends to the west municipalities traveling through Cataño, Bayamón, Toa Baja, Dorado, Vega Alta, Vega Baja and Manatí eventually reaching Barceloneta, Arecibo and Hatillo.
- **PRI-3:**

[24] U.S. Department of Transportation. Federal Highway Administration. Office of Planning, Environment, and Realty (HEP).

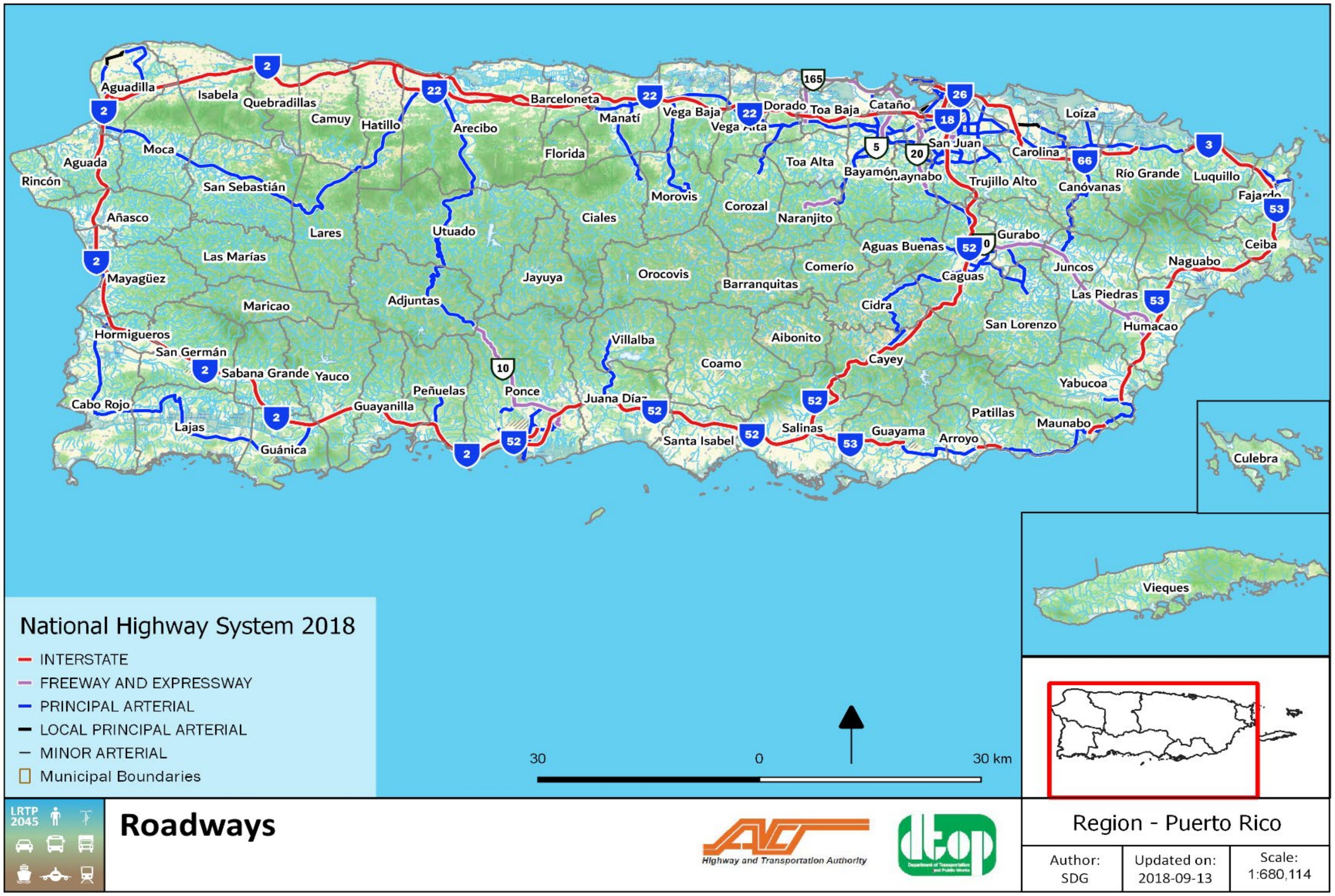
- **PR-3**: PR-3 is a 159.2 km road that originates in San Juan where it runs for 38.8 km towards the East and Southeast TPRs, it connects San Juan, Carolina, Canóvanas, Rio Grande, Luquillo, Fajardo, Ceiba, Naguabo, Humacao, Yabucoa, Maunabo, Patillas, Arroyo, Guayama and Salinas. It alternates between various classifications but it is primarily a principal arterial that forms part of the interstate system from PR-66 intersection in Rio Grande to Fajardo and intermittently from Yabucoa to Guayama.
- **PR-26**: Román Baldorioty de Castro Expressway runs for 15.5 km between San Antonio Bridge in San Juan and the start of PR-3 in Carolina. The road has a tangent segment with PR-37 at Cangrejo Arriba Barrio[25] and exits to PR-187 which leads to Loíza.
- **PR-53**: José Celso Barbosa Highway is a 59.3 km long road that commences in Fajardo and intersects the San Juan Region after exiting Ceiba on the southeast corner, in here it goes from Naguabo to Yabucoa where it connects to Maunabo through PR-901. This highway is incomplete and has additional intermittent segments on the municipalities of Salinas, Guayama, Arroyo and Patillas.
- **PR-66**: Roberto Sánchez Vilella Highway, leads east with 14.1 km in length. The road starts at the PR-3 Intersection and extends through Carolina, Canóvanas and ends on PR-3 in Rio Grande.

[25] Puerto Rico is divided into 78 municipalities, which the Census Bureau treats as similar to counties in the United States for census data presentation purposes. The 902 municipality subdivisions consist of 827 barrios and 75 barrios-pueblo. A barrio-pueblo represents the seat of government of each municipality except Florida, Ponce, and San Juan. The Census Bureau identifies 37 areas in the Caribbean Sea that are not within a municipality subdivision; these areas are not assigned to any municipality subdivision and are not counted in the number of municipality subdivisions. In 23 municipalities, all or part of 20 barrios-pueblos and 10 barrios are further subdivided into 145 sub-barrios. U.S. Census Bureau.

Figure 2.69: Puerto Rico Roadways by NHS Identification

Source: PRHTA's Roadway Systems' Office, 2016 HPMS

Figure 2.70: Puerto Rico Roadways



Source: National Highway System as it appears on the NHS 2018 layer for Puerto Rico provided by the Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym)

Effect of Hurricane María on Roadway System

As a consequence of Hurricane María's landfall in Puerto Rico on September 2017, the roadway infrastructure was damaged by flooding, debris and landslides. 388 bridges (out of 1772) were reported with damages out of which 26 of these were reported as collapsed, 31 with failure in approach and the rest with other reported damages. Damaged bridges by municipalities are included in Table 2.46.

Table 2.46: Bridges Over Waterways with Reported Damages due to María in Puerto Rico

Municipality	Bridges with Reported Damages due to María	Total Number of Bridges	Percentage of Damaged Bridges
Adjuntas	11	27	41%
Aguada	1	18	6%
Aguadilla	0	9	0%
Aguas Buenas	5	13	38%
Aibonito	5	15	33%
Añasco	2	22	9%
Arecibo	4	26	15%
Arroyo	3	12	25%
Barceloneta	2	6	33%
Barranquitas	10	14	71%
Bayamon	12	62	19%
Cabo Rojo	1	18	6%
Caguas	8	58	14%
Camuy	0	3	0%
Canóvanas	12	25	48%
Carolina	6	47	13%
Cataño	0	10	0%
Cayey	10	56	18%
Ceiba	3	24	13%
Ciales	6	18	33%
Cidra	3	19	16%
Coamo	8	30	27%
Comerío	1	16	6%
Corozal	6	25	24%
Culebra	0	1	0%
Dorado	0	12	0%
Fajardo	1	14	7%
Guánica	2	14	14%
Guayama	7	22	32%
Guayanilla	7	30	23%
Guaynabo	3	33	9%
Gurabo	0	7	0%
Hatillo	0	6	0%
Hormigueros	1	9	11%
Humacao	9	46	20%
Isabela	0	4	0%
Jayuya	10	34	29%

Municipality	Bridges with Reported Damages due to María	Total Number of Bridges	Percentage of Damaged Bridges
Juana Diaz	6	33	18%
Juncos	0	16	0%
Lajas	3	5	60%
Lares	7	14	50%
Las Marias	6	13	46%
Las Piedras	10	18	56%
Loíza	3	5	60%
Luquillo	6	17	35%
Manatí	1	7	14%
Maricao	8	13	62%
Maunabo	2	19	11%
Mayagüez	10	45	22%
Moca	3	12	25%
Morovis	8	14	57%
Naguabo	11	40	28%
Naranjito	2	17	12%
Orocovis	11	18	61%
Patillas	4	32	13%
Peñuelas	1	18	6%
Ponce	11	79	14%
Quebradillas	2	3	67%
Rincón	0	8	0%
Rio Grande	5	37	14%
Sabana Grande	6	21	29%
Salinas	4	22	18%
San German	8	34	24%
San Juan	6	91	7%
San Lorenzo	7	50	14%
San Sebastián	9	30	30%
Santa Isabel	0	6	0%
Toa Alta	4	14	29%
Toa Baja	6	20	30%
Trujillo Alto	2	11	18%
Utuado	19	54	35%
Vega Alta	2	10	20%
Vega Baja	1	13	8%
Vieques	1	11	9%
Villalba	9	23	39%
Yabucoa	12	38	32%
Yauco	13	36	36%
Total	**388**	**1772**	**22%**

Puerto Rico Highways and Transportation Authority

The municipality with higher quantity of closed bridges due to collapse is Utuado, followed by Arecibo, Canóvanas, Ciales, San Germán and Yauco as shown in Table 2.47. Utuado, Toa Baja and Ponce have the highest quantity of bridges with failures in approach, as seen in Table 2.48.

Table 2.47: Closed Bridges Due to Collapse

Municipality	Closed Bridges Due to Collapse
Caguas	1
Corozal	1
Juana Díaz	1
Maricao	1
Mayagüez	1
Moca	1
Morovis	1
Patillas	1
San Sebastián	1
Villalba	1
Arecibo	2
Canóvanas	2
Ciales	2
San Germán	2
Yauco	2
Utuado	6
Total	**26**

Source: PRHTA

Table 2.48: Bridges with Failure in Approach Roadways / Slab

Municipality	Bridges with Failure in Approach Roadways / Slab
Adjuntas	1
Arecibo	1
Arroyo	1
Canóvanas	1
Ciales	1
Coamo	1
Guayama	1
Guayanilla	1
Jayuya	2
Juana Díaz	1
Las Marias	1
Mayagüez	1
Moca	1
Naguabo	2
Orocovis	1
Ponce	3
Quebradillas	1
San Germán	1
San Sebastián	1
Toa Baja	3
Utuado	3
Vega Alta	1
Yauco	1
Total	**31**

Source: PRHTA

Traffic Patterns

Figure 2.71 shows 2016 traffic volumes throughout the island of Puerto Rico. The traffic volumes map for Puerto Rico displays the road density in terms of graduated bandwidth and color. It shows that the traffic is concentrated on the primary interstates (PR-18, PR-22, PR-26 and PR-52) leading out of San Juan, with minimum nearing 60,000 vehicles per day and reaching a maximum just over 100,000 vehicles.

The Highway Capacity Manual (HCM) 2010 defined Level of Service (LOS) as "a quantitative stratification of a performance measure or measures that represent quality of service"[26]. Where service measures are used to determine LOS for transportation system elements. There are six LOS, ranging from A to F. From the traveler's perspective, LOS A denotes the best operating conditions and LOS F the worst. LOS for vehicles are determined, based on the HCM, using density calculation; nonetheless, a volume over capacity (v/c) calculation was used to determine LOS in the model considering the model does not provide link specific volumes but rather trip volumes between nodes. Table 2.49 shows LOS criteria for Freeway facilities as a function of volume to capacity ratio based on HCM 2000 that interrelate v/c LOS with (HCM 2010) Density LOS definitions.

Table 2.49: LOS Criteria as a Function of Volume Capacity Ratio

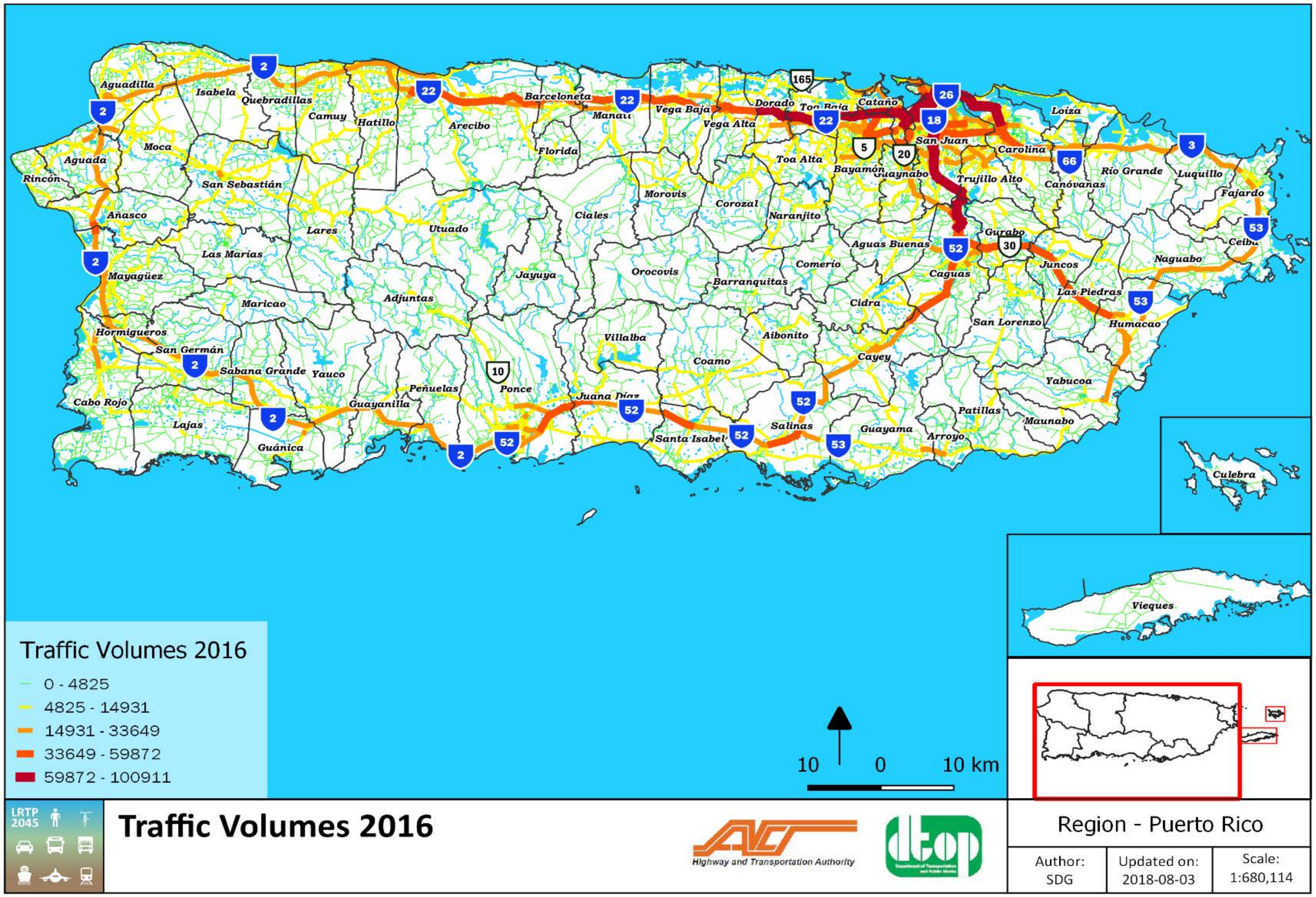
Level of Service	v/c
A	< 0.34
B	0.34 - 0.56
C	0.56 - 0.76
D	0.76 - 0.90
E	0.90 - 1
F	> 1

Source: HCM 2000

Figure 2.72 presents 2016 LOS throughout the Puerto Rico based on information from the calibrated network model for the average day period. LOS E and F are mainly observed on the Freeways, Highways and Principal Arterial, a more detailed description of these can be found in each of the respective regions' report.

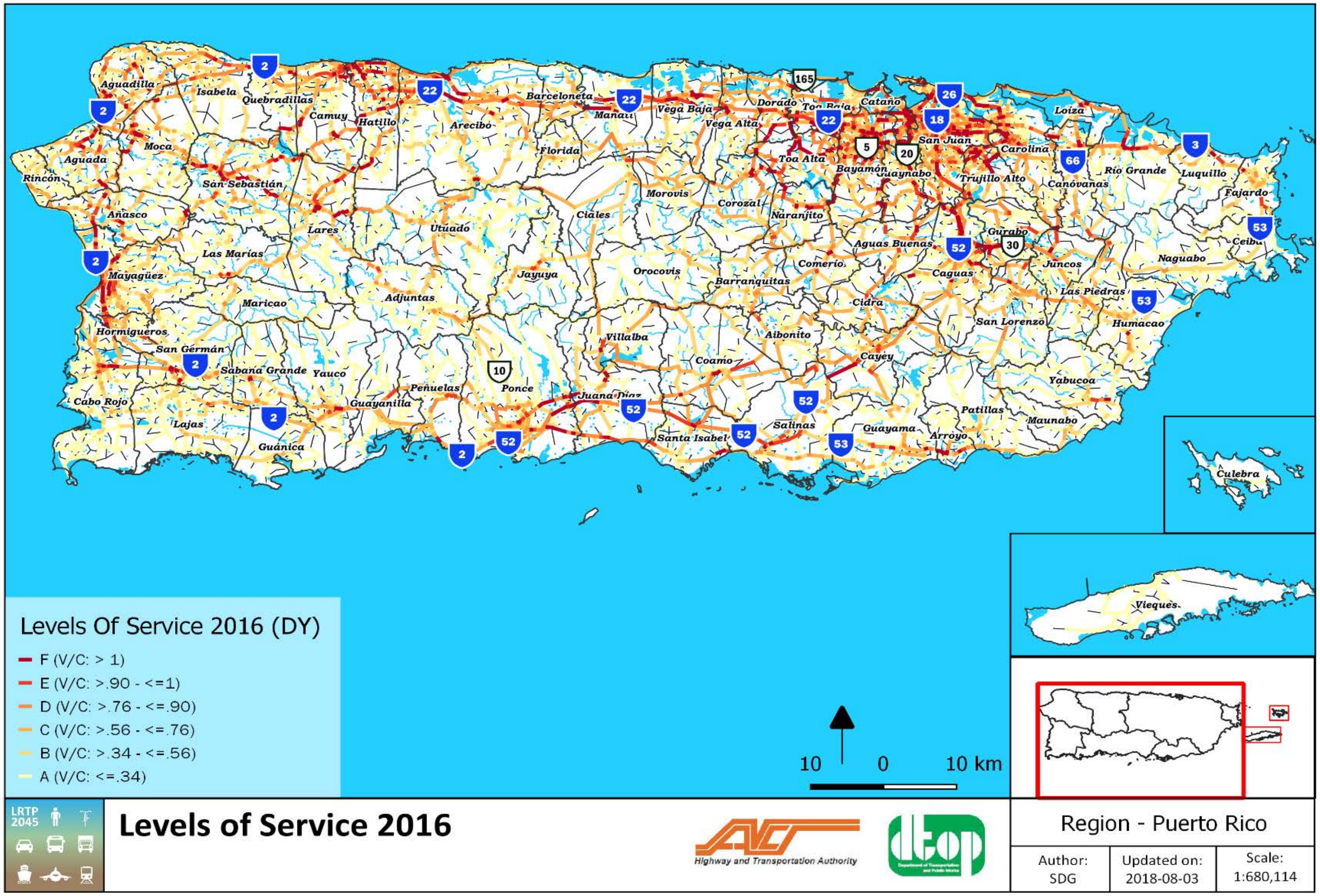
[26] Highway Capacity Manual (2010).

Figure 2.71: Puerto Rico Traffic Volumes 2016



Source: P.R. Network Model Calibrated by Steer Davies Gleave for the year 2016 using Cube Voyager

Figure 2.72: Puerto Rico Levels of Service 2016; Average Day



Source: P.R. Network Model Calibrated by Steer Davies Gleave for the year 2016 using Cube Voyager

Regional Freight Network

Puerto Rico's freight comes mainly from San Juan TMA since this is the location of the main cargo port of the Island (load movement in Region's ports will be explained later in this section). Supplies for markets enters Puerto Rico through seaports and airports. Trade represent 7.5% of the Puerto Rico's GDP using 23.7% of labor force.

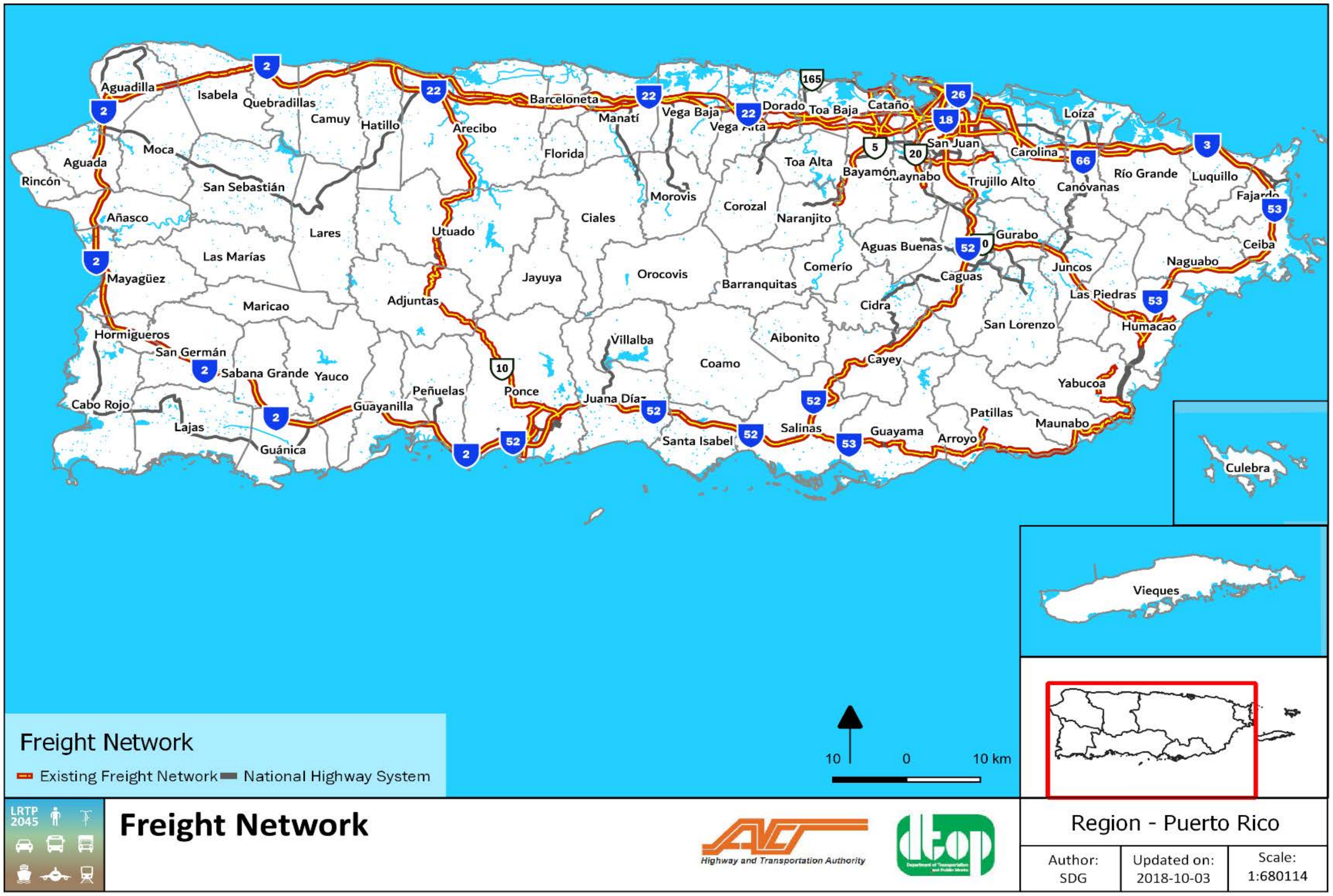
Figure 2.73 shows the freight network in Puerto Rico. The network is shown as defined from the FHWA and mainly consists of the interstate system in addition to some local principal arterials in San Juan Central Area and other minor arterials that provide access to town center; a more detailed description of the Freight Network can be found in the regional documents.

Figure 2.74 displays truck activity in Puerto Rico as a graduated color graph that represents daily vehicle traffic in terms of a truck volume to total vehicle volume ratio, categorized in three classes: Less than 5%; Between 5% and 10%; and Greater than 10%.

The map illustrates how truck traffic is increased on the primary interstate highways. Increased traffic can also be observed around ports and industrial zones which is expected and perhaps less obvious in minor arterial roads crossing town centers.

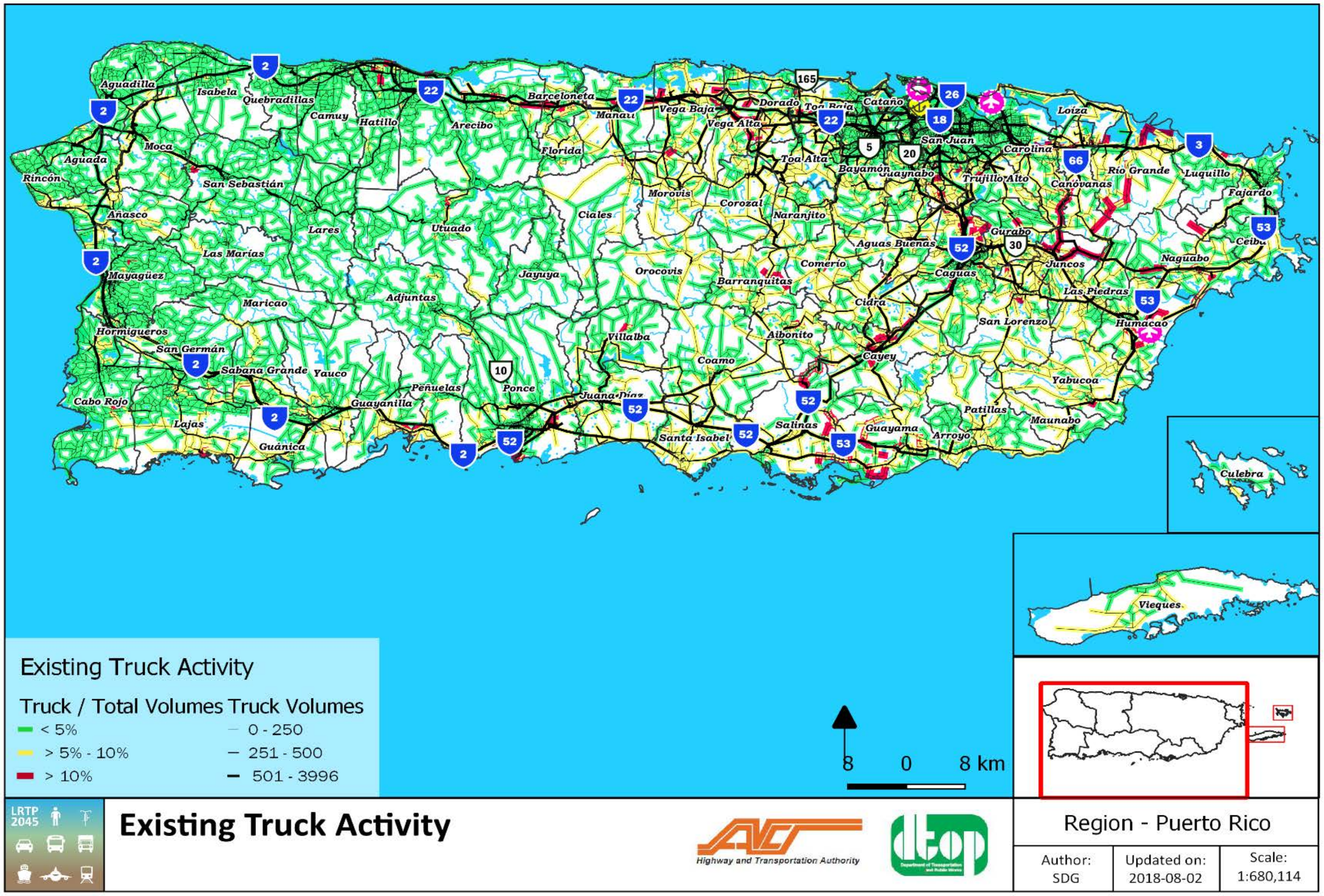
Figure 2.75 shows the freight network hotspots in Puerto Rico, indicating sections of the road where traffic is operating at or over the capacity of the road and at the same time being highly used by trucks. These hotspots are largely concentrated on the San Juan central area, the interstate system and other local principal and minor arterials throughout the island. A more detailed description of the freight network hotspots can be found in the regional documents.

Figure 2.73: Puerto Rico Freight Network



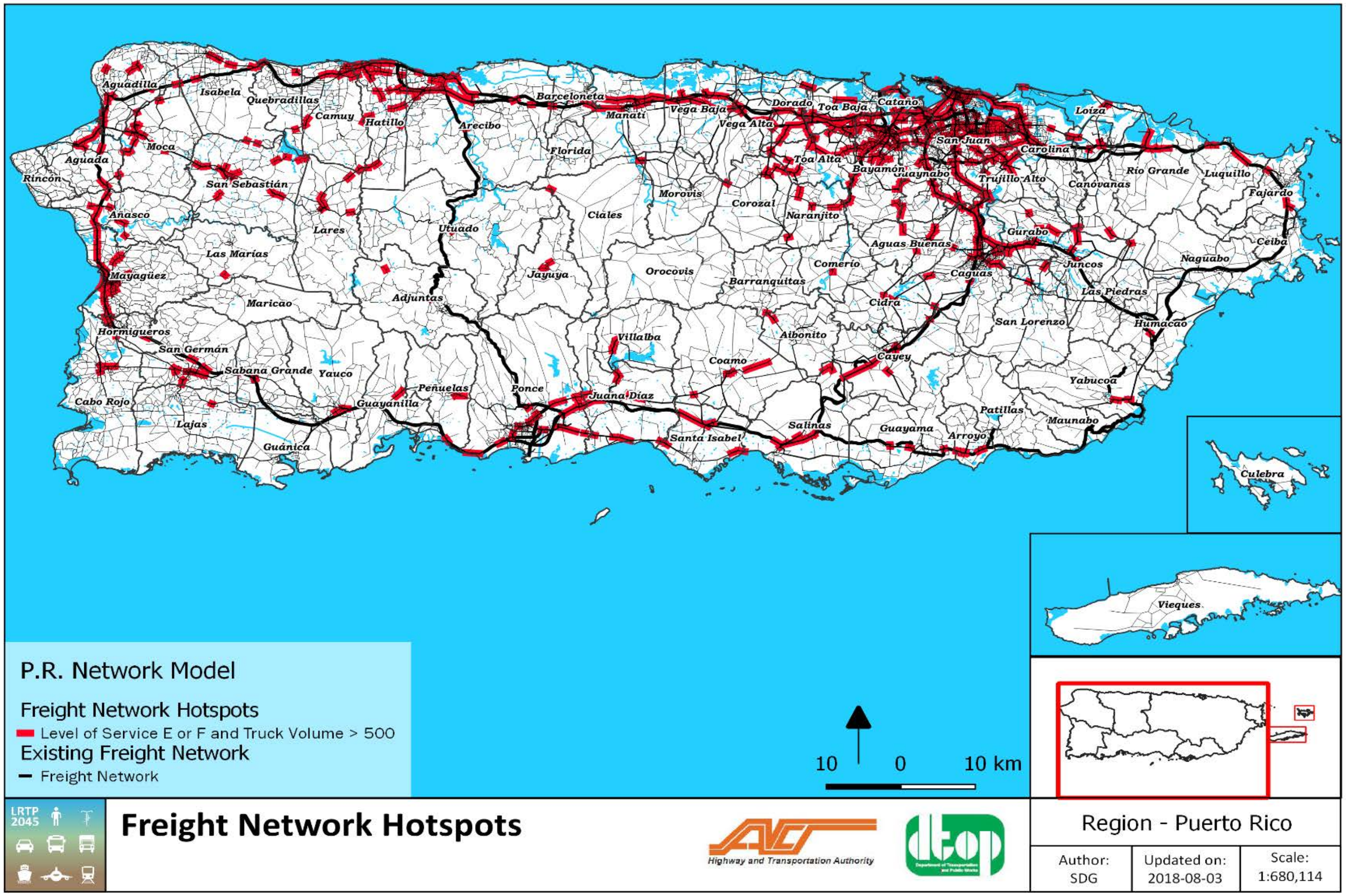
Source: The existing Freight Network information layer was obtained form the Federal Highway Administration (FHWA)

Figure 2.74: Puerto Rico Existing Truck Activity



Source: P.R. Network Model Calibrated by Steer Davies Gleave for the year 2016 using Cube Voyager

Figure 2.75: Puerto Rico Freight Network Hotspots



Source: The existing Freight Network information layer was obtained form the Federal Highway Administration (FHWA)
P.R. Network Model Calibrated by Steer Davies Gleave for the year 2016 using Cube Voyager

Size and Weight Enforcement Program

The weight and size of trucks is regulated in Puerto Rico by the traffic and vehicle regulations of the DTPW. Through Puerto Rico there are 68 semi-permanent weighting stations, 28 of them are located in the San Juan TMA, 7 of them are located in Aguadilla TMA; 4 of them are located in the North TPR; 3 of them in the East TPR; 12 of them in the South TPR; 7 of them in the Southeast TPR; and 7 of them are located in the Southwest TPR. The stations within each region are highlighted in the regional documents. The stations in Puerto Rico are shown in Table 2.50 and Figure 2.76.

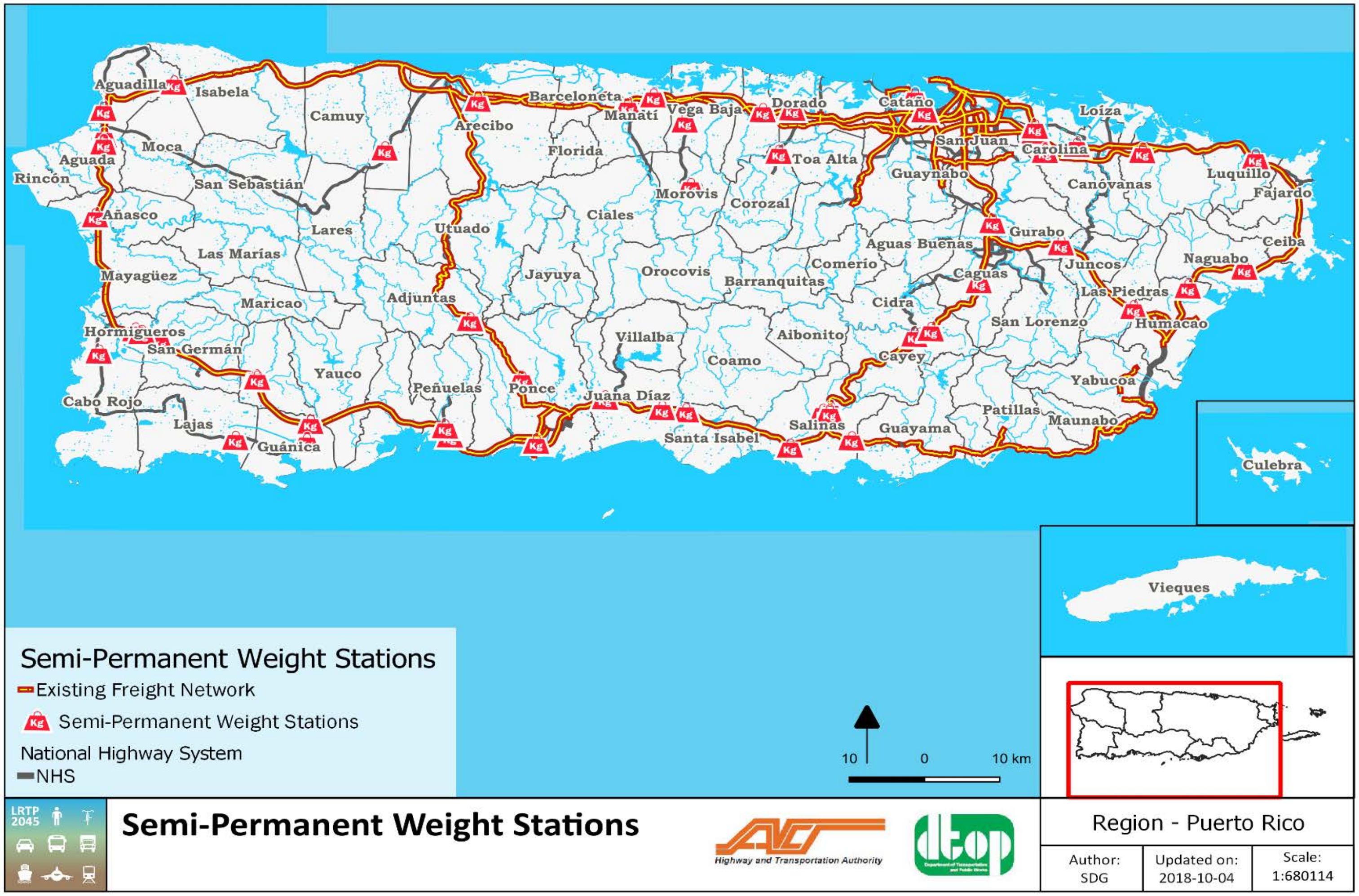
Table 2.50: Semi-Permanent Weighting Stations in Puerto Rico

Station Number	Road	Km	Municipality	Direction
1	PR-22	8	Guaynabo	San Juan
2	PR-22	8	Guaynabo	Arecibo
3	PR-3	8.1	Carolina	San Juan
4	PR-26	14.3	Carolina	San Juan
5	PR-3	14.3	Canóvanas	Fajardo
6	PR-165	33.8	Cataño	Toa Baja
7	PR-165	33.8	Cataño	San Juan
8	PR-22	26.1	Dorado	Arecibo
9	PR-2	50.7	Manatí	San Juan
10	PR-2	50.4	Manatí	Arecibo
11	PR-22	30.1	Vega Alta	San Juan
12	PR-22	45.6	Manatí	Mayagüez
13	PR-22	70.1	Arecibo	San Juan
14	PR-22	70.1	Arecibo	Mayagüez
15	PR-2	116.6	Isabela	Arecibo
16	PR-2	116.6	Isabela	Mayagüez
17	PR-111	4.1	Moca	San Sebastian
18	PR-2	145	Añasco	Ponce
19	PR-2	145	Añasco	Arecibo
20	PR-2	INT. PR-345	Hormigueros	Mayagüez
21	PR-2	193.5	Guánica	Mayagüez
22	PR-2	193.5	Guánica	Ponce
23	PR-12	INT. PR-52	Ponce	Ponce
24	PR-52	93.5	Juana Díaz	San Juan
25	PR-52	58.8	Salinas	San Juan
25.2	RAMPA 52	58.8	Salinas	PR-1
26	PR-1	82.7	Salinas	Salinas
27	PR-53	88.2	Guayama	Salinas
28	PR-30	9.7	Gurabo	Caguas
29	PR-30	23.3	Las Piedras	Caguas
30	PR-53	7.2	Ceiba	Humacao
31	PR-3	31.7	Luquillo	Humacao
32	PR-3	31.7	Luquillo	San Juan
33	PR-180	2.4	Salinas	Salinas

Station Number	Road	Km	Municipality	Direction
34	PR-142	3.2	Toa Alta	Corozal
35	PR-137	3.2	Vega Baja	Vega Baja
36	PR-137	14.1	Morovis	Morovis
37	PR-129	14	Lares	Lares
38	PR-100	5.9	Cabo Rojo	Cabo Rojo
39	PR-66	3.4	Carolina	Canóvanas
40	PR-10	14.7	Ponce	Adjuntas
41	PR-2	213.5	Peñuelas	Mayagüez
42	PR-2	215	Peñuelas	Ponce
43	PR-2	165.7	Hormigueros	Ponce
44	PR-116	12.6	Lajas	Cabo Rojo
45	PR-2	132	Aguada	Aguadilla
46	PR-2	133	Aguada	Mayagüez
47	PR-53	24	Naguabo	Fajardo
48	PR-53	24	Naguabo	Humacao
49	PR-53	37.9	Yabucoa	Humacao
50	PR-52	34.4	Cayey	San Juan
51	PR-52	79.5 (82.1)	Santa Isabel	San Juan
52	PR-10	21.1	Adjuntas	Ponce
53	PR-66	16.4	Rio Grande	San Juan
54	PR-66	16.4	Rio Grande	Rio Grande
55	PR-52	Plaza Peaje Caguas	Caguas	San Juan
56	PR-52	Plaza Peaje Caguas	Caguas	Cayey
57	PR-1	INT 738 54.8	Cayey	Caguas
58	PR-116	23.7	Guánica	Ponce
59	PR-116	23.7	Guánica	Mayagüez
60	PR-2	168.4	San Germán	Ponce
61	PR-3	132.9	Arroyo	Humacao
62	PR-52	85.3	Juana Díaz	Ponce
63	PR-52	85.3	Juana Díaz	Salinas
64	PR-2	183	Sabana Grande	San Germán
65	PR-2	182.7	Sabana Grande	Ponce
66	PR-22	45.6	Manatí	San Juan
67	PR-52	58.8	Salinas	Ponce

Source: PRHTA

Figure 2.76: Semi Permanent Weighing Stations in Puerto Rico



Source: the Semi-Permanent Weight Stations information layer was provided by the Puerto Rico Highway and Transporation Authority (ACT by its spanish acronym). The PR Freight Network was obtained from the Federal Highway Administration (FHWA)

Transit

Law 123-2014 created the Puerto Rico Integrated Transit Authority (PRITA) and authorizes the PRHTA to transfer operations, assets, rights, obligations, and funds related to Tren Urbano (TU) and the transit programs. In addition, it included the Metropolitan Bus Authority (*Autoridad Metropolitana de Autobuses, AMA*) bus routes and the Maritime Transportation Authority (MTA) to this new Authority. As provided by the law, PRITA works with the management and operational aspects of integration, to obtain the required state and federal consents and approvals that make it possible to formalize the corresponding transit systems integration. The mission of the agency is to provide the citizens with greater and better facilities for transit to ensure the effective mobility of people and goods; promote economic and social growth in the areas around the TU stations, AMA bus terminals and intermodal or multimodal stations[27].

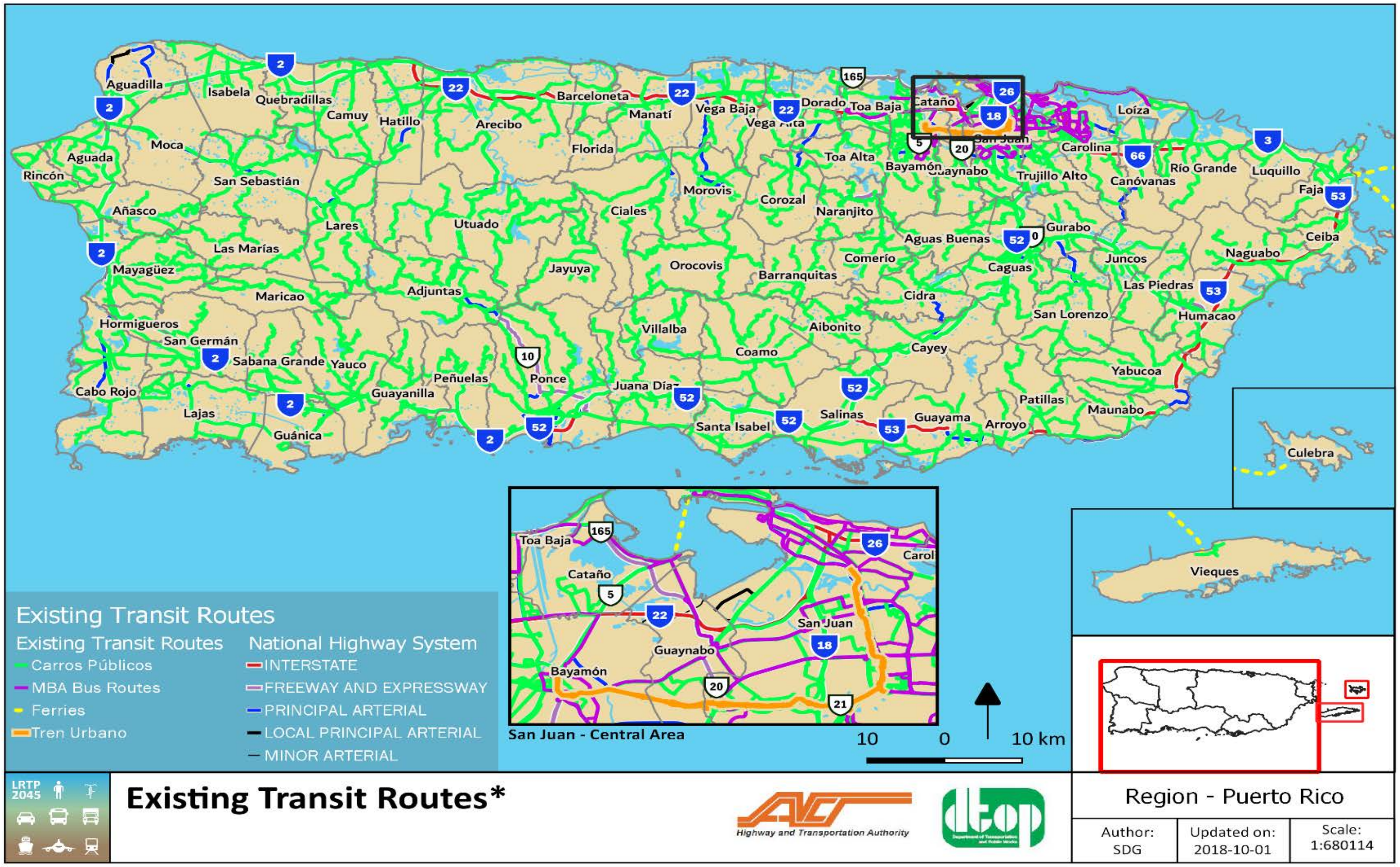
With the systems already mentioned (Tren Urbano, AMA buses and ferry services) there are also other services that provide transit in Puerto Rico, which include the Público services and the Municipal Transit services (provided by some municipalities in Puerto Rico.

Puerto Rico is divided in 3 main regions according to the MPO (San Juan TMA, Aguadilla TMA and Other Urbanized Areas (UZA), which includes the remaining 5 regions: North, East, South, Southeast and Southwest. In terms of transit, the San Juan TMA is the Region with the most varied transit services provision in Puerto Rico. It includes the only rail system in the island (TU), as well as all the AMA bus routes, Público service, Municipal services and a route of ferry service from the Maritime Transportation Authority (MTA) from Cataño to San Juan. The Aguadilla TMA Region has transit services throughout Públicos and Municipal services. The Other Urbanized Areas Regions have transit services throughout Públicos, Municipal services and two ferry routes from the Maritime Transportation Authority (MTA), from Vieques and Culebra to Fajardo.

Figure 2.77 shows the existing transit routes in Puerto Rico (excluding the Municipal operated transit services).

[27] http://www2.pr.gov/presupuestos/Presupuesto2015-2016/PresupuestosAgencias/285.htm.

Figure 2.77: Existing Transit Routes in Puerto Rico[28]



Source: Bus Routes information acquired from Puerto Rico Integrated Transit Authority (PRITA), the PR Público Routes network was provided by the Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym), the Ferry routes was created by the Maritime Transportation Authority (ATM by its spanish acronym), the PR HPMS layer was provided by the Puerto Rico Planning Board.
*Existing Transit Routes Excluding Municipality Operated Transit Services

[28] Excluding Municipality Operated Transit Services.

Tren Urbano

Tren Urbano is a mass transportation system that connects the municipalities of San Juan, Guaynabo and Bayamón, running on a 17.52km (10.7 miles) line. This transit system has 16 stations (elevated, at level and underground), as shown in Figure 2.78.

<u>San Juan</u>

San Juan is the municipality that contains the most TU stations, with a total of 12. These stations include:

- **Sagrado Corazón**: This elevated station is located to the south of Santurce Barrio, between two major Avenues: Ponce de León (PR-25) and Manuel Fernández Juncos (PR-35). The station serves as a major intermodal transit station, including a bus terminal with more than 10 AMA bus routes and some Público routes as well. It is the station with the highest average daily passenger boardings with almost 3,000[29]. Also, it is one of the stations with a park and ride facility.
- **Hato Rey**: This elevated station is one of three that is located in Hato Rey Norte. It is located in Arterial B Avenue, parallel to Luis Muñoz Rivera Avenue (PR-1), right in the financial district of Hato Rey. A major attraction of this station is it closeness to the Coliseum José Miguel Agrelot. There are no direct connections from any AMA bus routes to the station but there are 4 routes that have stops close by. There is a connection to the ferry services which has a route from Hato Rey to Old San Juan, however this route is not operating as of July 2018.
- **Roosevelt**: Also located in Hato Rey Norte, at the intersection of Luis Muñoz Rivera Avenue (PR-1) and Franklin Delano Roosevelt Avenue (PR-23). The station serves some private universities and colleges in the area including the Puerto Rico Polytechnic University. There is one AMA service that connects with the station, Route T-2 and another route that passes close to the station, Route C-1.
- **Domenech**: This elevated station is one of three that is located in Hato Rey Norte, at Luis Muñoz Rivera Avenue (PR-1) in the intersection of Guayama Street; right in front of the station are the administrative offices of the Department of Labor and Human Resources. There is one AMA bus route that connects directly with the station, Route C-1.
- **Piñero**: This elevated station is located in the Hato Rey Sur Barrio, between two major Avenues: Ponce de León (PR-25) and Luis Muñoz Rivera (PR-1), north of Jesus T. Piñero Avenue (PR-17). The station has a AMA bus terminal that includes 4 routes: Route E-40, Route T-8, Route T-41 and Route D-26.
- **Universidad**: This underground station is located in Universidad Barrio, in Ponce de León Avenue (PR-25) underneath the University of Puerto Rico (UPR) Rio Piedras Campus. The three AMA bus routes that serve this station are Route T-8, Route D-26 and Route C-1.
- **Río Piedras**: This underground station is located in Pueblo Barrio, in Ponce de León Avenue (PR-25) in the urban center of Río Piedras. This station has the second highest

[29] According to the SDG Analysis of Indicadores PR.

average daily boardings in San Juan Municipality with almost 2,000[30] However, the station is 4th in total daily boarding in the whole system. There are no direct AMA bus routes that connect with the station but there are 2 routes that are very close in José N. Gándara Avenue. Also, less than ½ mile away there are three different transit terminals (Terminal Sur, Terminal Este and Capetillo) which include AMA bus routes, some Público routes and Red Conecta trolley routes (San Juan Trolley System).

- **Cupey**: This elevated station is located in el Cinco Barrio, between Luis Muñoz Rivera Avenue (PR-1) and José Kiko Custodio Avenue (PR-21). The station is located between Universidad Metropolitana (UMET) Campus and the community of Villa Nevarez. Additionally, there are some government buildings including Molecular Sciences and Research Building from the UPR and the Department of Natural Resources. This is a multimodal transfer station that connects 5 AMA bus routes including Route D-13, Route D-15, Route D-18, Route T-7, and Route T-9. Also, this station has a park and ride facility.
- **Centro Médico**: This ground level station is one of two stations located in Monacillo Urbano Barrio, in one of the main entrances of Centro Médico, the biggest and most important hospital conglomerates in Puerto Rico also holding the School of Medicine of the UPR. There are no AMA Bus routes that pass through this station, there is however a trolley transit route from the Municipality of San Juan that passes through this station.
- **San Francisco**: In Monacillo Urbano Barrio, in José de Diego Avenue with the intersection of José Kiko Custodio Avenue (PR-21). There are no AMA bus routes that service this station. It’s one of the stations with a park and ride facility.
- **Las Lomas**: This elevated station is one of two stations located in Gobernador Piñero Barrio, in Street 31 SO. This station is in the residential area of Las Lomas. It’s one of the stations with the lowest average daily boardings (third to last) from the system. There are no AMA bus routes that connect with the station, but there is one route close by (Route D-27). There is also a San Juan trolley service that connects to the station.
- **Martínez Nadal**: This at level station in Gobernador Piñero Barrio, between Rafael Martínez Nadal Expressway (PR-20) and José Kiko Custodio Avenue (PR-21). As of July 2018, there are three AMA bus routes that connect with the station. They are Route T-4, Route T-8, and Route D-27. There are some trolley services that connect to the station from the municipalities of Guaynabo and San Juan. This station is right next to the maintenance and garage facilities of Tren Urbano. Also, it’s one of the stations that has a park and ride facility.

<u>Guaynabo</u>

Guaynabo has only one station of Tren Urbano:

- **Torrimar:** This elevated station is located in Pueblo Viejo Barrio, between Ramírez de Orellano Avenue and Oviedo Street. It is located in a residential area (Torrimar), very close to a sports complex. This station is the second to last on average daily boardings. It is not served with any other transit routes. This station has a park and ride facility.

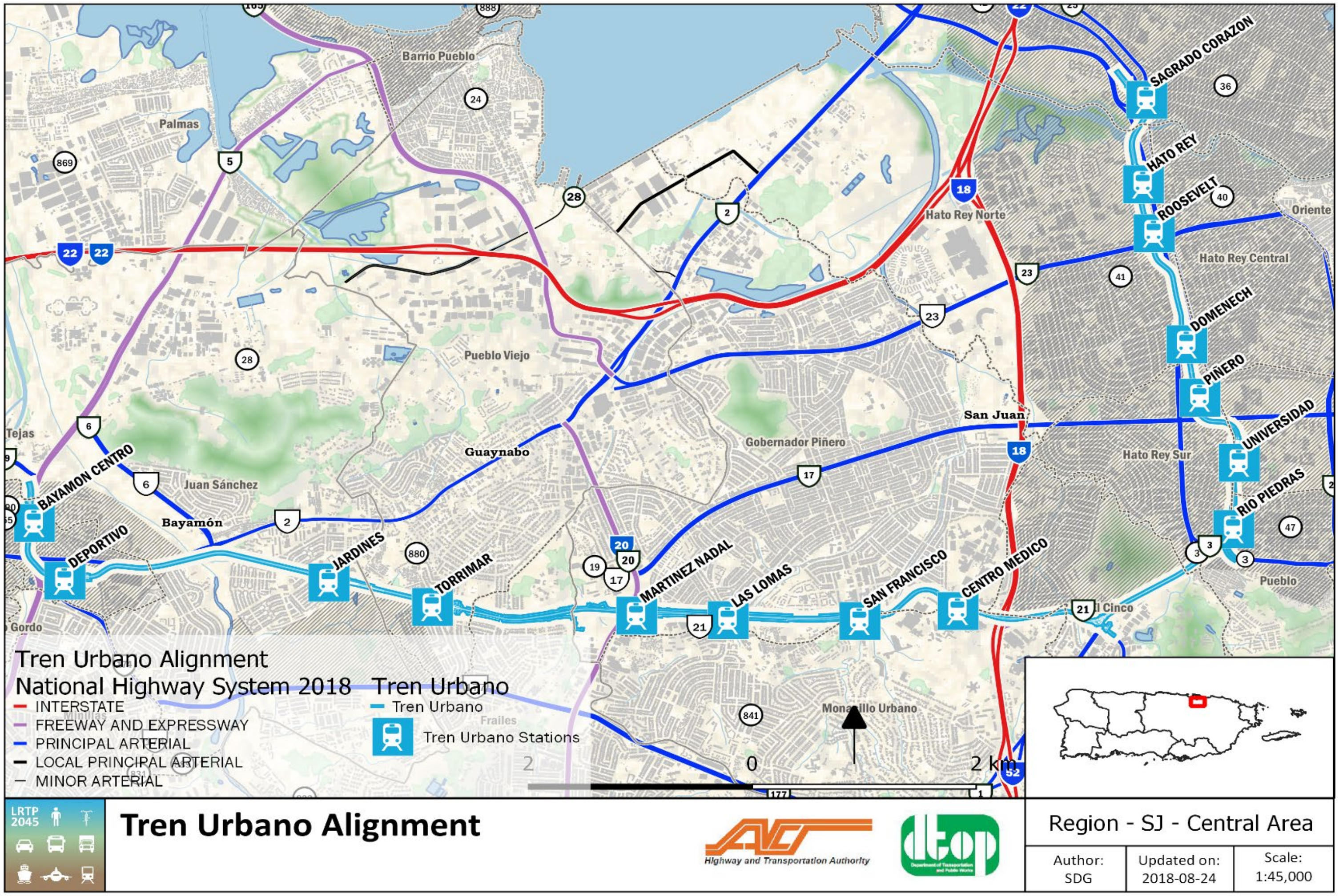
[30] According to the SDG Analysis of Indicadores PR.

Bayamón

Bayamón is served by three Tren Urbano stations; these are:

- **Jardínes**: This at ground level station is located in Juan Sánchez Barrio, between Marginal North Street and Marginal South Street. It is located in the residential area of Jardínes. It has the lowest total of average daily boardings of all the TU stations. It is not served with any other transit routes and has a park and ride facility.
- **Deportivo**: This elevated station is one of two located in Pueblo Barrio, within the Bayamón's sport complex parallel to PR-2. It is the third in number of average daily boardings of the whole system. There are no direct connections with AMA bus routes, but there are two AMA services that pass close: Route T-2, Route D-92.
- **Bayamón**: This elevated station is located in Pueblo Barrio, parallel with Rio Hondo Expressway (PR-5) in the intersection with Bobby Capó o Avenue. It is the end terminals of Tren Urbano in the west and is the second station in total average daily boardings. There are four AMA bus services covering this point, including: Route T-2, Route D-91, Route D-92 and Route E-20 to Toa Baja (formerly known as Metro Urbano). The station has a park and ride facility.

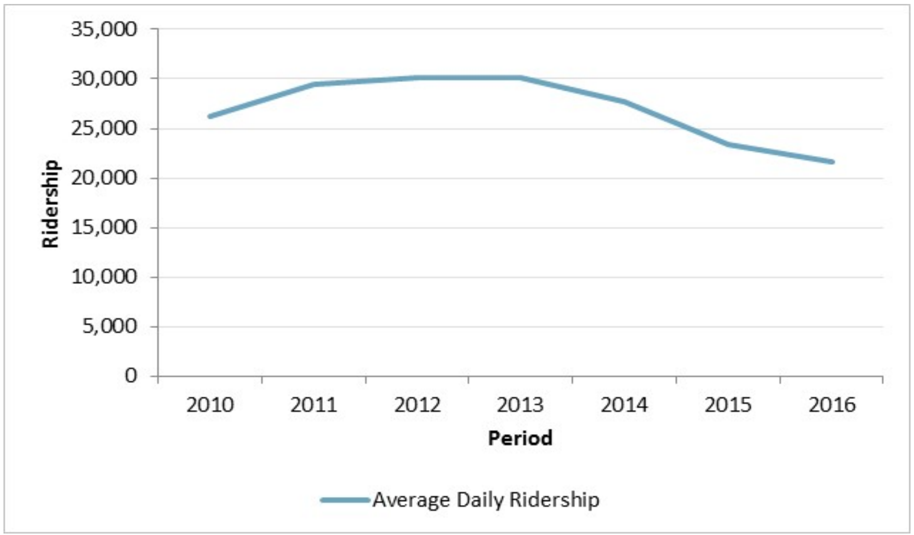
Figure 2.78: Tren Urbano Alignment



Source: Tren Urbano and Tren Urbano Stations information layer was provided by the Puerto Rico Integrated Transit Authority (PRITA)

In 2016, Tren Urbano had an average daily ridership of 21,599, a 17.8% decrease since 2010 corresponding to a loss of 4,679 riders as shown in Figure 2.79. Table 2.51 shows the TU stations in terms of daily boardings.

Figure 2.79: Average Daily Ridership – Tren Urbano



Source: SDG Analysis of Indicadores PR.

Table 2.51: 2016 Average Daily Boarding by Station – Tren Urbano

Station	Average Daily Boarding (2016)	% of Total
Bayamón	2,649	12.26%
Deportivo	2,219	10.27%
Jardínes	334	1.55%
Torrimar	453	2.10%
Martínez Nadal	1,435	6.64%
Las Lomas	614	2.84%
San Francisco	1,094	5.06%
Centro Médico	1,523	7.05%
Cupey	1,156	5.35%
Río Piedras	1,920	8.89%
Universidad	1,661	7.69%
Piñero	913	4.23%
Domenech	805	3.73%
Roosevelt	1,130	5.23%
Hato Rey	865	4.01%
Sagrado Corazón	2,828	13.09%
Total	**21,599**	**100.00%**

Source: SDG Analysis of Indicadores PR.

Metropolitan Bus Authority (AMA)

The AMA transit bus service offers daily bus transportation in San Juan, Guaynabo, Bayamón, Cataño, Levittown (Toa Baja), Trujillo Alto, Carolina and Loíza.

The service is divided in the following 4 categories:

- Express Routes (starting with an E): limited number of stops, headways between 10 to 30 minutes in peak periods and route mostly on exclusive lanes or expressways allowing for higher speeds. This category consists of 3 services: **E-10, E-20, E-40.**
- Trunk routes (starting with a T): primary routes connecting Tren Urbano stations and transit terminals with headways between 20 and 30 minutes in peak periods. This category consists of 10 routes: **T-2, T-3, T-4, T-5, T-6, T-7, T-8, T-9, T-21, T-41.**
- Circulation routes (starting with a C): short length routes around Tren Urbano stations or transit terminals operating at headways between 20 and 30 minutes in peak periods. This category consists of 7 routes: **C-1, C-22, C-35, C-36, C-43, C-44, C-51.**
- Distribution routes (starting with a D): connecter routes between Tren Urbano or transit terminals to sub-urban or rural areas with frequencies between 30 and 90 minutes in peak periods. Some of these routes were intended to be shared with Público services. This category consists of 10 routes: **D-13, D-15, D-18, D-26, D-27, D-37, D-45, D-53, D-91, D-92.**

There are a total of 30 bus routes, with 23 being operated by the AMA and 7 ran by private operator First Transit, which are divided into three categories: Metrobus, TU CONEXION, Metro Urbano. A brief description of the routes is presented here and the route alignments are shown in Figure 2.80.

- **T-2**: TU Bayamón Station – TU Sagrado Corazón Station
  This route travels from the municipality of Bayamón onto the municipality of San Juan in Santurce. Its journey and some principal stops include the TU Bayamón station, Bayamón Pueblo Barrio, PR-2/Santa Rosa mall/Villa Caparra, FD Roosevelt Avenue – PR-23 / San Patricio / Las Américas, Roosevelt TU station, Hato Rey – Milla de Oro (financial district) and Sagrado Corazón TU.
- **T-4**: TU Martínez Nadal Station – Cataño
  This route travels from the municipality of San Juan onto the municipality of Cataño at the ferry terminal. Its journey and some principal stops include the TU Martínez Nadal Station, Altamira shopping center, Piñero Avenue (PR-17), San Patricio Avenue, PR-24 / Metro Office / City View Park, Cataño Pueblo Barrio and finally the ferry terminal of Cataño.
- **T-5**: Iturregui – Old San Juan
  This route travels from the municipality of Carolina onto the municipality of San Juan. Its journey and some principal stops include the AMA bus terminal in Iturregui (Carolina), Laguna Gardens, airport Luis Muñoz Marín, Isla Verde Avenue, Loíza Street, Roberto Sánchez Vilella Minillas Government Center, Ponce de León Avenue (PR-25), Puerta de Tierra - Del Tren Street and finally Covadonga AMA bus terminal in Old San Juan.
- **T-6**: Iturregui – Carolina Pueblo

This route travels across the municipality of Carolina. Its journey and some principal stops include the AMA bus terminal in Iturregui (Carolina), El Comandante Avenue, Campo Rico Avenue, Universidad del Este (UNE) Campus, Sánchez Osorio Avenue, Plaza Carolina, Roberto Clemente Avenue, Guillermo Angulo Coliseum, and finally the AMA bus terminal in Carolina Pueblo Barrio.

- **T-7**: Carolina Pueblo – Cupey

  This route travels from the municipality of Carolina onto the municipality of San Juan in Cupey. Its journey and some principal stops include the AMA bus terminal in Carolina Pueblo Barrio, Carolina city hall, 65 de Infantería Avenue (PR-3), UPR University in Carolina, Plaza Escorial, and finally the TU Cupey Station.

- **T-8**: Martínez Nadal – Piñero

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Sagrado Corazón TU station, Piñero Avenue(PR-17), Luis Muñoz Marín park, Barbosa Avenue (PR-27), UPR University in Río Piedras, Ponce de León Avenue (PR-25) and finally Piñero TU station.

- **T-9**: Río Piedras – Old San Juan

  This route travels across the municipality of San Juan. Its journey and some principal stops include the AMA bus terminal in Capetillo (Río Piedras), Barbosa Avenue, Borinquen Avenue, Sagrado Corazón TU Station, Fernández Juncos Avenue (PR-35) Convention Center District, Puerta de Tierra - Del Tren Street and finally Covadonga AMA bus terminal in Old San Juan.

- **T-21**: TU Sagrado Corazón – Old San Juan

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Sagrado Corazón TU station, Ponce de León Avenue (PR-25 Santurce), Roberto Sánchez Vilella Minillas Government Center, Condado sector, Ashford Avenue, Puerta de Tierra (Del Tren Street), and finally Covadonga AMA bus terminal in Old San Juan.

- **T-41**: Iturregui – TU Piñero

  This route travels from the municipality of Carolina onto the municipality of San Juan. Its journey and some principal stops include the AMA bus terminal in Iturregui (Carolina), Campo Rico Avenue, Ramal PR-8, Mall of San Juan, Simón Madera Street, De Diego Street, PR-47, Barbosa Avenue (PR-27), Mayagüez Street, Auxilio Mutuo Hospital, and finally Piñero TU station.

- **C-1**: TU Sagrado Corazón – Río Piedras

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Sagrado Corazón TU station, Hato Rey – Milla de Oro (Financial District), Polytechnic University, San Juan Judicial Center, UPR Río Piedras Campus, José Gándara Avenue and finally Capetillo AMA bus terminal.

- **C-43**: Iturregui – Vista Mar (Carolina)

  This route travels across the municipality of Carolina. Its journey and some principal stops include the AMA bus terminal in Iturregui (Carolina), Pontezuela Avenue, Vista Mar Extension, Jardínes de Country Club, Galicia Avenue, Universidad del Este (UNE) Campus University, PR-190 and finally El Comandante Avenue.

- **C-44**: Carolina – Villa Carolina

  This route travels across the municipality of Carolina. Its journey and some principal stops include the AMA bus terminal in Carolina Pueblo, Sánchez Castaño Avenue, Villa Carolina, Roberto Clemente Avenue, Julia de Burgos Park, Campo Rico Avenue, Museo del Niño, and finally Calderón Avenue.

- **C-51**: Carolina – UPR / Escorial

  This route travels across the municipality of Carolina. Its journey and some principal stops include the AMA bus terminal in Carolina Pueblo, Sánchez Castaño Avenue, Lagos de Blasina residential area, Plaza Carolina shopping center, Figaldo Díaz Avenue, Julia de Burgos Park, Monserrate Avenue, Villa Fontana residential area, PR-190, Villa Flores residential area, UPR Carolina Campus and finally Plaza Escorial shopping center.

- **D-13**: TU Cupey – Interamericana

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Cupey TU Station, PR-176, Universidad Metropolitana (UMET), Lomas Verdes Avenue(PR-177), Señorial Plaza shopping center, Interamericana University, PR-1, Las Cumbres Avenue and finally Emiliano Pol Avenue.

- **D-15**: TU Cupey Station – TU Sagrado Corazón Station

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Cupey TU station, Río Piedras, De Diego Avenue, San Francisco Hospital, PR-181N, Manuel A. Pérez housing project, Barbosa Avenue (PR-27), Bolivia Street, Hato Rey TU Station and finally Sagrado Corazón TU Station.

- **D-18**: TU Cupey – Riveras de Cupey

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Cupey TU station, Paraná Street, Señorial Plaza shopping center, Winston Churchill Avenue, Las Cumbres Avenue (PR-199) and finally Campanilla Street.

- **D-26**: TU Piñero Station – Trujillo Alto

  This route travels from the municipality of San Juan onto the municipality of Trujillo Alto. Its journey and some principal stops include the Piñero TU Station, Ponce de León Avenue (PR-25), UPR University in Río Piedras, AMA bus terminal in Capetillo Río Piedras, De Diego Street, PR-181, Park Gardens and finally Venus Gardens.

- **D-27**: TU Martínez Nadal Station – Guaynabo

This route travels from the municipality of San Juan onto the municipality of Guaynabo. Its journey and some principal stops include the Martínez Nadal TU Station, Metropolitan Hospital, Paz Granela Avenue, Lomas Verdes Avenue (PR-177), Camino Alejandrino Roas, PR-838, Esmeralda Avenue, Los Jardínes Shopping Center, Quijote Morales Coliseum and finally Guaynabo Pueblo.

- **D-37**: Cataño – Levittown

  This route travels from the municipality of Cataño onto the municipality of Toa Baja. Its journey and some principal stops include the ferry terminal of Cataño, Las Nereidas Avenue, Vistas del Morro residential area, Comerío Avenue, PR-165, PR-167, Sábana Seca Avenue, Levittown and finally Toa Baja Governmental Center.

- **D-45**: TU Sagrado Corazón Station – Loíza

  This route travels from the municipality of San Juan onto the municipality of Loíza. Its journey and some principal stops include the Sagrado Corazón TU station, Sagrado Corazón, Román Baldorioty de Castro Expressway marginal, Isla Verde, Balneario de Carolina, Piñones, PR-187 and finally Loíza CDT (Medical Center).

- **D-53**: Old San Juan – Luis Muñoz Marín Airport

  This route travels from the municipality of San Juan onto the municipality of Carolina. Its journey and some principal stops include the Covadonga AMA bus terminal in Old San Juan, Puerta de Tierra – Del Tren Street, Convention Center, Condado, McLeary Street, Loíza Street, Isla Verde and finally Luis Muñoz Marín International Airport.

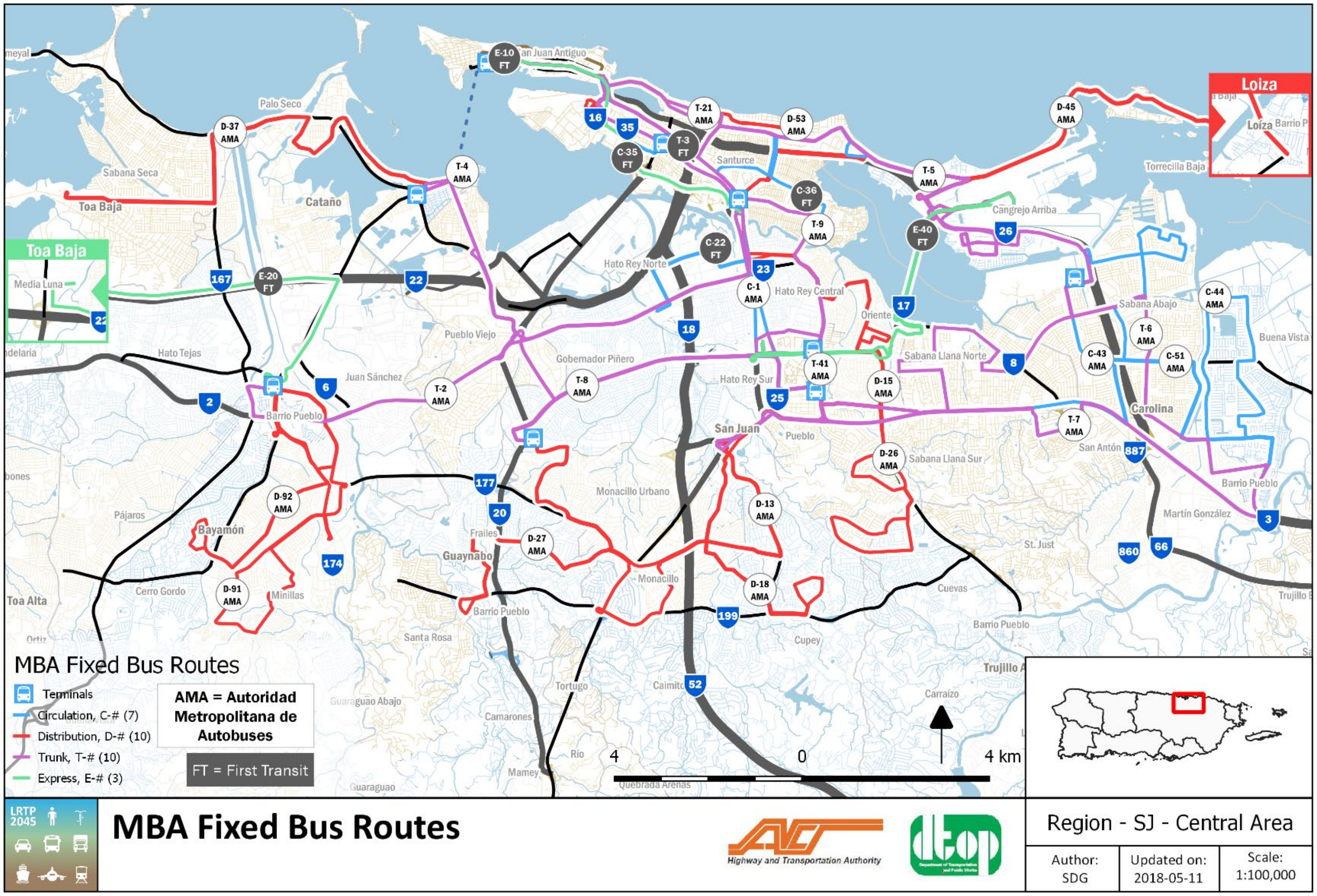
- **D-91**: TU Bayamón Station – Santa Juanita

  This route travels across the municipality of Bayamón. Its journey and some principal stops include the Bayamón TU Station, Bobby Capó Avenue, HIMA San Pablo Hospital, Santa Rosa, Main Avenue, UPR Bayamón Campus, Driver Services Centers (*Centro de Servicios al Conductor, CESCO*), Laurel Avenue, Santa Juanita Avenue, Hostos Avenue and finally Bayamón Regional Hospital.

- **D-92**: TU Bayamón Station – Magnolia

  This route travels across the municipality of Bayamón. Its journey and some principal stops include the Bayamón TU Station, Bayamón sports complex, PR-174, Lomas Verdes Avenue (PR-177), Bayamón lineal park, and finally Magnolia Gardens urbanized area.

Figure 2.80: AMA Fixed Route Bus Routes



Source: Bus Route Information acquired from the Puerto Rico Integrated Transit Authority (PRITA), 2015.

Table 2.52 shows passengers per day for each AMA route from May 2016.

Table 2.52: May 2016 Daily Passengers – AMA

Routes	Direction or Terminal	Passengers per day
T-2 SC-BAY	Sagrado Corazón to Bayamón	1,919
T-2 BAY-SC	Bayamón to Sagrado Corazón	1,873
T-4	Martínez Nadal	1,130
T-5 SJ-ITU	San Juan to Iturregui (Carolina)	1,789
T-5 ITU-SJ	Iturregui (Carolina) to San Juan	2,303
T-6 CAR-ITU	Carolina to Iturregui (Carolina)	904
T-6 ITU-CAR	Iturregui (Carolina) to Carolina	996
T-7 CAR-CU	Carolina to Cupey	718
T-7 CUP-CAR	Cupey to Carolina	783
T-8 MN-PIÑ	Martínez Nadal to Piñero	493
T-8 PIÑ-MN	Piñero to Martínez Nadal	512
T-9 SJ- CUP	San Juan to Cupey	1,379
T-9 CUP-SJ	Cupey to a San Juan	1,329
T-21 SJ-SC	San Juan to Sagrado Corazón	687
T-21 SC-SJ	Sagrado Corazón to San Juan	1,057
T-41 PIÑ-ITU	Piñero to Iturregui (Carolina)	916
T-41 ITU-PIÑ	Iturregui to Piñero	859
C-1	Sagrado Corazón	1,464
C-43	Iturregui (Carolina)	251
C-44	Carolina	256
C-51	Carolina	137
D-13	Cupey	496
D-15 CUP-SC	Cupey a Sagrado Corazón	243
D-15 SC-CUP	Sagrado Corazón to Cupey	310
D-18	Cupey	272
D-26	Piñero	799
D-27	Martínez Nadal	302
D-37	ATM Cataño	186
D-45	Sagrado Corazón	656
D-53	San Juan	853
D-91	Bayamón	674
D-92	Bayamón	263

Source: Sample Data taken from AMA Report (Data from April-May 2016)

First Transit Operated Routes

First Transit operates 7 bus routes under contract with AMA including Metrobus, TU Conexión and the Metro Urbano BRT:

Metrobus

- **E-10**: TU Sagrado Corazón Station– Covadonga San Juan

  This direct route travels across the municipality of San Juan. Its journey includes the Sagrado Corazón TU Station, Puerta de Tierra - del Tren Street, and finally the AMA bus terminal in Covadonga Old San Juan.

- **T-3**: TU Sagrado Corazón Station – Old San Juan

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Sagrado Corazón TU Station, Ponce de León Avenue (PR-25 Santurce), Centro de Bellas Artes, Ponce de León Avenue (PR-25 Miramar), Puerta de Tierra –Del Tren Street and finally the AMA bus terminal Covadonga in Old San Juan (Figure 2.53).

TU CONEXIÓN

- **E-40**: TU Piñero Station – Luis Muñoz Marín Airport

  This direct route travels from the municipality of San Juan onto the municipality of Carolina. Its journey and some principal stops include the Piñero TU Station, Mall of San Juan, and finally the Luis Muñoz Marín International Airport's departures terminal.

- **C-22**

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Sagrado Corazón TU Station, Chardón Street, Hostos Avenue, Arterial B Avenue and finally Plaza Las Américas.

- **C-35**: TU Sagrado Corazón Station – Convention Center

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Sagrado Corazón station of Tren Urbano, Fernández Juncos Avenue (PR-35), Hipódromo Street, Hoare Street, Convention Center District, Miramar, Santurce, and finally Ponce De León Avenue (PR-25).

- **C-36**: TU Sagrado Corazón Station – Llorens Torres housing community

  This route travels across the municipality of San Juan. Its journey and some principal stops include the Sagrado Corazón TU Station, Borínquen Avenue, Eduardo Conde Avenue, Degetau Street, Llorens Torres housing community, Loíza Street, Tapia Street, Ponce De León Avenue (PR-25 Santurce).

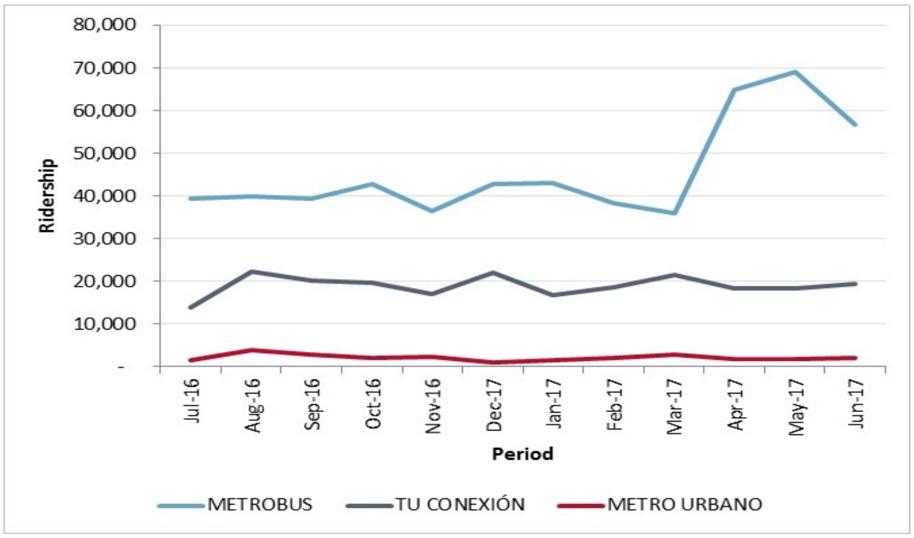
Metro Urbano

- **E-20**: TU Bayamón Station – Toa Baja

  This direct route travels from the municipality of Bayamón onto the municipality of Toa Baja. Its journey is from the Bayamón TU Station to Campanilla Toa Baja (PR-22 - lot, Park-and-Ride).

Figure 2.81 shows ridership for these routes. In fiscal year 2016-2017, the highest ridership took place in May, with Metrobus routes having higher passenger loads.

Figure 2.81: Ridership, Hours and Mileage – First Transit



Source: SDG Analysis of First Transit Report (Fiscal Year 2016-2017)

Públicos

Públicos are privately owned and operated services regulated under the Public Service Commission. Services are allowed to operate specific routes but without a specific schedule. Públicos are operated under individual or franchise agreements, with fares regulated by route and special insurance requirements. Vehicle capacity varies from eight 8 to 24, and the vehicles may be owned or leased by the operator. Públicos services have charged a variety of fares and do not have specific stops.

From data obtained from the National Transit Database (NTD), it is quite evident that the Públicos system has had a significant drop in trips made in between 2010 and 2016. This can be seen in Table 2.53. From 2010 to 2016 there have been more than 20 million fewer trips carried by Públicos across Puerto Rico, a drop of nearly 50%. Another summary statistic that shows a significant reduction is the annual passenger miles which has shown a decrease from 122,570,478 in 2013 to 90,291,870 in 2016.

Also, between Fiscal Year 2012 and Fiscal Year 2016, the Público system has lost 23% of its routes, down from 453 to 346. In the same 5-year period the number of vehicles available to provide transportation services have decreased by 31%[31]. Similarly, sponsorship has also seen a significant decline, and is expected to continue to decrease in the absence of policies and programs aimed at stabilizing this transportation service. Figure 2.82 presents the Público routes in Puerto Rico.

Table 2.53: Percent Change of Annual Unlinked Trips for Públicos from 2010 to 2016

	2010	2011	2012	2013	2014	2015	2016
Público (annual unlinked trips)	42,134,000	38,706,000	32,670,000	27,021,382	27,881,893	25,796,436	21,353,376
Change	-	(3,428,000)	(6,035,000)	(5,649,000)	861,000	(2,085,000)	(4,443,000)
% Change	-	(8.1%)	(15.6%)	(17.3%)	3.2%	(7.5%)	(17.2%)

Source: Prepared by SDG with data from the National Transit Database (NTD)

[31] Based on information provided by MTCG, Inc.

Figure 2.82: Público Routes in Puerto Rico

Source: the "carros públicos" information layer was provided by the office of Strategic Planning from the Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym)

Municipal Services

According to information obtained from the National Transit Database (NTD), there are several Municipalities (32) in Puerto Rico that provide and operate a transit service for their citizens that use diverse types of vehicles – predominantly motor trolleys. Although not all of them but almost all of them are free of charge, (31 of the 32 municipalities are free of charge – Yauco is the only municipality that has a fare on its municipal transit services) fixed routes with pre-defined[32] stops within the municipal limits. For the 32 municipalities with a municipal transit service, there were approximately 6,564,210 total annual unlinked passenger trips[33], with 6,438,421 for the regular transit service and 125,789 for the demand response service.

Table 2.54 and Figure 2.83 present the Municipalities with a transit service in Puerto Rico:

Table 2.54: Municipalities with a Transit Service in Puerto Rico

#	Municipalities with a transit service in Puerto Rico
1	Adjuntas
2	Aguada
3	Barceloneta
4	Bayamón
5	Caguas
6	Camuy
7	Carolina
8	Cataño
9	Cayey
10	Cidra
11	Comerío
12	Dorado
13	Fajardo
14	Guaynabo
15	Gurabo
16	Hatillo
17	Hormigueros
18	Humacao
19	Juncos
20	Lares
21	Manatí
22	Mayagüez

[32] In some cases, there are fixed routes with no predefined stops (as long as a user it's in the establish route the driver picks up the passenger – request stop service), especially in rural communities. Also, this has been the case has an aftermath of Hurricane María, some of the infrastructure from stops was destroyed or badly damaged (signage poles, signs, shelters, among others).

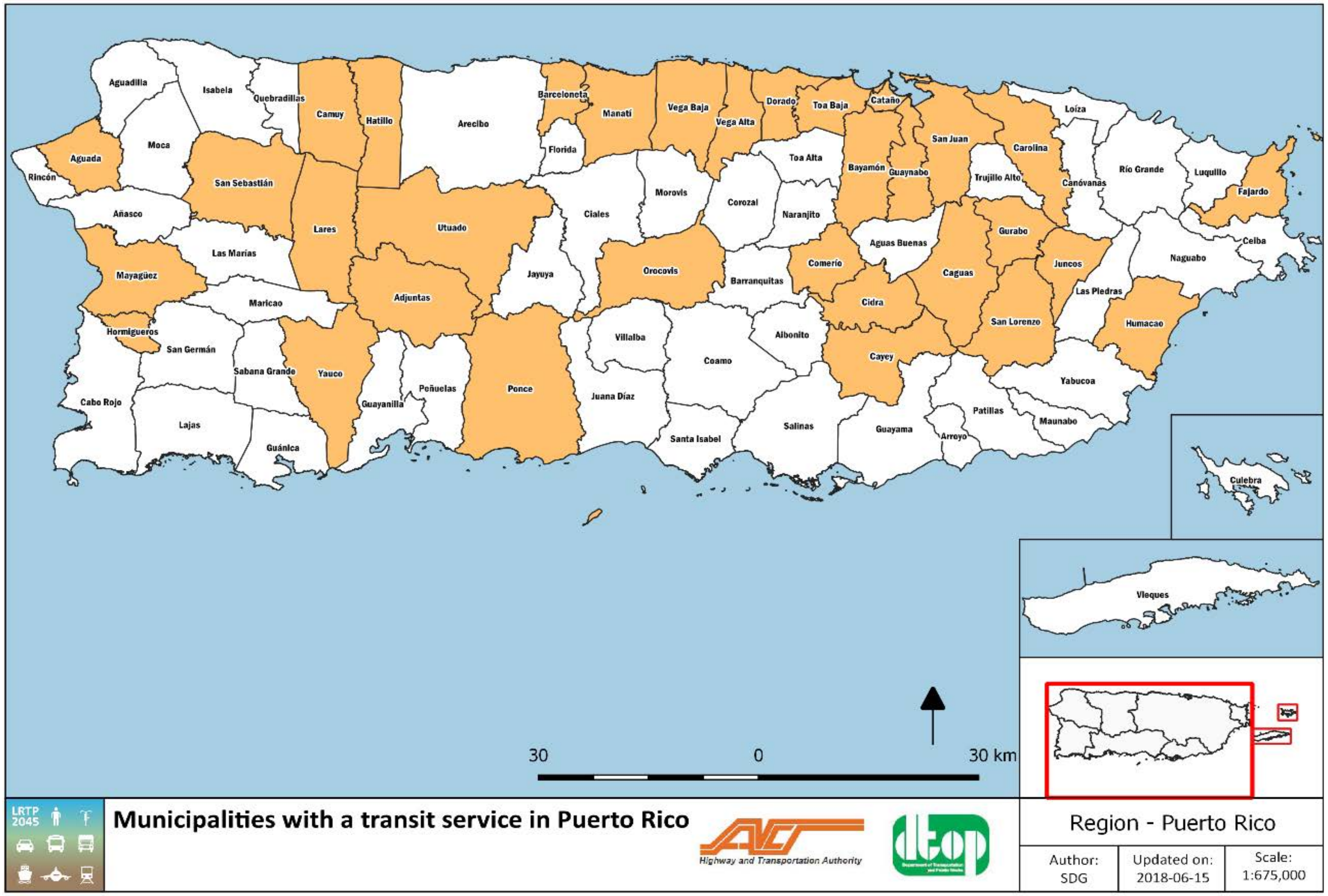
[33] According to NTD, 2016 data (UPT= Annual unlinked passenger trips).

#	Municipalities with a transit service in Puerto Rico
23	Orocovis
24	Ponce
25	San Juan
26	San Lorenzo
27	San Sebastián
28	Toa Baja
29	Utuado
30	Vega Alta
31	Vega Baja
32	Yauco

Source: Prepared by SDG with data from the National Transit Database (NTD).

Additionally, there are several Municipalities that provide paratransit services to the elderly and people with disabilities regardless of providing municipal transit services.

Figure 2.83: Municipalities with a Transit Service in Puerto Rico

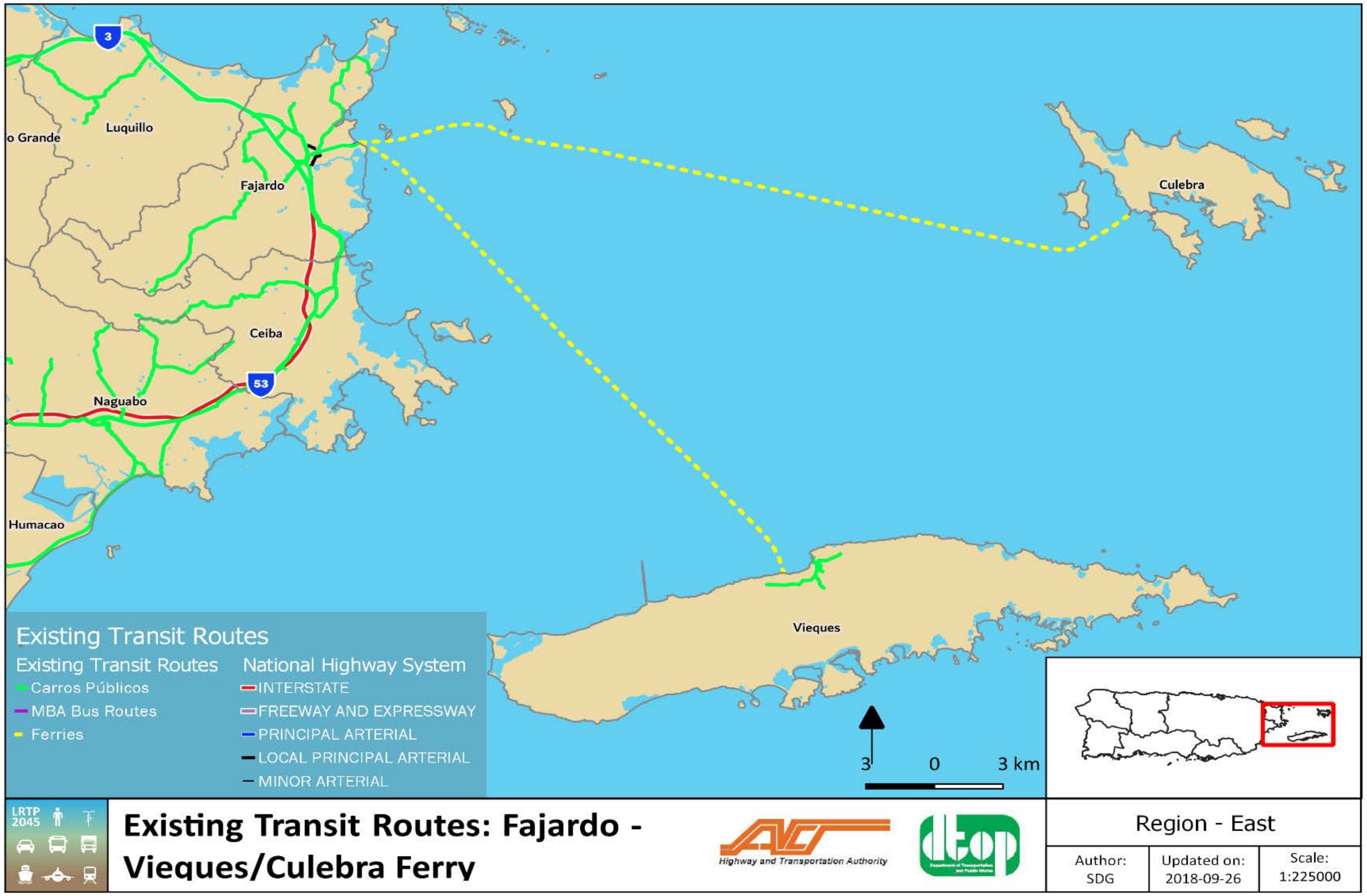


Source: Prepared by SDG with data from the National Transit Database (NTD).

Maritime Transportation Authority (MTA)

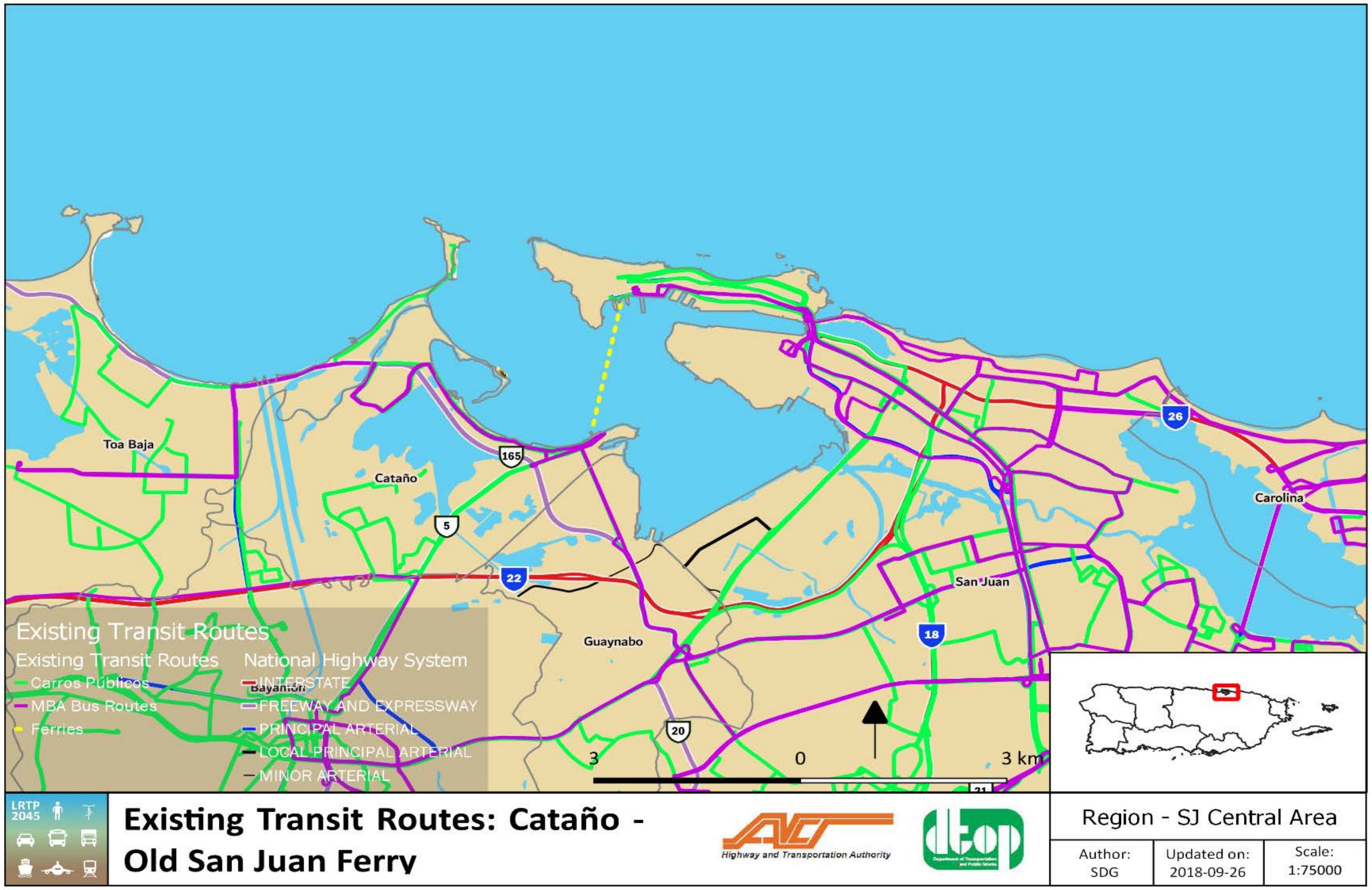
The MTA Act is a public corporation which controls, administers, operates and maintains the maritime transportation service to Fajardo, Vieques, Culebra, San Juan, and Cataño. The service of MTA in the San Juan TMA consists of a line between Cataño Pier and Old San Juan Pier as can be seen on Figure 2.84 below and it is mostly used by commuters and tourists. Since February 2018 the service works from Monday to Friday from 5:45 AM to 10:00 PM; on weekends the services work from 8:00 AM to 10:00 PM..

Figure 2.84: Existing Transit Routes: Vieques/Culebra – Fajardo



Source: Bus Routes information acquired from Puerto Rico Integrated Transit Authority (PRITA), the PR Público Routes network was provided by the Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym), the Ferry routes was created by the Maritime Transportation Authority (ATM by its spanish acronym), the PR HPMS layer was provided by the Puerto Rico Planning Board.

Figure 2.85: Existing Transit Routes: Cataño – Old San Juan Ferry



Source: Bus Routes information acquired from Puerto Rico Integrated Transit Authority (PRITA), the PR Público Routes network was provided by the Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym), the Ferry routes was created by the Maritime Transportation Authority (ATM by its spanish acronym), the PR HPMS layer was provided by the Puerto Rico Planning Board.

Bicycle and Pedestrian Facilities

In recent years, transportation alternatives are becoming crucial in terms of economic development, environmental preservation and health considerations. Worldwide tendencies are directing their focus to (1) a less motor vehicle use mindset (2) encourage bicycle-pedestrian modes of transportation and (3) combining available transportation alternatives.

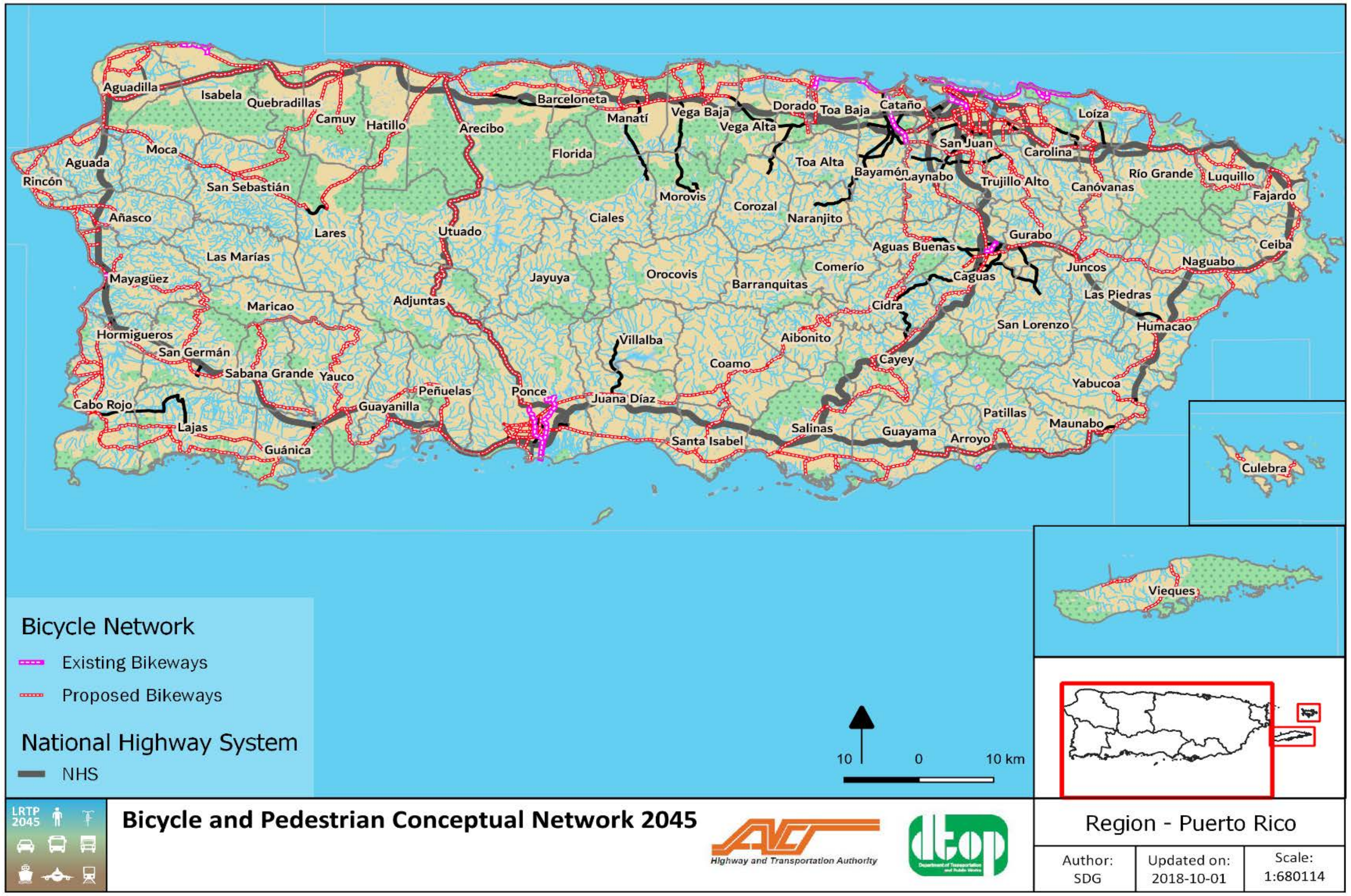
The Puerto Rico Department of Transportation and Public Works (DTPW) and The Highway and Transportation Authority (PRHTA) have adopted goals and objectives to plan and develop a multi-modal transportation system that integrates all transportation modes to improve the mobility and access conditions, create a more livable urban environment and a more efficient transportation system, including the use of non-motorized modes.

Some of the main objectives of this plan are:

- To promote the use of cycling and walking;
- To provide for the integration of urban centers through cycling and pedestrian networks;
- To include bicycle/pedestrian facilities into Statewide and Municipal Transportation Plans; and
- To improve mobility, accessibility and safety for users of public roads by providing cycling and walking infrastructure.

The Comprehensive Bicycle and Pedestrian Plan for Puerto Rico, adopted by the Public Policy Committee of the Puerto Rico MPO on September 18, 2018, was developed as the policy document to guide state and local efforts to improve access and mobility conditions and develop new pedestrian and cyclist facilities to improve the quality of life of our communities. (See Appendix C). Figure 2.86 shows the proposed cyclist network for the long term in the Comprehensive Bicycle and Pedestrian Plan for Puerto Rico.

Figure 2.86: Puerto Rico Bicycle and Pedestrian Conceptual Network 2045



Source: Existing Bicycle Network was provided by the Puerto Rico Highway and Transportation Authority, 2017.
Proposed Bicycle Network created by Steer Davies Gleave, 2017.

Table 2.55 identifies some of the main roads with high incidence of pedestrians in Puerto Rico.

Table 2.55: Puerto Rico's Most Used Roads for Walking[34]

Puerto Rico Roads			
San Juan	**Aibonito**	**Dorado**	**Mayagüez**
Paseo del Morro	PR-14	PR-165	PR-380
Calle del Morro	PR-722	PR-693	PR-108
Del Valle Boulevard	**Cayey**	**Vega Alta**	PR-64
Muñoz Rivera Ave. (Old San Juan)	PR-15	PR-693	PR-2
Ashford Ave.	**Humacao**	**Vega Baja**	PR-65
Magdalena Ave.	Dr. Vidal Street	PR-689	PR-106
Ponce de León Ave.	PR-3R	PR-2	PR-2R
Puerto Viejo Vecinal Street	Antonio López Street	PR-687	Valle Sur Street
PR-176	**Bayamón**	**Rincón**	Catatuna Street
PR-199	Paseo Lineal	PR-413	Jolosa Street
Aguada	**Aguadilla**	PR-115	Andalucía Street
PR-115	Borinquen Ave.	**Quebradillas**	Julio Bouliz Street
Rotario Ave.	Path to las Ruinas	PR-481	Pablo Alemar Street
San Francisco Street	**Añasco**	Municipal Street	Manuel Maymón Street
Cristóbal Colón Street	PR-2	PR-2	Ricardo Seguinot Street
Carrizales Street	**Isabela**	**Yauco**	Roberto Cole Street
Camino Playa	PR-2	PR-127	Luis Castellón Street
Manuel Ruiz Street	PR-466	PR-133	Efraín Mon Rivera Ave.

[34] Comprehensive Bicycle and Pedestrian Plan for Puerto Rico, 2017.

Puerto Rico Roads			
Ponce	PR-4466	**Guayanilla**	Balboa Street
Las Américas Ave.	**Coamo**	PR-127	
Miramar Street	PR-14	**Guánica**	
Federal Ave.	PR-150	PR-324	
Glenview Ave.	PR-153	**Juana Díaz**	
A Street	PR-545	PR-510	
El Monte Street	**Cabo Rojo**	PR-149	
G Street	PR-305	Footpath	
H Street	PR-301	Lajas	
I Street	PR-101	PR-305	
PR-139			
PR-5139			
PR-333			

Source: Comprehensive Bicycle and Pedestrian Plan for Puerto Rico

There are 12 cycling facilities in Puerto Rico, most of them located in the San Juan TMA:

- Paseo del Atlántico Phase I, PR-187, Carolina;
- Paseo del Atlántico Phase II, PR-187, Isla Verde Avenue, Carolina;
- Paseo del Atlántico Phase III and IV, Ocean Park and Condado, San Juan;
- Paseo Río Bayamón, Bayamón;
- Paseo Honor al Río, Caguas;
- Paseo Piñones, Loíza;
- The Cyclist Route, PR-165, Toa Baja, Dorado;
- Parque Lineal Enrique Martí Coll, San Juan;
- Paseo Puerta de Tierra, San Juan;
- Los Tubos MTB Trail, Manatí;
- Hacienda la Esperanza Natural Reserve, Manatí;
- Paseo Lineal Coastal Zone, Isabela;
- Parques Lineales Río Portugués y Bucaná, Ponce; and
- Parque Lineal Río Yagüez, Mayagüez.

Figure 2.87 gives a visual representation of some of the cycling facilities in the island.

Figure 2.87: Bicycle Facilities by Region – Puerto Rico

Paseo del Atlántico Phase I
(Carolina, PR)

Paseo del Atlántico Phase II
(Carolina, PR)

Paseo del Atlántico Phase III/IV
(Condado - San Juan, PR)

Paseo Río Bayamón
(Bayamón, PR)

Paseo "Honor al Río"
(Caguas, PR)

Paseo Piñones
(Loíza, PR)

Ruta del Ciclista PR-165
(Toa Baja - Dorado, PR)

Parque Lineal Enrique Martí Coll
(San Juan, PR)

Paseo Puerta de Tierra
(Isleta de San Juan, PR)

Source: Comprehensive Bicycle and Pedestrian Plan for Puerto Rico

Aguadilla TMA

Paseo Lineal Zona Costanera - Isabela, P.R.

Source: Comprehensive Bicycle and Pedestrian Plan for Puerto Rico

South Region

Parques Lineales Río Portugués y Bucaná - Ponce P.R.

Source: Comprehensive Bicycle and Pedestrian Plan for Puerto Rico

Southwest Region

Parque Lineal Río Yagüez - Mayagüez P.R.

Source: Comprehensive Bicycle and Pedestrian Plan for Puerto Rico

In terms of cyclist activity, Table 2.56 shows the some of the most used roads for cycling in Puerto Rico.

Table 2.56: Puerto Rico's Most Used Roads for Cycling

Puerto Rico Municipalities				
San Juan	**Trujillo Alto**	**Cataño**	**Vega Baja**	**Caguas**
Del Morro Street	PR-181	PR-165	PR-2	PR-189
Del Valle Boulevard	**Carolina**	**Toa Baja**	PR-686	**Gurabo**
Luis Muñoz Rivera Ave.	PR-37	PR-165	Sol Ave.	PR-189
Ponce de León Ave.	PR-187	**Dorado**	**Manatí**	**Juncos**
Ashford Ave.	**Loíza**	PR-165	PR-686	PR-189
Magdalena Ave.	PR-187	PR-693	PR-685	PR-31
McLeary Ave.	**Río Grande**	PR-696	PR-2	PR-162
Linderberg Street	PR-187	PR-6693	**Aguas Buenas**	PR-722
Cagual Street	PR-3	PR-695	PR-174	**Las Piedras**
Miraflores Street	**Guaynabo**	PR-694	PR-173	PR-31
José N. Gándara Street	PR-165	PR-659	**Aibonito**	**Humacao**
PR-47	PR-23	**Vega Alta**	PR-14	PR-3
PR-27	PR-833	PR-693	PR-718	**Yabucoa**
PR-3	PR-834	PR-689	**Naguabo**	PR-3
PR-181	Bayamón	**Cidra**	PR-31	**Maunabo**
S. Alcides Reyes Street	Paseo Lineal	PR-173	PR-192	PR-3
Isabela	**Lares**	**San Sebastián**	**Rincón**	**Aguadilla**
PR-2	PR-111	PR-111	PR-115	PR-2
PR-466	**Aguada**	**Añasco**	PR-413	PR-111
Moca	PR-115	PR-115	**Barceloneta**	PR-467
PR-111	PR-441	PR-402	PR-681	PR-107
Coamo	Camino Playa	**Luquillo**	PR-684	PR-110
PR-14	**Culebra**	PR-3	PR-140	PR-459
PR-153	PR-251	**Fajardo**	PR-2	**Arecibo**
Santa Isabel	PR-250	PR-3	**Camuy**	PR-681
PR-1	**Vieques**	**Ceiba**	PR-2	PR-2
PR-153	PR-200	PR-3	**Quebradillas**	Victor Rojas Ave.
Juana Díaz	PR-997	Roosevelt Road Trails	PR-2	**Hatillo**
PR-1	**Peñuelas**	**Guayanilla**	**Yauco**	PR-2
PR-14	PR-127	PR-132	PR-127	**Guánica**
Ponce	PR-385	PR-127	PR-121	PR-116
PR-1	PR-132	PR-335	PR-335	**Cabo Rojo**
PR-14	**Patillas**	**Arroyo**	PR-2	PR-303
PR-123	PR-3	PR-3	PR-693	PR-301
PR-2	PR-799	**Lajas**	PR-689	PR-307
Sabana Grande	PR-184	PR-116	**Mayagüez**	PR-308
PR-120	**San Germán**	PR-305	PR-114	PR-3301
PR-121	PR-102	PR-303	PR-2	12 Street
PR-102	PR-360	PR-304	PR-341	Los Vélez Path
David Meléndez Street	PR-329		Jardínes Ave.	Las Guanábanas Path
Hormigueros	PR-347			PR-100
PR-114	PR-114			Monte Carlo Path

Source: Comprehensive Bicycle and Pedestrian Plan for Puerto Rico

Panoramic Route

The DTPW and the PRHTA completed the Corridor Management Plan (CMP) for the Panoramic Route in 1998 with an allocation of National Scenic Byways Program FHWA. The Update of the CMP for the Panoramic Route includes goals for the preservation of the cultural and scenic values of the Route, as well as for the safety of its users.

- Conservation: To conserve the significant quality of the Panoramic Route's scenic beauty and views, and the outstanding value of its natural and cultural resources for the future generations of users of the Route;
- Safety: To ensure the safety of the Route for all users by adopting compatible and appropriate design standards for scenic roads, by providing adequate information, signage, and security measures, in a way that enhances its natural and scenic qualities; and
- Education and Information: To educate and inform Panoramic Route users about the Corridor's cultural and historic values, as well as the scenic and natural qualities for their enrichment, and so that they engage in the Route's preservation and become satisfied tourists of the Route.

The Update of CPM should be a community-based strategy to conserve the intrinsic resources of the scenic byways in a sustainable balance with economic development and tourism.

The plan consists of a broad conceptual vision of a comprehensive action plan that calls both for immediate action within a long-range program. The CMP should meet the following objectives:

- To preserve the intrinsic qualities of the Route;
- To preserve scenic views;
- To improve the conservation and maintenance of roads;
- To protect the easement;
- To encourage the appropriate use of adjacent land; and
- To promote socio-economic development.

The Panoramic Route provides visitors of all ages diverse opportunities to explore the Island's cultural, historical, natural, scenic and recreational resources as well as to experience local traditions and the rural way of life. Serving as a gateway, connecting the traveler to other regions (Table 2.25 includes a list of the Panoramic Route municipalities within the Sa Juan TMA and Other Urbanized Areas Regions) in a safe and coherent manner, educating the users about its resources, the Route preserves and enhances the natural beauty of the interior of Puerto Rico for residents and visitors, while represented an opportunity of socio-economic development.

Table 2.57: Panoramic Route Municipalities

Regions	Municipalities	State Roads	Length in km
San Juan TMA	Maunabo	3, 901, 760	11.6
	Yabucoa	3, 182, 181, 901	32
	San Lorenzo	181, 7740	7.3
	Cayey	184, 179, 742, 7741, 741, 15, 715, 1, 7722	29.35
	Aibonito	7722, 722, 7718, 725, 14, 723	20
	Barranquitas	143	2.3
	Orocovis	143	16.7
UZA Southeast Region	Patillas	7740, 184	3.9
	Guayama	179, 742, 7741	13.3
UZA South Region	Coamo	723, 143	16.2
	Villalba	143	2.3
	Juana Diaz	143	1.2
	Ponce	143	7.6
UZA North Region	Jayuya	143	6.8
	Adjuntas	143, 123, 518, 131, 525, 135	31.4
	Utuado	143	3.8
UZA Southwest Region	Maricao	128, 105, 365, 366, 120	26.8
	Sabana Grande	366, 120	2.5
	Mayagüez	119, 339, 105	16.6
Aguadilla TMA	Lares	135, 128	8.5
	Las Marías	120, 106	6.7
	21 Municipalities	40 state roads	266.85

Source: CMP

Figure 2.88: Panoramic Route

Source: The Panoramic Route layer was obtained from the Puerto Rico Highway and Transportation Authority (PRHTA), National Highway System as it appears on the NHS 2018 layer for Puerto Rico provided by the Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym)

Airports, Seaports, and Freight

Puerto Rico is an important location and a central focus for tourism and commercial activity. Well known for its natural resources, its music, kind people and its potential for development, the island represents a significant site to national air, terrestrial and maritime transportation.

Puerto Rico has ten (10) available principal airports included in the National Plan of Integrated Airport Systems (NPIAS) for the period of 2017-2021. This National Plan identifies existing and proposed airports that are significant to national air transportation and are in consequence eligible to receive Federal grants under the Airport Improvement Program (AIP)[35]. The Island-wide movement of passengers and goods occurs through:

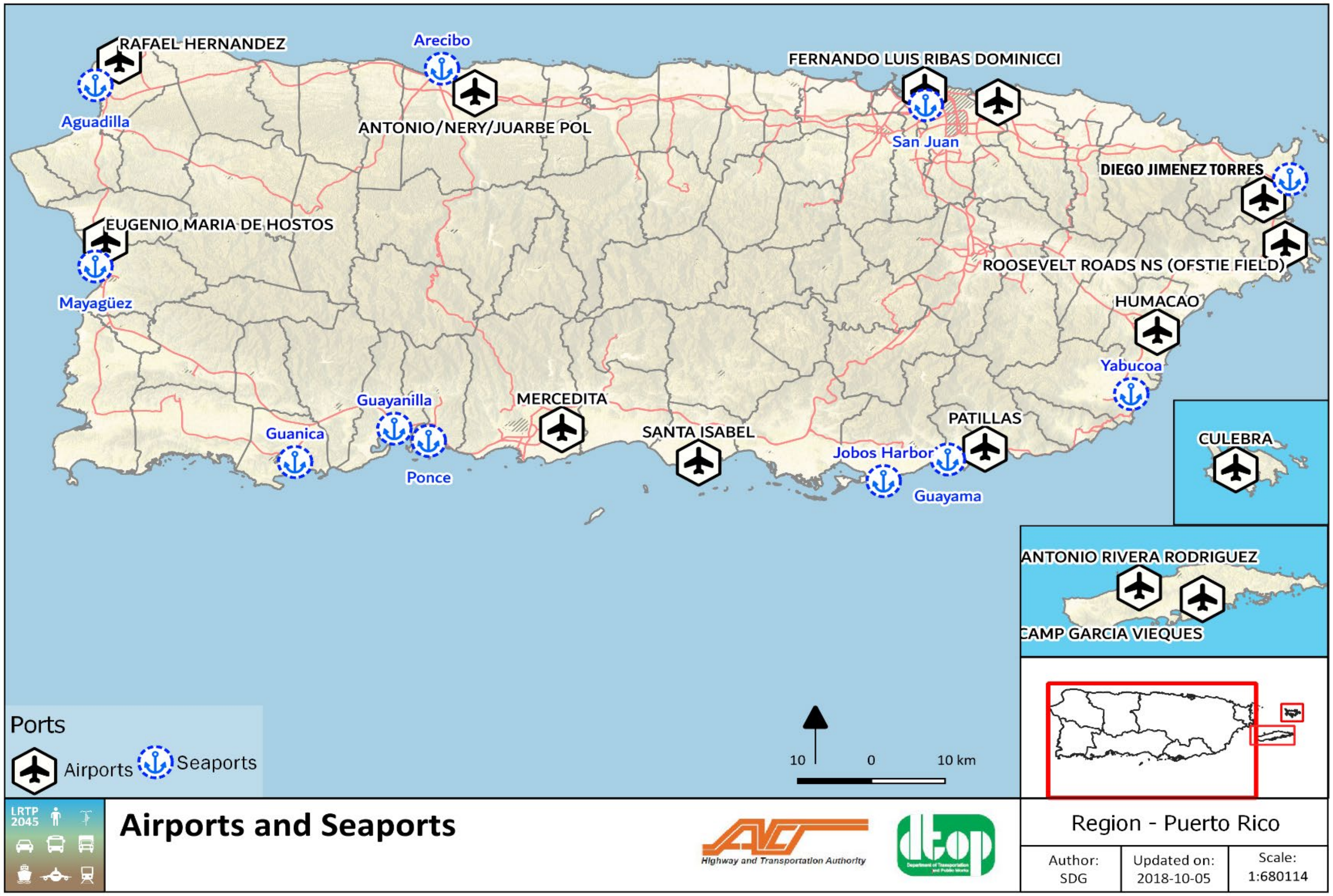
- The Rafael Hernández Airport (BQN) in Aguadilla;
- The Antonio Nery Juarbe Airport (ABO)36 in Arecibo;
- The Eugenio María de Hostos Airport (MAZ) in Mayagüez;
- The Mercedita International Airport (PSE) in Ponce;
- The Fernando Luis Ribas Dominicci (SIG) in San Juan;
- The Luis Muñoz Marín International Airport (SJU), in Carolina;
- The Benjamín Rivera Noriega Airport (CPX) in Culebra;
- The José Aponte De La Torre Airport (RVR) in Ceiba;
- The Hermenegildo Ortiz Quiñones Airport (X63) in Humacao; and
- The Antonio Rivera Rodríguez Airport (VQS) in Vieques.

In terms of maritime transportation, there are some available seaports in municipalities such as San Juan, Yabucoa, Fajardo, Guayama, Ponce, Guayanilla, Guánica, Mayagüez, Aguadilla and Arecibo. Figure 2.89 shows the location of the already mentioned airport and seaport facilities.

[35] Federal Aviation Administration, www.faa.gov/airports/planning_capacity/npias/reports/.

[36] Abbreviation as stated in the National Plan of Integrated Airports 2017-2021.

Figure 2.89: Puerto Rico Airports and Seaports



Source: the Airports and Seaports layer was obtained from the Puerto Rico Planning Board gis server at: http:/geoserver.gis.pr.gov/wfs

Island-wide Airport Facilities

Despite the numerous air transportation facilities in the island, some of them carry a fundamental role in fulfilling the citizen's needs. For example, the Luis Muñoz Marín International Airport (SJU), located in Carolina, serves as the main airport in Puerto Rico and is the only facility operating under a public-private partnership (Aerostar Airport Holdings, LLC). The SJU serves as the principal connection of the island with national and international destinations. The Rafael Hernández Airport (BQN), located in Aguadilla, is also a crucial facility in terms of transportation. It is the second largest airport and a principal cargo management center in the island.

Other airports help assist the connectivity between the island. The Antonio Nery Juarbe (ABO) and the Hermenegildo Ortiz Quiñones (X63) support the general aviation needs and links the population with the island's aviation system. The Fernando Luis Ribas Dominicci (SIG) facility is a single runway that accommodates over 100,000 passengers each year traveling to and from the mainland and nearby destinations. The Eugenio María de Hostos (MAZ), the principal airport in the SWTPR, serves as an important connection to the Luis Muñoz Marín International Airport (SJU).

The Vieques and Culebra municipalities are also served through air transportation. The Benjamin Rivera Noriega (CPX), José Aponte De La Torre (RVR) and the Antonio Rivera Rodríguez provide passenger services to destinations such as Vieques, Culebra, Fajardo, San Juan and the U.S Virgin Islands.

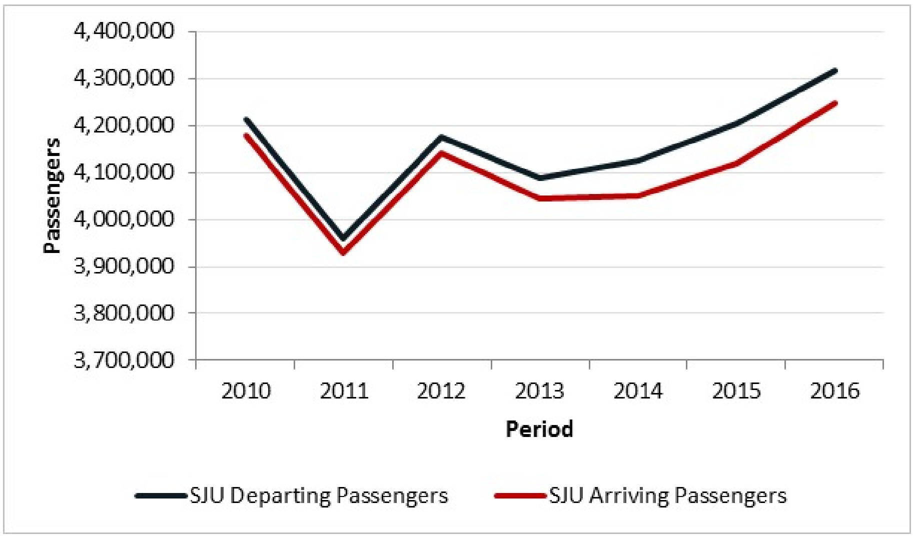
Operations

In terms of flight operation, there are two (2) principal facilities in the island: The Luis Muñoz Marín International Airport (SJU) and the Rafael Hernández Airport (BQN). For example, both airports registered 170,508 and 48,633 operations in 2016, respectively.

Passengers

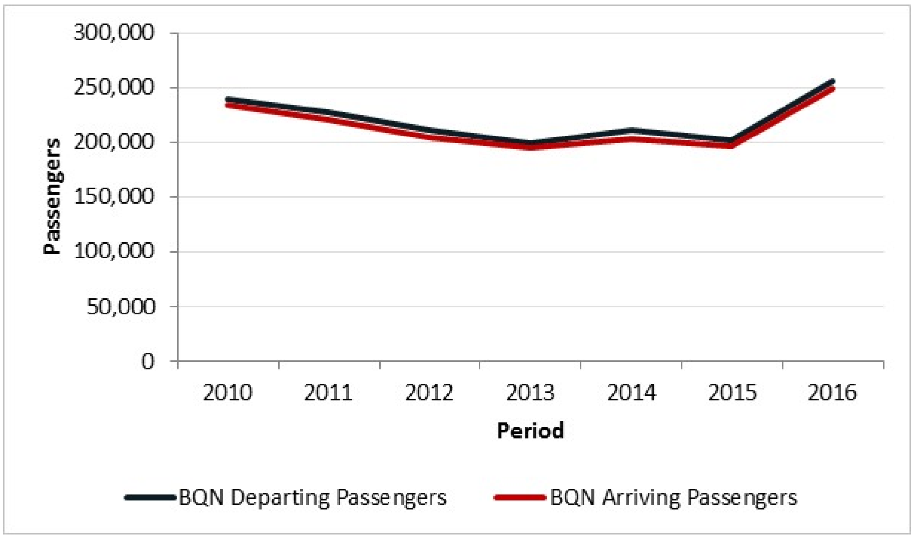
In 2016, the Luis Muñoz Marín International Airport (SJU) served 4,246,525 arriving passengers and 4,315,855 departing passengers. Also in 2016, The Rafael Hernández Airport (BQN) served the 248,384 arriving passengers and 256,031 departing passengers. Both facilities account for the highest volumes of scheduled enplaned revenue passengers[37] in the island. Figure 2.90 and Figure 2.91 show passenger departure versus arrival in both principal airports.

Figure 2.90: SJU Passengers Departure versus Arrival



Source: SDG Analysis of Bureau of Transportation Statistics

Figure 2.91: BQN Passengers Departure versus Arrival



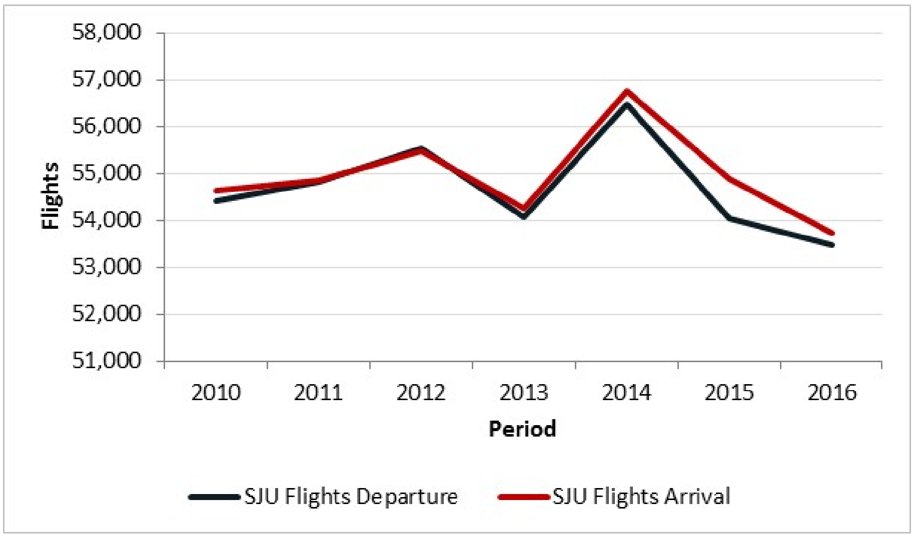
[37] According to 14 CFR 152.3 [Title 14 Aeronautics and Space; Chapter I Federal Aviation Administration, Department of Transportation; Subchapter I Airports; Part 152 Airport Aid Program; Subpart A General], Passengers enplaned means—"(1) United States domestic, territorial, and international revenue passenger enplanements in scheduled and non-scheduled service of air carriers; and (2) Revenue passenger enplanements by foreign air carriers in intrastate and interstate commerce".

Source: SDG Analysis of Bureau of Transportation Statistics

Flights

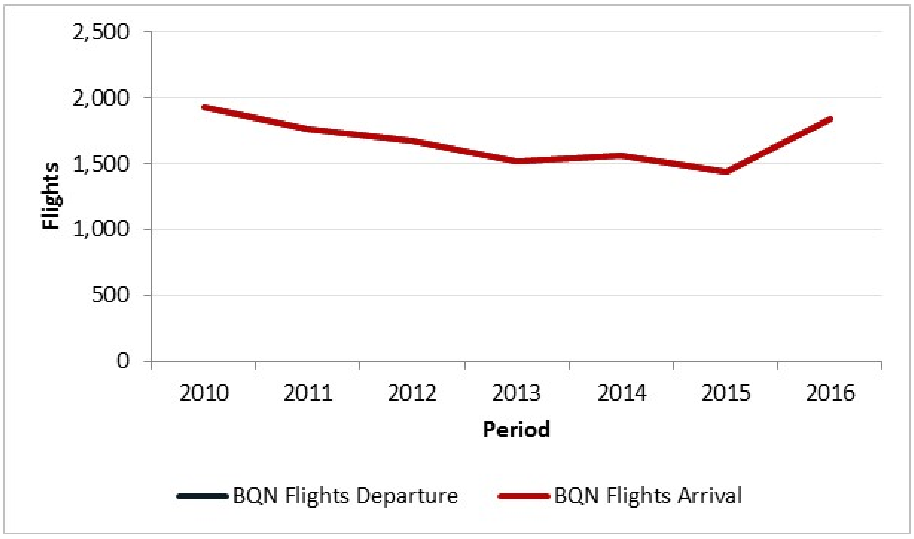
In 2016, Luis Muñoz Marín International Airport (SJU) served 107,216 total flights, including both arriving and departing flights. In 2016, Rafael Hernández Airport (BQN) served 3,686 total flights, also including both arriving and departing flights. Both airports account for the most served flights in the island. Figure 2.92 and Figure 2.93 show flight departure versus arrival in both facilities.

Figure 2.92: SJU Flights' Departure versus Arrival



Source: SDG Analysis of Bureau of Transportation Statistics

Figure 2.93: BQN Flights' Departure versus Arrival

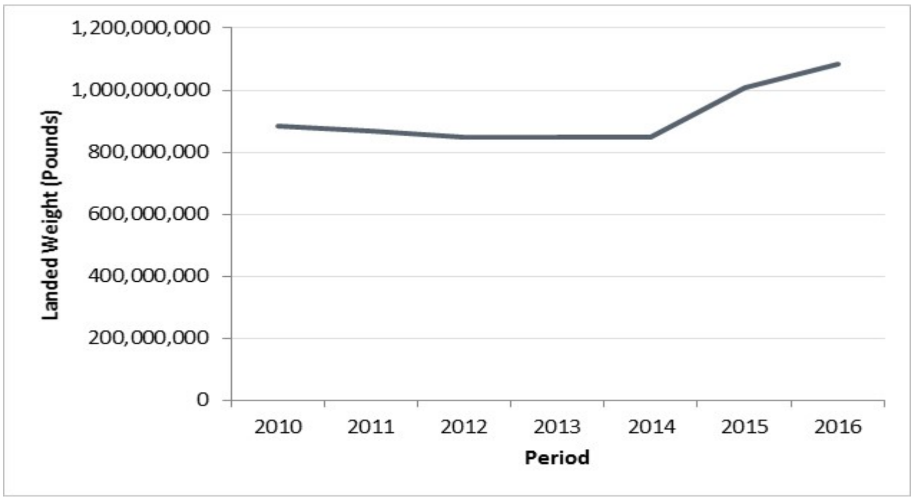


Source: SDG Analysis of Bureau of Transportation Statistics

Cargo

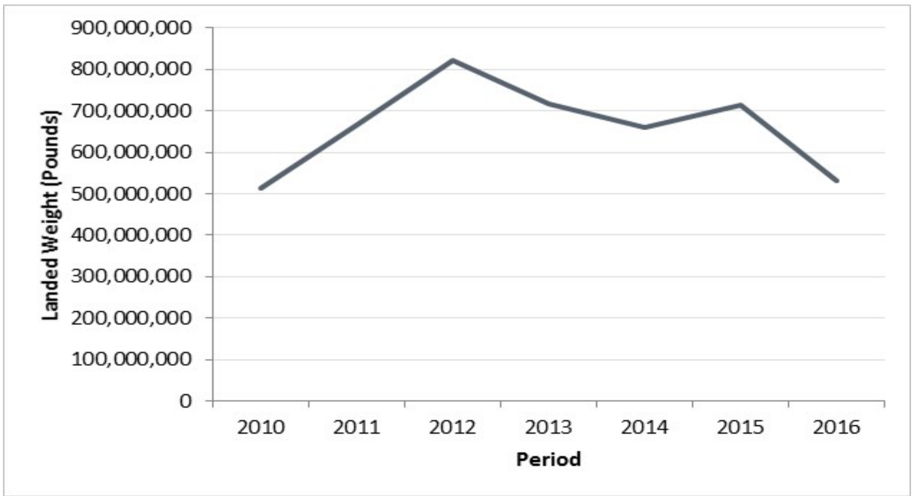
The Luis Muñoz Marín International Airport (SJU) and the Rafael Hernández Airport (BQN) are the highest ranking airports regarding cargo[38]. Both were nationally ranked 34th and 49th respectively in 2016[39]. This relatively high ranking is an indicator of the key role both airports play as cargo terminals for the Island. The SJU had 1,084,961,328 pounds of landed weight, while the BQN had 532,393,460 million pounds of landed weight[40]. Figure 2.94 and Figure 2.95 show a description of their respective numbers.

Figure 2.94: SJU Landed Weights



Source: SDG Analysis of Federal Aviation Administration

Figure 2.95: BQN Landed Weights



[38] Aeroweb. Forecast International's Aerospace Portal. Top 100 U.S. Airports in 2016.

[39] Aeroweb Forecast International's Aerospace Portal.

[40] Definition from Federal Aviation Administration: "Landed weight means the weight of aircraft transporting only cargo in intrastate, interstate, and foreign air transportation. An airport may be both a commercial service and a cargo service airport".

Source: SDG Analysis of Federal Aviation Administration

Island-wide Seaports

Puerto Rico is a principal destination in the Caribbean and an important source for economic activity. It also has the capability of managing maritime transportation through its geographical limits. Various seaports in the island cover the citizen's needs, provide for cruises' arrival and promote a platform for cargo management and overall development.

The San Juan Port is the biggest seaport in the island. This Port is composed of various facilities around the San Juan Bay, which include passenger and cargo facilities. San Juan, Cataño and Guaynabo are the municipalities surrounding this facility, property of the Puerto Rico Ports Authority. Important maritime activity occurs not only in the metropolitan area of San Juan. The Teófilo Morales Rodríguez Port in Yabucoa receives 33% of the crude and refined oil products that enter the island. This facility has an approximate capacity of 4.6 million barrels of storage for refined products like fuel oil and crude oil. The Rafael Cordero Santiago Port, in the municipality of Ponce, is another main facility, with ambitious projections for the future. The Fajardo, Vieques and Culebra Ports serve as connections between mainland citizens and the neighbouring citizens of Vieques and Culebra, and viceversa.

The Mayagüez Port is the third (3) ranked facility in the island in terms of activity. Located along highways PR 64, PR 341 and PR 3341, it is a multipurpose seaport that handles various types of cargo and receives weekly visits by ships serving the Dominican Republic. Currently, the Mayagüez Port is the only facility in the islands' western coast capable of docking large cruise ships. Other important maritime harbors in the island include the Aguadilla Port, the Jobos Harbor Port in Guayama, "El Puerto de la Playa de Guayanilla" in the Guayanilla municipality, "El Puerto del Malecón de Guánica" in the Guánica municipality, and the Arecibo Port. Figure 2.88 shows the island-wide available seaports.

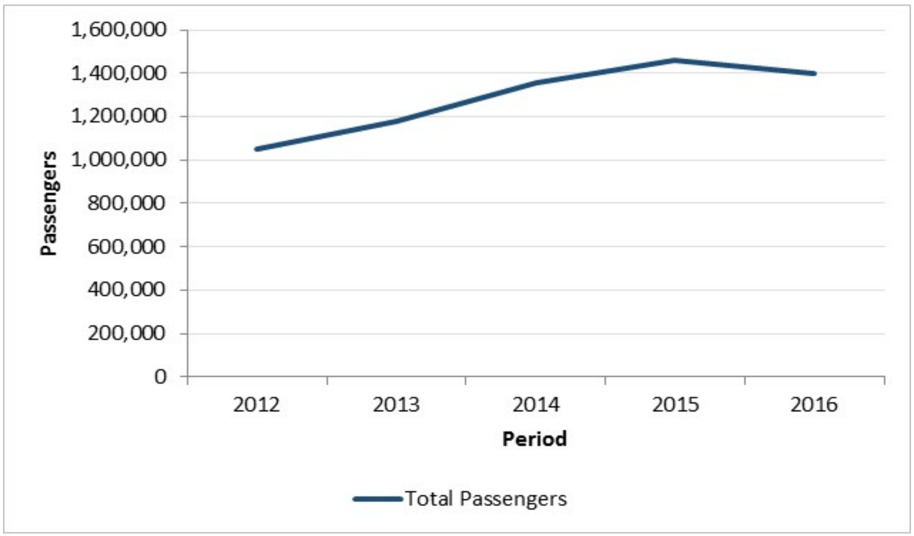
Passengers

From 2012 to 2016, The San Juan Port, the main seaport in the island, showed an increase of 33.9% in total passenger movements, as shown in Figure 2.95. From those movements, 32.2% were Home Port passengers[41] and 67.8% were in-transit passengers[42], as shown in Figure 2.97.

[41] Homeport (SJ) = "These are passengers who start and finish their cruise trip in the port of San Juan. Puerto Rico Tourism Company".

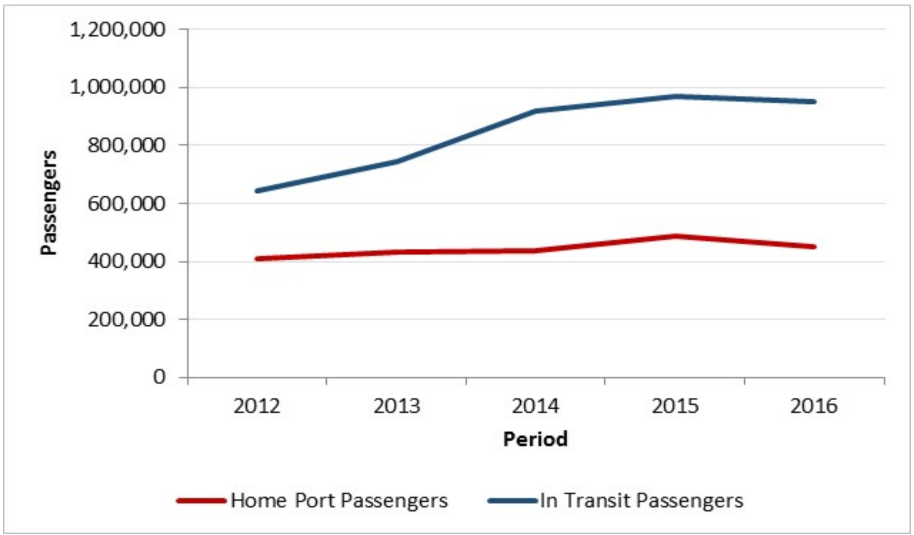
[42] In Transit: "These are passengers who begin their cruise trip in other foreign port, dock for a short period of time in San Juan Port, and then continue to other destinations. Puerto Rico Tourism Company".

Figure 2.96: Total Passengers – Port of San Juan



Source: SDG Analysis of Puerto Rico Tourism Company

Figure 2.97: Home Port vs. In Transit Passengers – Port of San Juan



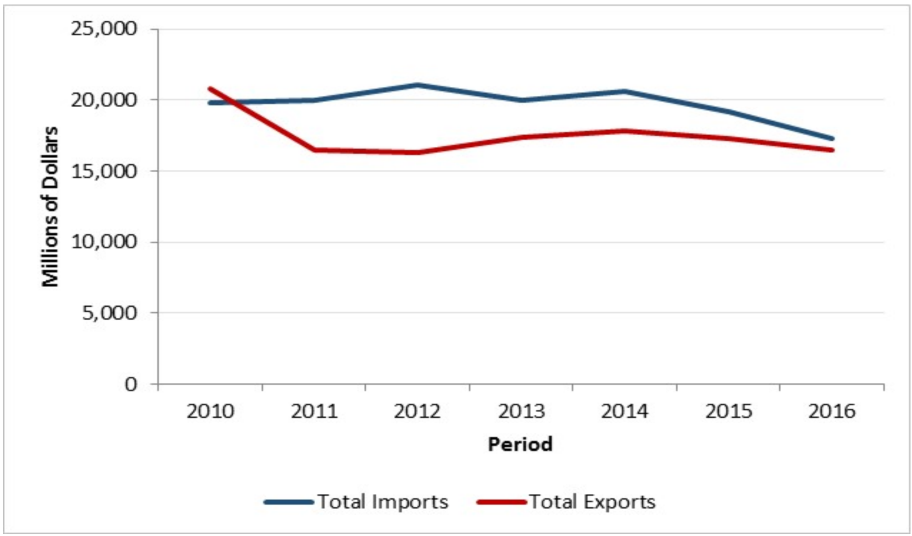
Source: SDG Analysis of Puerto Rico Tourism Company

Cargo

The Port of San Juan's ranked 24th in exports, 12th in imports and 18th in total trade within U.S. by volume of cargo. Table 2.26 show shows the Port of San Juan ranked 17th in exports, 19th in imports and 17th in total trade within U.S. by value of cargo. From 2010 to 2016, there has been a 19.4% decrease in total trade.

Figure 2.98 shows that since 2010 to 2016 imports have decreased in 12.5%, and exports have decreased in 20.6%.

Figure 2.98: Puerto Rico General Imports - Puerto Rico Customs District of Unlading and Puerto Rico Exports - Domestic and Foreign Merchandise



Source: U.S. Census Bureau, U.S. Merchandise Trade, Selected Highlights (Report FT 920)

Apart from the cargo movement in the island's main Port, there is also specific information about tons and barrels in some of the other maritime facilities. Table 2.58, Table 2.59, Table 2.60, Table 2.61, Table 2.62 and Table 2.63 show tons and barrels according to the Treasury Department Manifest for the Rafael Cordero Santiago (Ponce), Guayanilla, Mayagüez, Fajardo, Guánica and Jobos Harbor (Guayama) Ports.

Table 2.58: Ponce Port's Tons and Barrels through 2016

		2011-12		2012-13		2013-14		2014-15		2015-16	
PORT		TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS
Ponce				20,402	2,487,495	41,779	66,054	103,757	30,563		

Source: Puerto Rico Ports Authority

Table 2.59: Guayanilla Port's Tons and Barrels through 2016

	2011-12		2012-13		2013-14		2014-15		2015-16	
PORT	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS
Guayanilla	71	10,000	89	18,885,902	57,435	29,858,791	9,386	30,349,712	319,015	31,325,476

Source: Puerto Rico Ports Authority

Table 2.60: Mayagüez Port's Tons and Barrels through 2016

	2011-12		2012-13		2013-14		2014-15		2015-16	
PORT	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS
Mayagüez	57,289		105,187	15,167	45,171	40,000	58,484	128,703	51,482	124,163

Source: Puerto Rico Ports Authority

Table 2.61: Fajardo Port's Tons and Barrels through 2016

	2011-12		2012-13		2013-14		2014-15		2015-16	
PORT	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS
Fajardo						940,875		161,872		503,610

Source: Puerto Rico Ports Authority

Table 2.62: Guánica Port's Tons and Barrels through 2016

	2011-12		2012-13		2013-14		2014-15		2015-16	
PORT	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS
Guánica			5,010				5,000		10,163	

Source: Puerto Rico Ports Authority

Table 2.63: Guayama Port's Tons and Barrels through 2016

	2011-12		2012-13		2013-14		2014-15		2015-16	
PORT	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS	TONS	BBLS
Jobos	-	-	-	-	-	-	376,004	132,100	961,012	850,700

Source: Puerto Rico Ports Authority

3 CHAPTER 3 TRANSPORTATION PLANNING PROCESS FOR THE FUTURE

This chapter presents the 2045 LRTP's planning process, starting with the definition of its vision, goals and objectives. Also, this chapter will cover how the latest Fast-Act planning factors are being considered in the plan and the strategic approach in terms of transportation modes and to mitigate the effects of extreme weather events through a resilience infrastructure. This chapter is divided into 3 sections:

1. Vision, Goals and Objectives;
2. Planning Factors; and
3. Strategic Approach to Transportation Planning in Puerto Rico.

VISION, GOALS AND OBJECTIVES

Vision

The 2045 LRTP for Puerto Rico should guide the development of its multimodal transportation system to build up livable communities and contribute to a strong competitive economy of the Region and the Island. Current changing trends in Puerto Rico require a comprehensive plan to address infrastructure needs that best contribute to conform the city envisioned for the future. The 2045 Plan is a platform that analyzes and develop the policies and strategies toward transportation investment in the Island for the next 27 years through a participatory process integrating the diversity of the economic, social, functional abilities as well as ages and different needs in the community. This planning process attempted to reach out the general public and key stakeholders, in conformance with regulations allowing effective citizen participation to assist the process of defining the path towards an integrated and multimodal transportation system.

The first step in this process was to define how our citizens foresee the future of Puerto Rico; how we envision our communities to be in terms of our living spaces which include where do we live, work, recreate, shop, and how do we travel to those daily destinations.

As future trends are ever changing, a comprehensive plan is required to attend to those needs and changes. This Plan is the principal guide for investing in the Island's transportation infrastructure over the next 27 years. It has been developed through interaction with the public and key stakeholders, in conformance with regulations. These interactions enable effective citizen participation to assist the process of defining the path towards an integrated and multimodal transportation system.

The 2045 LRTP vision was originally based on the 2040 LRTP and was revisited in a consulting participatory process developed through active participation with the public and the committees that supported development of this document. Also, the importance of resilience (especially after Hurricane María) is considered. The plan's **Vision** states:

"The Puerto Rico multimodal transportation system will offer safe, efficient, and effective accessibility and mobility for people and goods; focusing on infrastructure resilience, promoting livable and accessible communities and the sustainable socioeconomic development".

The 2045 LRTP's framework is multimodal in nature and focusses on meeting the Island's need for resilient and sustainable transportation options for all its residents. This framework will support the definition of specific interventions within each Region to: (1) rehabilitate existing roadway network, or complete the current strategic highway network; (2) improve transit services; (3) consider non-motorize accessibility infrastructure and interventions; (4) allow for proper access to air, and sea ports; (5) allow for more efficient freight movements, while working to integrate and interconnect the respective modes considering the complete street principles.

Goals and Objectives

To aid the implementation of the 2045 LRTP Vision; four goals were developed with specific objectives. The updated 2045 LRTP goals and objectives are focused on four general topics, or the four E's: Efficiency, Environment, Effectiveness and Economy.

The 2045 LRTP's goals and objectives were updated to reflect the interests and views of the citizens, while continuing the previously set goals in the Island's 2040 LRTP and following modern planning trends and requirements. These updated goals and objectives also emphasize the imperative to adapt to climate change, and the capability of the transportation infrastructure to withstand extreme weather events.

Several open houses and interactive technical workshops were held as part of the required public involvement (the public involvement process is detailed in Chapter 4), which ensured that decisions were made considering the public insight. The Island's 2045 LRTP goals and objectives were presented in interactive materials, informational boards and surveys for the citizens, municipalities and advisory committees to assess the priorities of each group and to all them to propose changes. The results supported a project rating methodology towards future investment in transportation infrastructure.

Table 3.1 presents the resulting updated goals and objectives that guided the development of the 2045 LRTP. All goals and objectives play a specific role in fulfilling the vision's intent and complement each other. These goals and their supporting objectives are clearly described, along with narrative to amplify their meaning.

Table 3.1: 2045 LRTP's Goals and Objectives

Focus	Goal	Objectives	
Efficiency	**GOAL A: To Improve Transportation System's Performance** Manage the Island's transportation facilities and services in a proactive and efficient manner to enable better economic development, maximizing the use of available assets and concentrating in safety and security.	1	Ease traffic delays and travel time through accurate congestion management programs.
		2	Optimize the use of available transportation assets and develop a better investment management structure to balance the efficiency of prior investments.
		3	Use available resources to preserve transportation assets in state of good repair.
		4	Develop strategies to deal with the cost of managing and operating the Island's transportation systems.
		5	Improve transportation system's safety and security and its ability to provide support when emergencies occur.
Environment	**GOAL B: Focus on the environment's sustainable development** Incorporate a careful and responsible environmental management to harmonize the need of a clean environment, social justice and a well-functioning economy.	1	To promote transportation infrastructure that preserves balanced ecosystems minimizing adverse impacts to the Island's natural environments.
		2	Reduce greenhouse gas emissions, energy consumption, and carbon footprint emittance; promote "smart growth", livable communities and improve air quality.
		3	Support integrated transportation and land use planning to achieve livable communities, less motorized vehicle dependency and enhance alternative modes of transportation.
		4	Improve alternative modes of transportation and travel demand strategies.
		5	Reduce transportation infrastructure's vulnerability for it to withstand extreme weather events for resilient infrastructure.
Effectiveness	**GOAL C: Improve transportation mobility and access for the people and for goods** Achieve better mobility and access for all the transportation system users; provide more travel choices, integration between modes and connections between major population centers.	1	Improve connectivity between the Island's fundamental activity Regions, such as, but not limited to employment centers, touristic areas, and dense residential districts.
		2	Concentrate efforts in enhancing the connectivity of the Island's available modes of transportation.
		3	Facilitate mobility to residents, visitors and workers in the Island by increasing the availability of travel choices.
		4	Invest in areas where users get the most benefit.
		5	Facilitate the access of transportation to elderly population, people with disabilities, or economic disadvantaged communities.
Economy	**GOAL D: Reinforce Economic Vitality**	1	Facilitate the efficient movement of freight, business and tourism activities to achieve economic competitiveness.

	Procure the sustainment of livable and viable communities by encouraging economic strength, economic competitiveness and the flexibility to withstand economic difficulties.	2	Encourage potential public-private collaborations.
		3	Focus in providing commercial connectivity throughout the Island.

Source: SDG/PRHTA

Goal A: To Improve Transportation System's Performance

Description

Manage the Island's transportation facilities and services in a proactive and efficient manner to enable better economic development, maximizing the use of available assets and concentrating in safety and security.

Supporting Objectives

Objective A.1: Ease traffic obstruction delays and travel time through accurate congestion management programs:

Assess congestion management needs by using objective criteria, analysis and evaluation on a small scale to improve intersections and transit access; and on a larger scale to address system bottlenecks.

Objective A.2: Optimize the use of available transportation assets and develop a better investment management structure to balance the efficiency of prior investments:

Concentrate investment to achieve a better use of existing significant infrastructure, increase available street's capabilities and corridor person capacity, in a cost-effective manner.

Objective A.3: Use available resources to preserve transportation assets in state of good repair:

Allow investment and available economic resources to preserve and rehabilitate existing transportation infrastructure in good service condition to extend its life and provide a safe and secure operating environment for users.

Objective A.4: Develop strategies to deal with the cost of managing and operating the Island's transportation systems:

Increase the possibility of (1) achieving better project definition; (2) targeting priority projects; and (3) maximize benefits in relation to costs, by utilizing infrastructure inventories, asset management plans and congestion management network data files.

Objective A.5: Improve transportation system's safety and security and its ability to provide support when emergencies occur:

Provide investment to promote safe-secure transportation facilities, better services before and after emergencies, resilience-redundancy capabilities to resist or assist during extreme climatic events, incidents and system blockage.

Goal B: Focus on the Environment's Sustainable Development

Description

Incorporate a careful and responsible environmental management to harmonize the need of a clean environment, social justice and a well-functioning economy.

Supporting Objectives

Objective B.1: To promote a transportation infrastructure that preserves balanced ecosystems minimizing adverse impacts to the Island's natural environments:

Develop transportation related solutions focused in minimizing adverse impact to the natural environments, including better use of existing infrastructure.

Objective B.2: Reduce greenhouse gas emissions, energy consumption, and carbon footprint emittance; promote "smart growth", livable communities and improve air quality:

Pursue projects and programs that reduce reliance on motorized travel and better manage vehicle congestion; promote the use of energy efficient products and more "reduce, reuse, recycle" practices in infrastructure projects.

Objective B.3: Support integrated transportation and land use planning to achieve livable communities, less motorized vehicle dependency and enhance alternative modes of transportation:

Invest in the redevelopment of Traditional Urban Centers, with higher population density, to facilitate access to alternative modes of transportation and make them pedestrian/transit friendly. Intensify interagency coordination to focus on better land use, travel efficiency and easier access to businesses.

Objective B.4: Improve alternative modes of transportation and travel demand strategies:

Use Congestion Management Programs or transportation network analysis to manage travel demands and improve the coverage, capacity and service of alternative modes of transportation.

Objective B.5: Reduce transportation infrastructure's vulnerability for it to withstand extreme weather events through a resilient and reliable infrastructure:

Develop plans and design/reconstruction approaches to reduce the chance that transportation infrastructure gets damaged during hurricanes or severe weather events, through focusing primarily on resiliency and redundancy. Meet the needs of the citizens by enabling emergency services and the flow of goods in the event of any extreme climate conditions.

Goal C: Improve Transportation Mobility and Access for the People and for Goods

Description

Achieve better mobility and access for all the transportation system users; provide more travel choices, integration between modes and connections between major population centers.

Supporting Objectives

Objective C.1: Improve connectivity between the Island's fundamental activity Regions, such as, but not limited to employment centers, touristic areas, and dense residential districts:

Address the Island's most important transportation corridors, their infrastructure and surroundings, and help serve numerous travel demand markets such as commercial centers, employment areas, dense housing districts, education facilities, airports, seaports, industrial and distribution districts and tourism hubs.

Objective C.2: Concentrate efforts in enhancing the connectivity of the Island's available modes of transportation:

Improve connectivity and continuity of the Island's transportation networks, establish links for easier movement from a non-motorized transportation area to a motorized area; promote use of the bicycle not only for recreational activities, but as part of the transportation chain. Facilitate connections between pedestrian and/or bicycle establishments and transit.

Objective C.3: Facilitate mobility to residents, visitors and workers in the Island by increasing the availability of travel choices:

Focus in promoting the use of non-vehicular modes of transportation, improving designated facilities, their connections and their capability to function as a dependent way to address citizens' needs.

Objective C.4: Invest in areas where users get the most benefit:

Investment will be directed taking first into account the citizens' traveling tendencies and needs.

Objective C.5: Facilitate the access of transportation to elderly population, people with disabilities, or economic disadvantaged communities:

The 2045 LRTP will continue to provide mobility for citizens with imminent needs such as, but no limited to people with functional diversity, the elderly, those with no accesso to a private vehicle and/or with income limitations.

Goal D: Reinforce Economic Vitality

Description

Procure the sustainment of livable and viable communities by encouraging economic strength, economic competitiveness and the flexibility to withstand economic difficulties.

Supporting Objectives

Objective D.1: Facilitate the efficient movement of freight, business and tourism activities to achieve economic competitiveness:

Analyze the Island's principal freight corridors and travel tendencies to manage traffic congestion and improve the efficiency of deliveries and goods movement.

Objective D.2: Encourage potential public-private collaborations:

Consider private sector collaborations when appropriate to work as a partner with the public sector in successful project implementation, investment effectiveness and achieve costs-effective of capital and operating expenditures.

Objective D.3: Focus in providing commercial connectivity through the Island:

Invest in the completion of projects that facilitate connections to airports, seaports, distribution areas, and commercial/industrial districts. Improve effectiveness of the commercial distribution process through the Island. Invest in completing the Island's strategic highway network.

PLANNING FACTORS

The Fixing America's Surface Transportation Act, also known as the FAST-Act, was signed into law in December 2015 and replaces the previous Moving Ahead for Progress in the 21st Century Act (MAP-21). This legislation, like its predecessor, outlines the requirements for the transportation planning process, including the compliance with planning factors. Although planning factors have been part of previous highway legislation, the FAST-Act added some factors, for a total of ten planning factors, two more than the previously stated by MAP-21. Key transportation planning factors of the FAST-Act are, resiliency and reliability, the mitigation of storm water impacts and the enhancing of travel and tourism.

Planning factors identify the most important aspects of the transportation development. All projects, strategies, goals and objectives considered in developing the 2045 LRTP were designed to meet the FAST-Act required planning factors. Taking this into account, the ten identified factors in this legislation were considered when analyzing the Island's economic development patterns, the path to achieve a more efficient use of the transportation system and resilience capabilities and the possible strategies to attend congestion issues, improve safety and mobility. The 2045 LRTP goals and objectives considered the planning factors. The FAST-Act is the authorizing legislation in the development of Puerto Rico's 2045 LRTP. Table 3.2 summarizes how the Island's 2045 LRTP goals and objectives will meet the planning factors as required by the referred legislation. All planning factors where adequately considered by relating them to two or more goals/objectives. These key objectives will determine the priority of the projects included in the plan's financial analysis and help secure the proposed investment on the short, mid and long-term compliance with the FAST-Act Planning Factors.

Table 3.2: Relation between Planning Factors and 2045 LRTP Goals

	Planning Factors	2045 LRTP Goals related to Planning Factor
1	Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency.	Goal A: considers traffic congestion reduction, optimize use of assets and use of resources and existing infrastructure while dealing with efficient cost management. Goal C: considers improving and enhancing connectivity, increase travel choices, and invest in higher cost/benefit initiatives. Goal D: considers improving economic competitiveness thru movement, private investment in infrastructure and improving commercial connectivity.
2	Increase the safety of the transportation system for motorized and nonmotorized users.	Goal A: considers state of good repair maintenance and improving safety. Goal B: considers integrated transportation and land use planning to achieve enhance alternative modes of transportation. Goal C: considers improving access to elderly population, people with disabilities.
3	Increase the security of the transportation system for motorized and nonmotorized users.	Goal A: considers state of good repair maintenance and improving security. Goal B: considers integrated transportation and land use planning to achieve livable communities. Goal C: considers improving access to activity centers, improving and increasing people movement populating the streets.
4	Increase the accessibility and mobility of people and freight.	Goal A: considers managing the Island's transportation facilities and services. Goal B: considers developing transportation related solutions by better use of existing infrastructure. Goal C: considers better mobility and access for all the transportation system users. Goal D: considers facilitating efficient movement of freight, business and tourism activities.
5	Protect and enhance the environment, promote energy conservation, improve the quality of life, and promote consistency between transportation improvements and state and local planned growth and economic development patterns.	Goal A: considers extending its life and provide a safe and secure operating environment for users. Goal B: considers incorporating a careful and responsible environmental management to harmonize the need of a clean environment, social justice and a well-functioning economy. Goal C: considers better mobility and access for all the transportation system users; provide more travel choices, integration between modes and connections between major population centers. Goal D: considers sustainment of livable and viable communities by encouraging economic strength, economic competitiveness and the flexibility to withstand economic difficulties.
6	Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight.	Goal B: considers projects and programs that reduce reliance on motorized travel and better manage vehicle congestion; promote the use of energy efficient products and more "reduce, reuse, recycle" practices in infrastructure projects and improve alternative modes of transportation and travel demand strategies. Goal C: considers improving and enhancing connectivity, increase travel choices, and invest in higher cost/benefit initiatives. Goal D: considers providing commercial connectivity Island-wide.
7	Promote efficient system management and operation.	Goal A: considers managing the Island's transportation facilities and services in a proactive and efficient manner to enable better economic development, maximizing the use of available assets and concentrating in safety and security. Goal B: considers applying Congestion Management Programs or transportation network analysis to manage travel demands and improve the coverage, capacity and service of alternative modes of transportation. Goal C: considers addressing the Island's most important transportation corridors, their infrastructure and surrounding developments. Goal D: considers investing in the completion of projects that facilitate commercial connections.
8	Emphasize the preservation of the existing transportation system.	Goal A: considers optimizing the use of available transportation assets and preservation of these assets. Goal D: considers congestion management on the Island's main freight network.
9	Improve the resiliency and reliability of the transportation system and reduce or mitigate storm water impacts of surface transportation.	Goal A: considers investment to promote better services before and after emergencies, resilience-redundancy capabilities to resist or assist during extreme climatic events, incidents and system blockage. Goal B: considers reducing transportation infrastructure's vulnerability for it to withstand extreme weather events for a resilience and reliable infrastructure.
10	Enhance travel and tourism.	Goal A: considers traffic congestion reduction, optimize use of assets and use of resources and existing infrastructure while dealing with efficient cost management. Goal C: considers facilitating mobility to visitors in the Island by increasing the availability of travel choices. Goal D: considers facilitating the efficient movement of tourism activities to achieve economic competitiveness.

Source: SDG and PRHTA

STRATEGIC APPROACH TO TRANSPORTATION PLANNING IN PUERTO RICO

The envisioned planning approach for the updated 2045 LRTP focuses on enhancing the quality of life through management of assets, environmental and social justice, improved accessibility and better economic development. This section presents the strategies needed to address transportation planning in Puerto Rico considering:

- Transit;
- Traffic;
- Non-motorized modes;
- Freight; and
- Resiliency.

Strategies for Transit in Puerto Rico

Transit has an important role, specifically as an alternative mode reducing congestion and pollution. As mentioned in Chapter 2, there is a tendency showing local population is aging which presents the need to increase accessible transit services widely Island-wide to provide alternatives to those with no access to private vehicle or who cannot drive (including the elderly, the young and people with disabilities). It is important to make transit a more available, attractive and competitive alternative to the private automobile. Also, there is a need to maintain transit assets in state of good repair as required by Transit Management Plans (TrAM[43]). Therefore, the LRTP has set out the following strategies:

Provide New Inter-Regional Express Transit Services

Rehabilitate, expand, and develop the transit system through the development of an inter-regional express transit service. This service will provide connections between major destinations within and between the Regions resulting in an Island wide transit network.

This service should be associated with mix-use developments. It would be important to support this service with incentives to encourage walking and the use of transit throughout community and land use planning from a local, regional and national perspective. This service will not be successful in isolation. It would require municipal-level local bus feeder services that would provide users with comprehensive transit networks beyond the main corridors. Such a network of services would be a competitive alternative to motor vehicles by providing access between major residential areas or municipal centers to major destinations including work, educational and service areas.

Another key element that would allow a successful new service is the use of exclusive transit managed lanes. For example, a contraflow bus lane along main corridors, would allow buses to avoid traffic congestion which can improve reliability of road transit services. Another example is allowing transit services use to managed lanes such as the dynamic toll lanes (DTL) along tolled roads within the highway system.

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[43] Transit Asset Management Plan, the official acronym is TAMP, but is the same acronym as the Transportation Asset Management Plan (TAMP), so in this report the term TrAM is used for the Transit Asset Management Plan to distinguish between both Plans.

Provide Enhanced and Improved Local Transit Service

As previously mentioned, support from local transit services is required for the support inter-regional services. As stated early in Chapter 2, Públicos have experienced a significant drop in ridership, routes and trips. A trend that is expected to continue in the absence of policies and programs aimed at stabilizing the services. The municipalities have been increasing their offering of transit services due to the needs of their communities in response to the reduction of Público services. As a result, ridership on municipal services has been increasing. Municipal services operations are paid by the municipalities and tend to be free of charge. The lack of fares possesses challenges to the services' coverage areas and long-term funding. As a result, it is important to provide recommendations about how to strengthen and support these services.

The integration of both Municipal and Públicos to the transit network system could be a practical alternative for many reasons including better use of resources, economic development alternatives and cost-effectiveness. Municipal and Públicos drivers in some municipalities have already entered into agreements. Agreements could include provisions such as:

1. Provide drivers with an economic incentive suitable for the specific route to ensure minimum income levels;
2. Stablish the service requirements including vehicles/drivers available to a particular route, fares, standards of service and frequencies;
3. Provide savings in mechanical and maintenance service consolidation; and
4. Define the required improvements for vehicles and costs of the responsible parties.

Transit Asset Management Plan

In 2016, the Federal Transit Administration (FTA), established a requirement for all public transportation providers that receive federal transit assistance to develop a TrAMP. According to 49 CFR Section 625.5, transit asset management is:

> "the strategic and systematic practice of procuring, operating, inspecting, maintaining, rehabilitating, and replacing transit capital assets to manage their performance, risks, and costs over their life cycles, for the purpose of providing safe, cost-effective, and reliable public transportation".

The goals and objectives defined by the LRTP must be followed by strategies that will help achieve a State of Good Repair (SGR) established by the TAM. The Final Rule for the TAM requires transit providers to collect and use asset condition data, set targets, and develop strategies to prioritize investments to meet their goals. The PRHTA will serve as the sponsor for the group plan that will include, the 78 municipalities and the Metropolitan Bus Authority (MBA). The Maritime Transport Authority (MTA) and the Tren Urbano will have their individual TAM under the PRHTA.

Following the principles of Performance-Based Planning for management of transit assets, systems and networks must be part of the planning and management process for the PRHTA. Performance Measures and Targets must be implemented to help analyze and improve the decision-making process for the transit systems. The Performance Measures and Targets for the TAM are divided into four categories of transit assets: rolling stock, facilities, infrastructure and equipment. The performance measures on Table 3.3 are based on FTA regulations.

Table 3.3: TAM Performance Measures

Type of Assets	Performance Measure
Rolling Stock	% of revenue vehicles that exceeded the Useful Life Benchmark (ULB).
	% of non-revenue vehicles that exceeded the Useful Life Benchmark (ULB).
Facilities	The percentage of facilities (by group) that are rated less than 3.0 on the Transit Economic Requirements Model (TERM) Scale.
	The percentage of track segments (by mode) that have performance restrictions. Track segments are measured to the nearest 0.01 of a mile.

Source: TAM Performance Measures Fact Sheet
https://www.transit.dot.gov/TAM/FTAOutreachMaterials/perfmsrFS

As part of the Final Rule for the TAM, PRHTA established performance targets for these performance measures. The targets were developed using data from capital assets that was collected from transit operators (26 municipalities and 3 agencies in total). Each inventory was analyzed and validated to determine the performance measure for each type of asset. The targets developed are shown in the Table 3.4:

Table 3.4: Targets for PR TAM

PRHTA Group Plan				
	Fleet Size	**FTA Default ULB**	**FY18 Base**	**FY19 Targets**
Asset-Rolling Stock				
Articulated Bus (AB)	2	14	0%	0%
Bus (BU)	184	14	9%	10%
Cutaway bus (CU)	100	10	6%	6%
Minibus (MB)	33	10	27%	14%
Minivan (MV)	2	8	0%	0%
Trolleybus (TB)	16	13	44%	44%
Van (Van)	80	8	39%	27%
Automobile (AO)	25	8	0%	0%
Asset-Equipment				
Automobile (AO)	40	8	53%	53%
Truck and other rubber vehicles	20	14	45%	45%
Maritime Transit Authority				
Asset Rolling Stock				
Ferryboat (FB)	14	41	0%	0%
ATI-TU				
Asset Rolling Stock				
Heavy Rail Passenger Car (HR)	74	31	0%	0%
Asset-Equipment				
Automobile (AO)	32	8	28%	34%
Trucks and other rubber vehicles	14	14	64%	56%
Asset-Facilities				
	Facilities	**TERM Scale (below 3)**	**FY18 Base**	**FY19 Targets**

Passenger/Parking	16	3	0%	0%
Administrative/Maintenance	2	3	0%	0%
Asset-Infrastructure				
	Track Segments	**FY18 Base**	**FY19 Targets**	
Rail Fixed Guideway-Performance Restriction	262	1.65%	5%	

Source: PRHTA

The performance measures and targets will become part of the planning process in the programming documents of the PRHTA, including the TIP and STIP. The future updates of the performance targets will be included in the TIP/STIP documents.

Strategies for the Puerto Rico Roadway Network

The strategies for the Puerto Rico roadway network aim to improve and maintain roadways and bridges in the Island. Since most of the road network is in need of preservation and improvements; the costs to repair these may be beyond the capacity of the government making this strategy very important considering all transportation modes depends on a safe and efficient roadway network that allows mobility.

To accomplish that, it is necessary to follow the strategies described below.

Improve, Rehabilitate and Preserve Existing Roadways

The PRHTA has developed a Transportation Asset Management Plan (TAMP) aiming to accomplish a systematic process of operating, preserving, and improving physical assets. Specifically, the plan seeks to rehabilitate pavements conditions and bridges to get the infrastructure to a state of good repair. As a federal requirement the NHS cannot have more that 5% of the pavement in a poor condition. That represents a challenge that needs to be addressed given that in 2016 the 16.2% of NHS pavement was estimated to be in poor condition. In the case of bridges, the target is of no more than 10% of the bridges on the NHS be in poor condition.

The objectives established to guide the TAMP are[44]:

1. "Improve and implement a comprehensive pavement management process that allow to achieve the condition targets while managing pavements with effective life-cycle strategies;
2. Improve and implement a comprehensive bridge management process to achieve and sustain a state of good repair, reduce life-cycle costs, and capitalize on effective preservation strategies;
3. In partnership with the MPO integrate effective asset management projects into the Transportation Improvement Program (TIP); and
4. Implement long-term pavement and bridge programs and strategies to address safety and achieve and sustain a state of good repair".

In order to meet the objectives, it will be necessary to:

[44] Initial Transportation Asset Management Plan, April 2018; PRHTA.

1. "Focus on achieving bridge and pavement conditions targets;
2. Invest more in preserving assets in good condition and avoid higher future costs;
3. Continue to replace deteriorated pavements and bridges that are too damaged to benefit from preservation;
4. Rely on documented processes to select projects and treatment strategies that reduce life-cycle costs;
5. Develop a better data on the conditions of pavements and bridges, particularly to identify those assets that can benefit from preservation;
6. Use modern bridge and pavement computer models to estimate needed investment levels and select projects, and;
7. Improve bridge and pavement conditions and then sustain them in a state of good repair[45]".

Enhance the Strategic Roadway Network and Other Key Roadways

As part of continuing enhancement of the strategic road network on the Island, it is important to identify projects that will promote economic development and reduce congestion. This continuing enhancement is especially important because this network connects much of the Island with a high-capacity and high-speed expressway. There are several priority roadway projects that are aligned with the PRHTA strategy to promote economic development and reduce congestion (Appendix J includes the list of Illustrative projects).

A project under development is the DTL between Caguas and San Juan to alleviate congestion levels on the road and provide access to a Bus Rapid Transit (BRT) system.

Public-private partnerships, also known as P3s; an alternative source of federal funding (competitive or loans), will represent the alternative solution mostly for large scale, complex projects such as the following in Puerto Rico:

- PR-5 Extension Toa Alta – Bayamón; and
- Congestion relieve projects on grade separated intersections (flyovers).

Within the Other UZAs and the Aguadilla TMA there are some projects such as the completion of PR-53 and PR-10, the extension of PR-22 to Aguadilla and improvements to PR-2 from Aguadilla to Mayagüez; which are key network enhancement projects constantly mention within the consultation process.

Strategies for Non-Motorized Modes

The strategy for Non-motorized modes aims to develop a multi-modal transportation system that integrates all transportation modes to improve mobility and access conditions and to create a more livable urban environment and a more efficient transportation system. To accomplish this, it is necessary to follow the strategies described below.

Comply with the Puerto Rico Complete Streets Plan and Design Guidelines

In September 2018, the MPO adopted the Puerto Rico Complete Streets Plan and Design Guidelines . The Complete Street are defined "as those designed to allow safe, comfortable

[45] Initial Transportation Asset Management Plan, April 2018; PRHTA.

and convenient access for pedestrians, cyclists, drivers, and public transport users, regardless of age, abilities or capacities". "Also, a complete street implies that mobility in all its forms, is safe, it has the infrastructure to make travel enjoyable, is aesthetically pleasing and promotes the social and economic exchange"[46]. This document considers the Americans with Disabilities Act (ADA) legislation which defines the responsibilities of, and requirements for, transportation providers to make transportation accessible to individuals with disabilities. This document makes part of this LRTP as Appendix D.

The main objectives of this plan and design guidelines are:

1. "Guide state and local efforts to improve access and mobility conditions and develop new facilities to improve the quality of life of our communities;
2. Improve and/or provide pedestrian and bicycle access to the transit system and the public space; and
3. Provide safe and "affordable access for people of all ages and abilities[47]".

The strategy of this Plan makes part of the strategies for non-motorized modes of this 2045 LRTP; which includes:

1. Updating decision-making processes;
2. Modifying approaches for measuring performance;
3. Types of complete streets measures – align with goals above;
4. Incorporating complete streets into the development process;
5. Providing ongoing community, stakeholders/institutional and professional education and training;
6. Internal and external communication and collaboration; and
7. Implementation of Plan through "project delivery, design and funding*"[48]*.

Comply with the Comprehensive Bicycle and Pedestrian Plan

In September 2018, the MPO adopted the Comprehensive Bicycle and Pedestrian Plan for Puerto Rico. The Plan "aims to make bicycling and walking safe, accessible and integrated transportation choices for residents and visitors"[49].

The main objectives of this plan are:

1. "Promote and increase the use of cycling and walking as alternative modes of transportation;
2. Enable the physical integration of urban centers through a cycling and pedestrian network that improves accessibility to different land uses;
3. Incorporate the development of projects and bicycle/pedestrian facilities into statewide and municipal transportation plans;

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[46] Puerto Rico Complete Streets Plan and Design Guidelines, Final Document; September 2018; PRHTA.

[47] Puerto Rico Complete Streets Plan and Design Guidelines, Final Document; September 2018; PRHTA.

[48] Puerto Rico Complete Streets Plan and Design Guidelines, Final Document; September 2018; PRHTA.

[49] Comprehensive Bicycle and Pedestrian Plan for Puerto Rico Final Document, September 2018; PRHTA.

4. Provide cycling and walking infrastructure to improve mobility, accessibility, and safety for all users of public roads; and
5. Develop and educational program for all users to share the public roads in a safe manner"[50].

The strategies of this Plan make part of the strategies for non-motorized modes of this 2045 LRTP; this includes:

1. "Identification of improvements for pedestrian and bicycle facilities;
2. Set up a timeframe to accomplish the improvements;
3. Development of a monitoring and evaluation process; and
4. Identification of many sources of grant funding available to advance walking and cycling"[51].

Strategies for Freight

Complete and Enhance Freight Network

The access route for the seaports and airports within the Region and Island-wide is the main highway network. This network provides the key connection between these facilities with the rest of the Region being important for the cargo movements and economic development.

As discussed with various stakeholders of cargo movement within the Island, there is a need to consider the addition of some main roads to the freight network. These are mainly roads providing access to/from ports and distribution centers to the strategic highway network.

Another important aspect is to continue considering strategies to reduce congestion on the strategic highway network. It is a key element within the Congestion Management Plan, which has the following objectives:

- "Monitor and evaluate performance of multimodal transportation system;
- Identify the causes of congestion;
- Identify and evaluate alternative actions that provide information supporting the implementation of actions; and
- Evaluate the efficiency and effectiveness of implemented actions"[52].

As part of this strategy, freight interventions should seek to incorporate, as possible, recommendations such as, bottleneck and capacity improvements and travel demand management that will enhance access between freight facilities and distribution centers.

Strategies for Resilience

Due to its geographical location, Puerto Rico is highly exposed to extreme weather events such as, tropical storms and hurricanes passing near or thru the Island every year usually between July and November. This exposure to heavy rains, high speed winds and storm surge, causes

[50] Comprehensive Bicycle and Pedestrian Plan for Puerto Rico Final Document, September 2018; PRHTA.

[51] Comprehensive Bicycle and Pedestrian Plan for Puerto Rico Final Document, September 2018; PRHTA.

[52] Congestion Management Progress Report, October 2012; PRHTA.

landslides and flooding which effects the transportation infrastructure (as proven by the recent severe damages from Hurricane María). It is very important to develop a transportation system able to “anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions”[53].

Damages to the transportation resulted in the isolation of communities that in many cases limited their ability to obtain supplies and services in the recovery phase after the hurricane in an efficient and timely manner. Therefore, incorporation of resilience and vulnerability of infrastructure systems into planning is paramount.

Vulnerability Assessment

In order to incorporate actions into decision making process, it is key to understand the existing transportation infrastructure’s vulnerabilities. Such an understanding would serve as basis for developing the resiliency strategy as stated by the FHWA framework: “assessing and addressing vulnerabilities allows agencies to build their resilience, or the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions”[54].

For the first time the LRTP incorporates a vulnerability assessment. This assessment was mainly triggered by the effects of Hurricane María on the transportation infrastructure. The assessment is focused in hurricane-related hazards (refer to Chapter 6).

A more comprehensive analysis should be completed not only considering flooding and landslides but also earthquakes given the possibilities of tectonic events in the Island. Additionally, analysis of design and construction elements that will make for a more resilient transportation infrastructure is recommended.

[53] FHWA’s Vulnerability Assessment and Adaptation Framework, 3rd Edition, December 2017.

[54] FHWA’s Vulnerability Assessment and Adaptation Framework, 3rd Edition, December 2017.

4 CHAPTER 4 PLANNING PROCESS, PUBLIC INVOLVEMENT, AND NEEDS ASSESSMENT FOR THE 2045 PLAN

The 2045 LRTP, involves that urbanized areas in the Region should carry out a continuing, cooperative, and comprehensive performance-based multimodal transportation planning process. The Plan 2045 document is the result of this complex process of identifying priorities for investment in surface transportation that will lead toward the economic development and mobility of the metropolitan area in the short term and at least 20 years horizon in the future (27 in this case). This chapter presents the methodology and how this process and framework was developed leading to define the criteria to identify project priorities including needs assessment toward the 2045 LRTP. This chapter is divided into 3 sections:

1. Description of the Planning Process;
2. Description of the Public Involvement Process; and
3. How to evaluate Infrastructure's Needs Assessment: Model Development and Calibration And overview of the technical approach.

PLANNING PROCESS

The planning process incorporated the following steps as an analytical framework toward a comprehensive process for the implementation of the 2045 LRTP considering continuing elements from the previous 2040 Plan:

1. Reviewing the plan's vision;
2. Clarifying the plan's vision by redefining goals and objectives;
3. Infrastructure needs assessment based on a travel demand model analysis and public involvement;
4. Develop a financial resources analysis; and
5. Set project options and cost-feasible plans.

The first two steps have already been discussed in this document Chapter 3 and Chapter 3. The financial analysis and project options will be discussed in 5 and Chapter 6.
As shown in Figure 1.1, all steps were approached through an analytical process that considered the public involvement requirements and continuous coordination with the

Island's MPO. The following sections provide detailed information on this involvement process.

PUBLIC INVOLVEMENT PROCESS

Public participation is an important aspect of any planning process. It is an integral part of the transportation system's improvement by helping to ensure that decisions are made in consideration to and for the benefit of the public needs and preferences. This public input helps agencies to: (1) make better informed decisions through collaboration, (2) build mutual understanding and trust between agencies and citizens.

Gathering this collaborative information, as part of the MPO's planning process, requires obtaining a broad insight from the public, professional and civic organizations, private companies and key governmental stakeholders. It is compulsory to consider all sectors for a final determination, especially those traditionally underserved by existing transportation systems, such as low-income and minority households.

The 2045 LRTP public involvement plan (PIP) was developed early in the process and was developed into a PIP report (complete version included in Appendix E).

The vision goals and objectives of the PIP are:

Vision: Involve and enable agencies, the interested parties and the community to provide meaningful input to the LRTP.

Goals

- Consult with the public and stakeholders to gather their ideas for solutions to the LRTP; and
- Inform and involve the public throughout the planning process.

Objectives

- Develop an effective, and proactive participation process that includes agencies, stakeholders, interested parties[55] and the public;
- Create communication channels with the public to encourage public participation and obtain input;
- Use of innovative tools and media to inform the public of upcoming planning activities; and
- Encourage the participation of minority and low-income populations in the LRTP development process.

Target Audience

While the communications thru digital and written media seeks to involve residents across the Island, targeted efforts were made to engage a wider group of stakeholders. Figure 4.1 illustrates the defined committees involved in the process.

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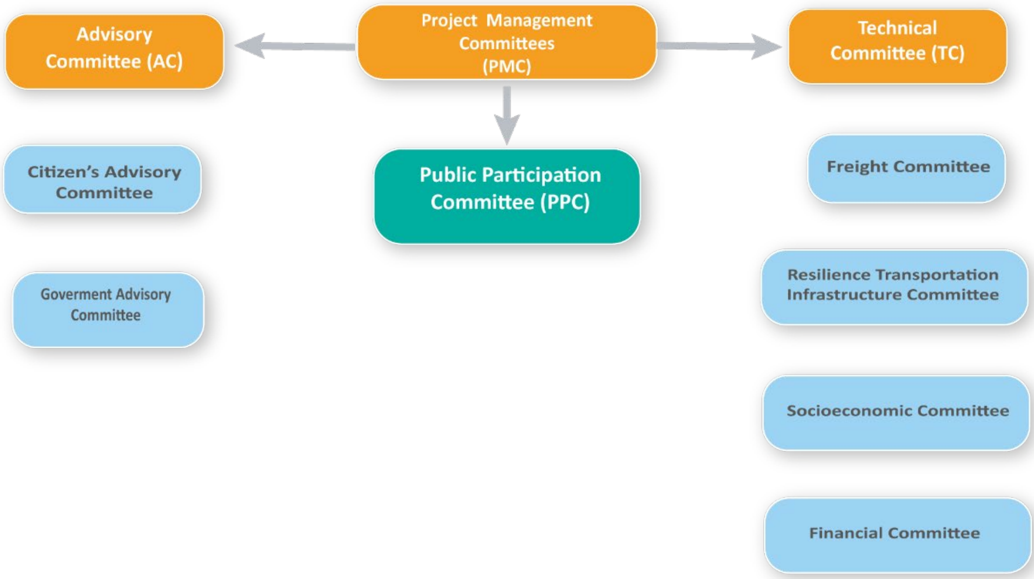
[55] The FAST-Act explicitly adds public ports and certain private providers of transportation, including intercity bus operators and employer-based commuting programs to the list of interested parties that an MPO must provide with reasonable opportunity to comment on the transportation plan.

Figure 4.1: LRTP Committees



Source: SDG

Committees were designated to ensure the participation of key stakeholders and as an outreach effort to capture the impressions and needs from elderly population, persons with physical disabilities, low income communities, academia and professional organizations, as well as freight mobility, technical advice, and vulnerability analysis through the Resilience committee. Meeting with the defined committees and the MPO were held regularly to inform progress and gather insight during the planning process. Open houses were organized to engage the public in the LRTP planning process throughout the Island.

Open Houses

While all aspects of community engagement and outreach are important, nothing can replace an open community forum where individuals can come and hear information about the study process and provide input regarding their specific needs and concerns. Two rounds of open houses were held to inform and received input from public. The first round took place during December 2017, and the second one between March and April 2018. Each open house round had a specific purpose.

First Round

The first round of open houses served as an educational process where citizens received information about the LRTP and provided input about their mobility needs. Considering Hurricane María had recently affected Puerto Rico's transportation infrastructure three months earlier, these open houses focused on gathering input on how this situation changed people's trips and which areas were most affected by the storm. For the same reason, the location of these open houses where at places attracting many people such as the CESCOs, transit hubs and universities to facilitate participation of a varied demographic. A total of 566 participants were registered in 11 locations. The locations and number of participants at each open house is shown in Figure 4.3.

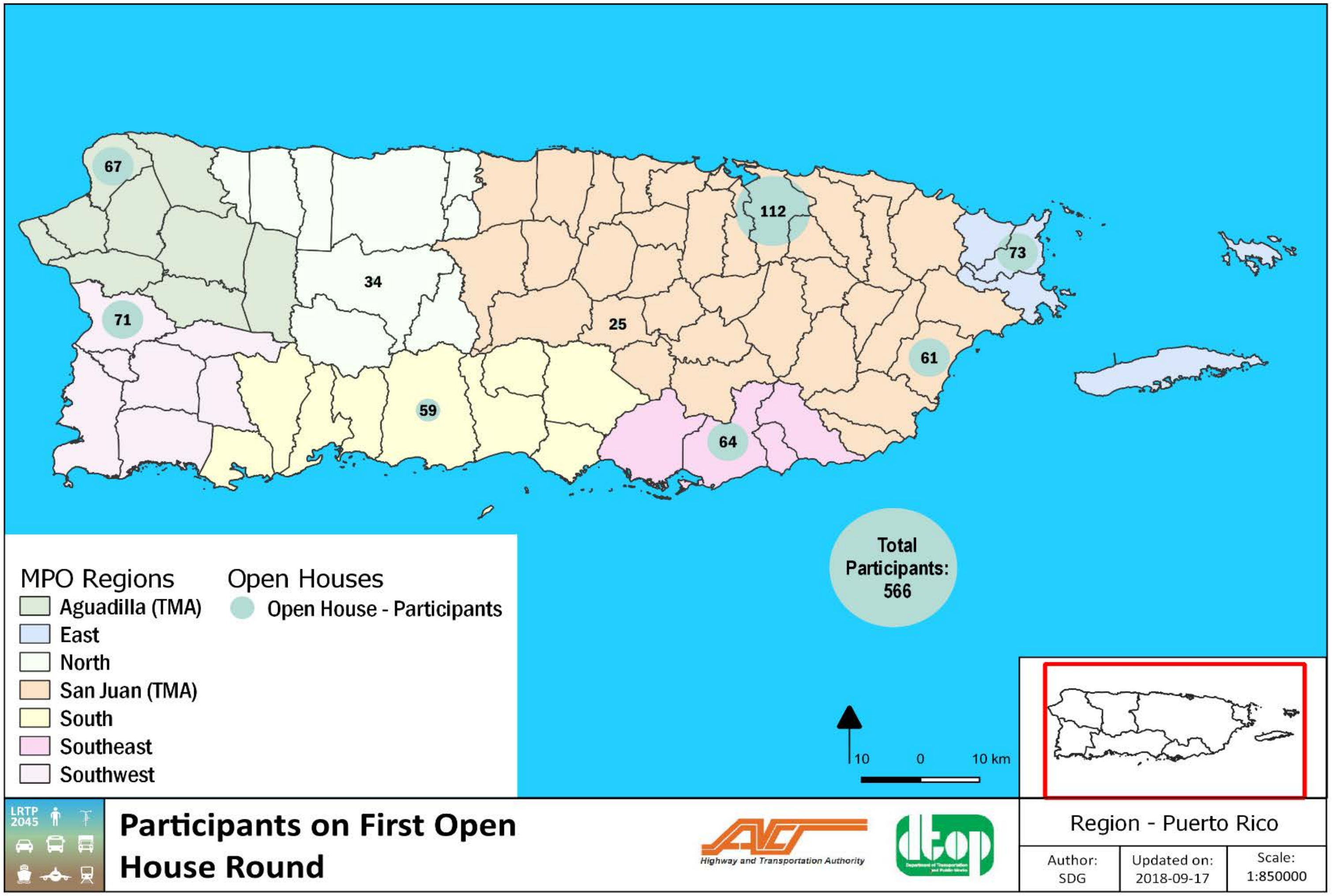
Figure 4.2: Open House – San Juan TMA (Humacao)

Source: SDG

These open houses had two main stations: one informative and the other interactive. The objective was to give the participants a way to receive information about the plan and to provide information regarding their needs and concerns about transportation issues. The structure allowed participants to interact by their own interest and time.

The informative stations had the general objective of informing participants about the development of a Long-Range transportation plan and to fulfill the public involvement requirements. An example is shown in and Figure 4.4.

Figure 4.3: Total participation First Round Open Houses



Source: SDG

Figure 4.4: Informative Boards

Source: SDG

The interactive stations had the objective of gathering information about participants' transportation needs and concerns. Participants provided their input through questionnaires, boards and maps. Through the questionnaire, participants had the opportunity to indicate their mobility needs, and transportation infrastructure effected by Hurricane María. Citizens were asked if changes were made to their regular trips because of the effects of this atmospheric event. Additionally, people had the opportunity to identify areas were the transportation infrastructure was significantly affected by the hurricane through an interactive map. For a complete report of results see Appendix E.

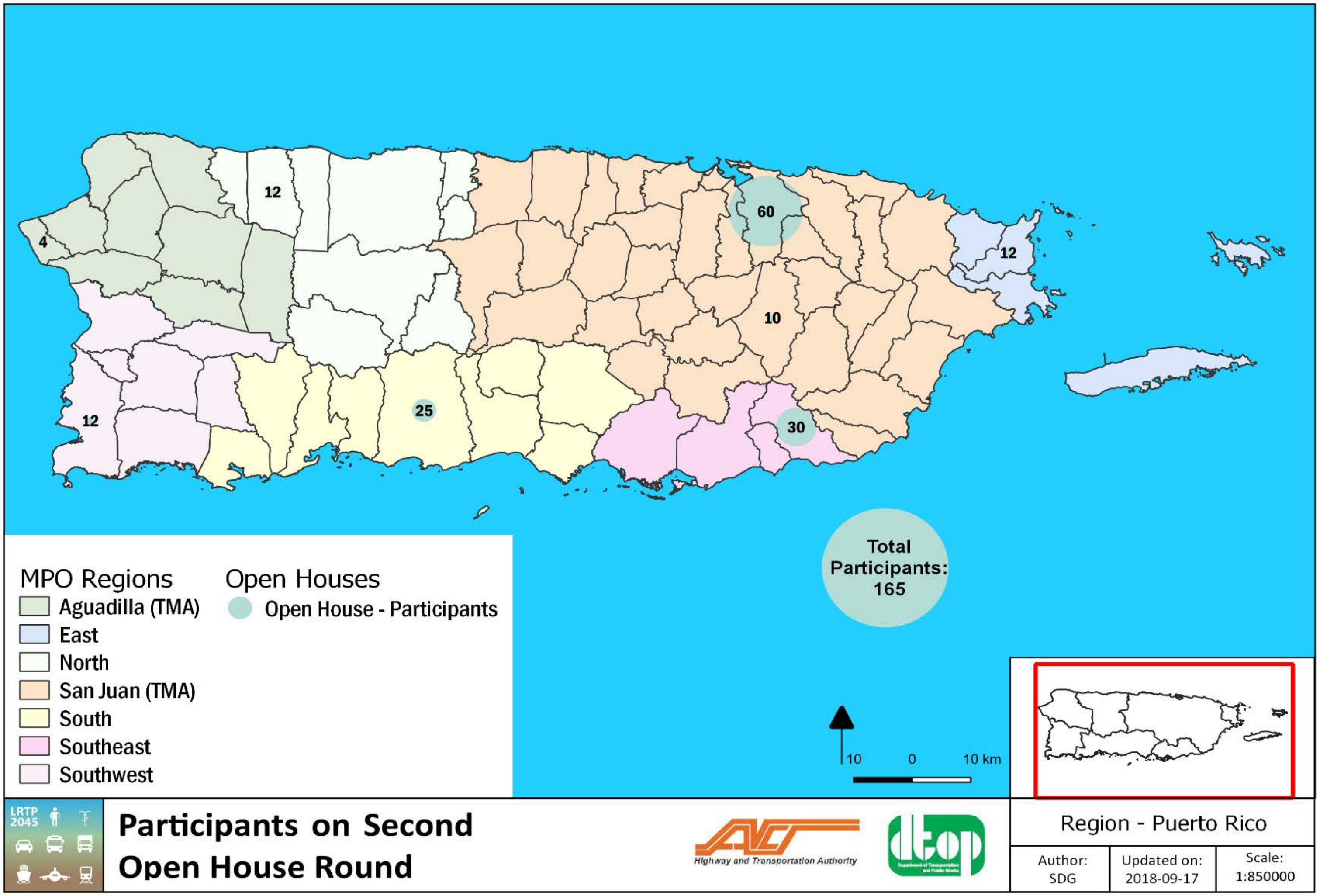
Second Round

The second round of open houses had the objective of: (1) informing the progress of the LRTP and (2) the validation of the citizens ideas and suggestions. These were published in the local newspapers and social media and were held at specific activity centers at municipalities within each Region. For example, see Figure 4.5. A total of 160 participant attended to the 8 locations as shown in Figure 4.6. The second round was also structured in two main stations: informative and interactive. This design followed the first round's method in which the participants received information about the plan, provided their needs and concerns about transportation issues and interacted by their own interest and time.

Figure 4.5: Second Open House – Other Urbanized Area Region (Camuy)

Source: SDG

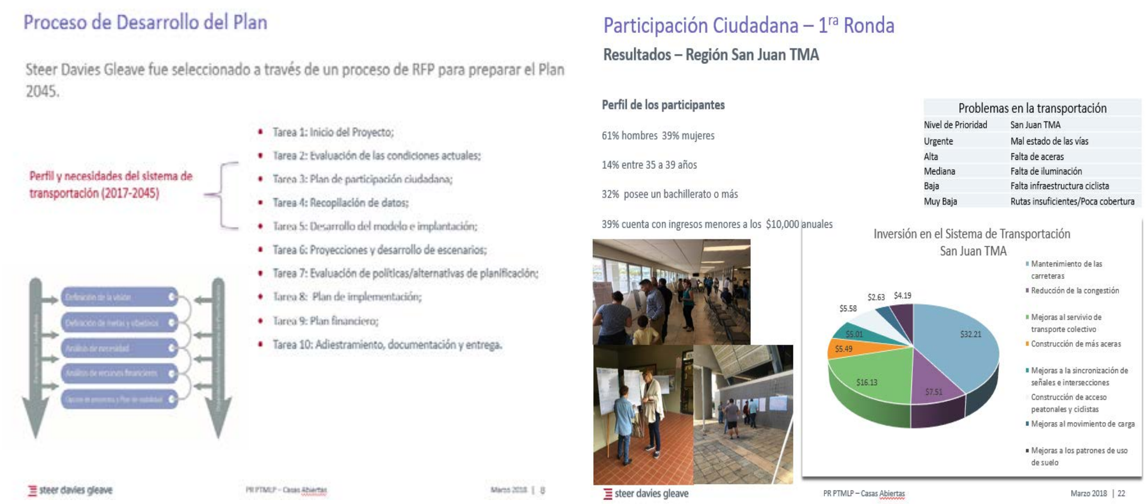
Figure 4.6: Total Participation Second Round Open Houses



Source: SDG

The informative station included the same data from the first round in benefit of new participants. It also included a presentation showing updates and results from the first open house as shown in Figure 4.7.

Figure 4.7: Example of the Presentation



Source: SDG

The interactive station's objective was to gather information about the plan's vision, goals, objectives and strategies. Participants provided their input through questionnaires, and interactives boards.

The main interactive exercise intended to validate the plan's vision and goals. Each participant had the opportunity to approach the vision as presented and provide recommendations on how to improve it. Also, they had the opportunity to organize the goals and objectives in terms of priority.

Most, 75%, of the participants agree with the LRTP's vision as presented. Most of the recommendations provided considered the following aspects:

- Transit and non-motorized modes emphasis;
- Adaptation of the transportation system to the Island's geography; and
- Promote livability and land use within urban centers.

As part of this open house's second round of interactive exercises, participants had the opportunity to identify and organize their main strategies when investing in transportation infrastructure. This input needs to be analyzed considering funding limitations and transportation challenges.

Other Engagement Initiatives

Individuals, organizations and stakeholders were provided with alternatives to engage in the plan's process and development. Table 4.1 summarizes those initiatives. These sectors were invited to committee meetings to inform on up-to-date on issues and decisions and to provide their inputs.

Table 4.1: Engagements Initiatives

Effort	Description
Household Travel Survey	An exercise in which citizens are asked to provide information about their households' composition, available vehicles and information on their typical trips. The objective of the survey is to collect information that will characterize urban mobility patterns in Puerto Rico. Results are presented in Chapter 2 and in Appendix L.
Resilience Webinar	Members of the Resilience Committee took a webinar from the Federal Highway Administration (FHWA) to know how by federal requirements transportation planning process could integrate mechanism to develop a more resilience transportation system. This committee the supported the development of a vulnerability analysis prepared as part of the LRPS.
MPO Meetings	Meetings to kept updated the MPO participants on the LRTP process and to gathered inputs and recommendations.
Municipal Sustainable Infrastructure Workshop	MPO participants had the opportunity to present their needs and alternatives for improvements to their Municipal transportation system. The main objective of this workshop was to identify projects alternatives with a regional impact. This identification process was made in collaboration with the municipalities.
INSEC	In order to reach a broader participation to validate the vision, goals and objectives, a short version of the second open house was presented at the training activity for community leaders by the Socio-Economic Community Institute, Inc (Instituto Socio-Económico Comunitario, Inc., INSEC).
Facebook Page	Digital platform to inform about the process and to gather inputs from the public.
Committee Meetings	As mentioned earlier in the chapter, meetings were held with all committees when appropriate, to provide inputs, discuss any particular point, and to be part of the decision-making process in benefit of the plan. The Committees included: Technical Committee, Freight Advisory Committee, Government Committee, Financial Committee, Economic Committee, Citizen Advisory Committee.

Source: SDG

The open houses provided information which was also presented at different audiences with the committees and with the MPO representatives. These provided an opportunity to participants to received information about the 2045 LRTP process and provide insight to influence the planning process.

The feedback on the analytical process of the PIP resulted in information that helped:

- To obtain an improved understanding of diverse opinions about the transportation conditions, its needs and general preferences;
- To refine the Vision, Goals and Objectives statement, and to rank the relative importance of goals and corresponding objectives;
- To Identify the transportation priorities by project types; and
- To identify detailed project improvement needs.

This process of gathering input from the public will serve as a powerful benchmark for the MPO's future planning works. Recurrent findings across all Regions

- Maintenance of existing facilities:

Participants agreed on the importance of having the Island's transportation infrastructure in good condition. Feedback reflected the need of repairing existing facilities and more importantly, of maintaining available infrastructure in a well state of repair;

- More emphasis in transit and non-motorized modes:
  The need to provide alternative modes of transportation aside from the private vehicle was evident. It was a recurrent response that pedestrian and cyclist infrastructure needs to be developed. Participants also responded with the need to improve the transit system and for it to connect with the rest of the Island and with main activity centers.
- More resilient transportation system:
  Participants indicated that is important to develop a sustainable and resilient transportation infrastructure, not only to withstand extreme natural disasters but also common natural events; such as long period of rain.
- Promote livable and land use within urban centers:
  Better coordination between transportation improvements and land use was also suggested by participants. Development of the transportation infrastructure needs to take into account the avoidance of urban sprawl and the promotion of more activities within urban centers.

MODEL DEVELOPMENT AND CALIBRATION

This chapter summarizes the model update and calibration efforts of the Puerto Rico travel demand model for the 2045 LRTP.

The Puerto Rico travel demand model (LRTP Model), also named as Island-wide model, spans the main Island of Puerto Rico and the Islands of Culebra and Vieques. It includes seven Regions which are subdivided into 4,296 transportation analysis zones (TAZ).

The model is a traditional trip-based model which has four sequential steps: trip generation, trip distribution, mode choice and assignment, as shown in Figure 4.8. The forecasting process classifies all trips into one of six cores trip purposes or commercial vehicle trips:

- Home-based work (HBW), further disaggregated into three subgroups based upon income level - including trips from home to work place or from work place to home;
- Home-based retail (HBR) – including trips from home to shops or restaurants;
- Home-based school (HBS) – including school trips from home to K-12;
- Home-based university (HBU) – including trips from home to university, mainly during off-peak;
- Home-based other (HBO) – including all home-based trips beginning or ending at places not listed above;
- Non-home based (NHB) – including trips with home as neither the origin nor the destination; and

- Non-household based vehicle classes – including commercial vehicles, medium weight trucks[56], and heavy trucks[57].

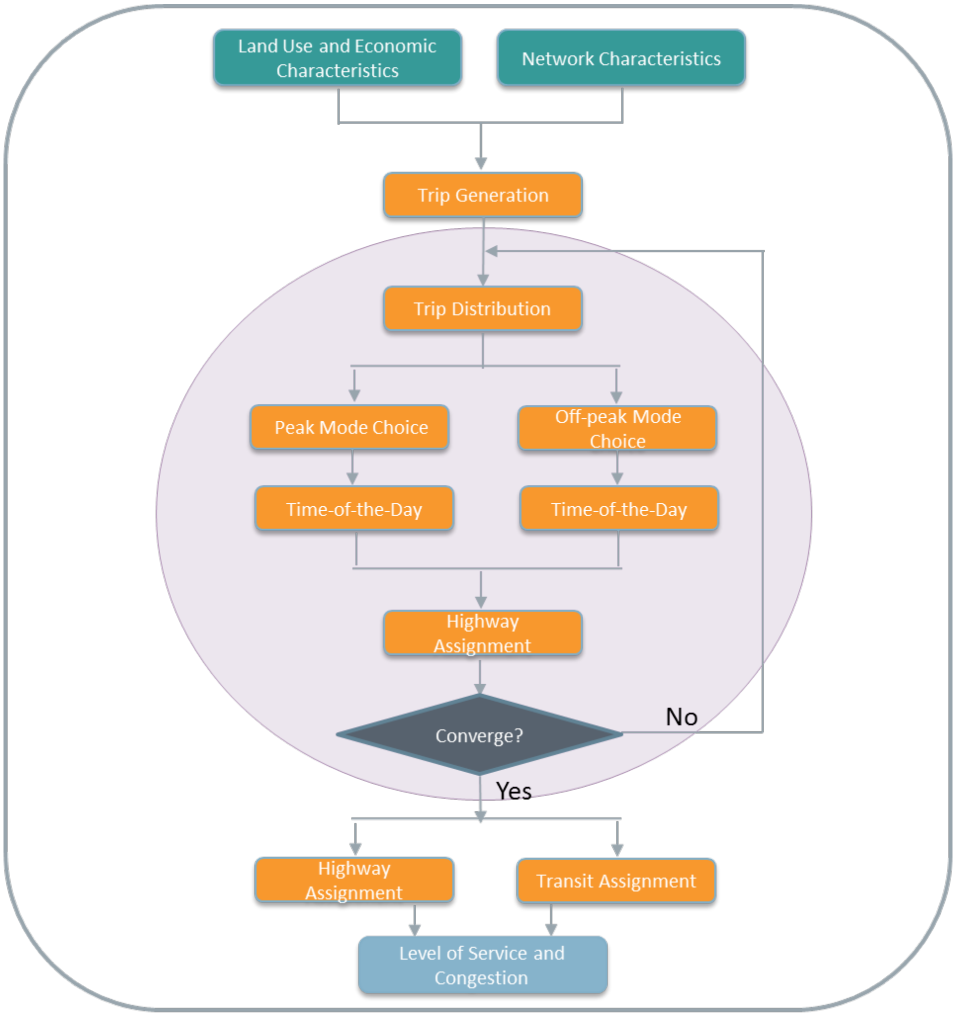
This section includes separate sections on each major model component, as follows:

- Socioeconomic inputs;
- Socioeconomic forecast;
- Trip generation;
- Trip distribution;
- Time of day choice;
- Mode choice and transit assignment; and
- Highway path building and assignment.

[56] Medium trucks are single-unit trucks with two or three axles in FHWA vehicle classifications 5-7.

[57] Heavy trucks include all single-trailer and multi-trailer combinations defined in FHWA vehicle classifications 8-13.

Figure 4.8: LRTP Model Structure



Source: SDG

Socioeconomic Inputs – Base Year 2016 Update

This section focuses on the process for updating the socioeconomics inputs of the 2045 LRTP Model from the 2010 calibrated scenario (in the 2040 LRTP Model) to new Base Year 2016. A two-stage process was completed:

- **Stage One:** Update all 4,296 Travel Analysis Zones (TAZs) from 2010 to 2016 levels using their corresponding municipal level growth from household, employment, and school data sources; and
- **Stage Two:** Holding municipal level control totals from the first stage constant, adjust individual TAZ's household and employment variables using TAZ specific information on new/closed employment centers, housing permits, and school closings/openings.

Stage One – Municipal Methodology

To properly capture socioeconomic change in the 78 municipalities from 2010 to 2016, the 2010 population was updated with real 2016 estimates from the U.S. Census Bureau and growth rates were applied to additional variables in the Base Year 2010 socioeconomic dataset, bringing them to 2016 figures. Table 4.2 outlines the data sources and methods used to update each socioeconomic variable. Growth rates were used instead of levels due to an inability to directly match original data sources on employment from the 2040 LRTP 2010 Base Year.

Table 4.2: Socioeconomic Variable Adjustment by Municipality with Explanation and Source

Socioeconomic Variables	Explanation of Adjustment	Source
Population	Used Municipality Level Population Estimates from U.S Census Bureau Annual estimates to update Population.	U.S. Census Bureau Annual Estimates
Households	The (2012-2016) ACS 5-year dataset provided number of occupied units and percent of occupied units that are 1-person, 2-person, 3-person, and 4-person plus households. From this a weighted average household size by municipality from (2012-2016) ACS 5-year dataset was calculated[58]. This was then applied to the already adjusted population to produce the number of households by TAZ.	American Community Survey (2012-2016 5-Year Estimates) (ACS) with SDG Analysis
Total Employment	Calculated growth rates by municipality between 2010 and 2016 using BLS QCEW total employment estimates, then applied to Base Year 2010 total employment. After which, used BLS LAUS total employment to scale up to 2016 reals as the LAUS accounts for agricultural and self-employment.	BLS Quarterly Census of Employment and Wages (QCEW), BLS LAUS
Retail, Service, Manufacturing, Government, and Other Employment Industries	Assumed constant share of employment by industry, used existing industry shares from 2010 Base Year, then applied these shares to adjusted Base Year 2016 total employment. Assumption was made after analysis of BLS QCEW data by industry, which supports this assumption.	BLS
Income	Calculated growth rates by municipality between (2006-2010) and (2012-2016) ACS 5-year datasets, then applied to Base Year 2010 income.	ACS
Students	Calculated growth rates by municipality between (2009-2010) and (2015-2016) school year data sets, then applied to Base Year 2010 students.	National Center for Education Statistics (NCES)
College	Calculated Compound Annual Growth Rate (CAGR) by College between 2010 and 2018 enrolment datasets. Matched colleges to their corresponding TAZ from Base Year 2010 and applied calculated CAGR over 6-years to make the proper transformation to 2016 college enrolment.	NCES
Dorms	Unchanged from Base Year 2010 (not used as inputs in trip generation model)	N/A

Source: SDG

[58] For households with 4-plus persons, an assumed average of 5 people per household was used to produce the weighted average calculation. This is different than the average household size by municipality discussed in Chapter 3, because these are weighted averages, and this process is more closely aligned to the work done in the 2040 LRTP report 2010 data.

Stage Two – TAZ Specific Adjustment

While Stage One accurately reflects municipality-level growth, it does not capture TAZ-level changes regarding new housing complexes and new or closed employment centers. Because municipal growth rates capture these internal dynamics at an overall level, it is important to redistribute the change across the other TAZ units in the corresponding municipality so that total employment and population are not affected. This process was completed after applying the methods outlined in Table 4.3.

Table 4.3: Socioeconomic Variable Adjustment by TAZ with Explanation and Source

Socioeconomic Variables	Explanation of Adjustment	Source
Households	Calculated the number of expected apartments for each permit. Developed metric of 'project cost per apartment', from publicly available data on completed projects. Used this metric to determine number of apartments for permit projects where not data was publicly available. Each new apartment was assumed equal to a new household. This was applied to the TAZ corresponding to each permit location.	Permit Management Office of Puerto Rico, (2010-2015) housing permits
Population	Population was adjusted for the inclusion of new households by applying the household size by municipality to the new Base Year household's variable.	ACS (2012-2016 5-Year Estimates)
Retail Employment	Calculated the estimated number of employees for each retail permit. Determined which shopping centers were completed prior to 2016 via research. Developed a metric of 'project cost per employee' from publicly available data on completed retail centers. Used this metric to determine employees for projects where employee data was not publicly available. This was applied to the TAZ corresponding to each retail permit location.	Permit Management Office of Puerto Rico, (2010-2015) housing permits
Service Employment	Accounted for new major hotels (defined as having over 100 rooms) and applied the associated employment change to the TAZ corresponding to each hotel location.	Puerto Rico Industrial Development Corporation (PRIDCO)
Manufacturing Employment	Accounted for closed manufacturing companies and applied the associated change in employment to the TAZ corresponding to each firm location.	PRIDCO

Source: SDG

Overview of Population and Employment Change

The geography of the seven Regions in Puerto Rico is displayed in Figure 2.1. The resulting population and employment by Puerto Rico from the updates discussed above are shown in Table 4.4. These and 2045 LRTP 2016 socioeconomic datasets are by place of work. Population has declined Island wide, as has employment, albeit, at a slower rate.

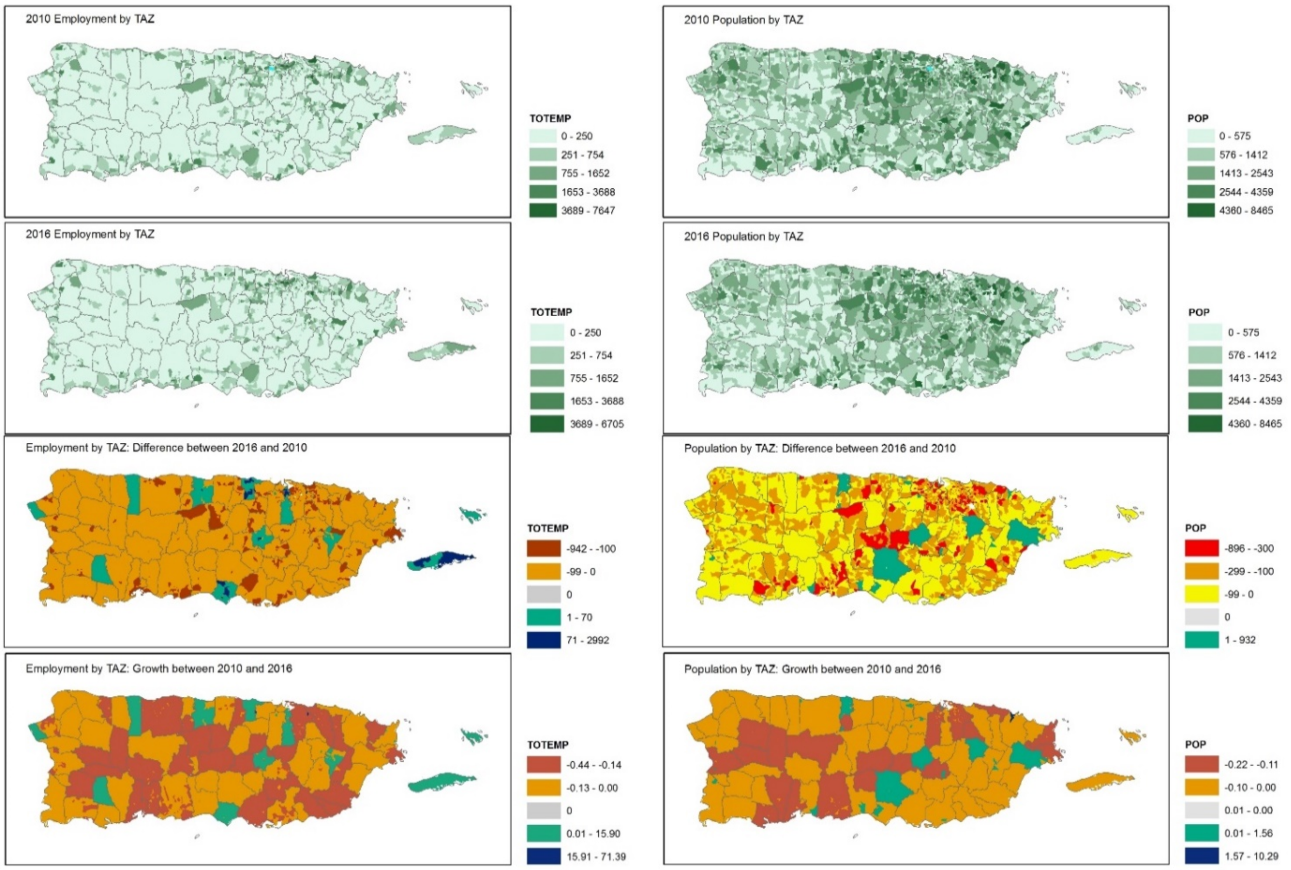
Table 4.4: Population and Employment –2045 LRTP Base Year 2016

Region	Population - Base Year 2016	Employment - Base Year 2016
Puerto Rico	3,411,307	986,151

Source: SDG

Figure 4.9 displays changes at the TAZ level between 2010 and 2016. It also shows that below the regional level, there are some municipalities that have experienced slight population and employment growth. The change between 2010 and 2016 is discussed in further depth in Chapter 2 during the Demographics, Population and Employment sections.

Figure 4.9: Population and Employment Change at the TAZ level, 2010 – 2016



Source: SDG analysis

Socioeconomic Inputs – Forecast Year 2045

This section details the processes of distributing these forecasts to the transportation analysis zone (TAZ) level, forecasting additional input variables, and producing final constrained models. The 2016 base socioeconomic inputs serve as the origin point for these processes.

Population and Employment Forecasts

As explained in Chapter 2, Employment in the 2045 LRTP 2016 base socioeconomic inputs are produced with BLS - LAUS. The LAUS employment is reported by “place of residence, an adjustment is carried out to convert to employment by place of work.”[59] The 2045 LRTP econometric forecasts were produced using the BLS Quarterly Census of Employment and Wages

[59] The adjustment is described in the 2010 report by 2040 LRTP. 2045 LRTP 2016 socioeconomic inputs applied growth rates to the 2040 LRTP 2010 data as noted in the chapter on Socioeconomic Inputs – Base Year 2016, making it also by Place of Work.

(QCEW), also by place of work, allowing growth rates from the 2045 LRTP employment forecasts to be applied the 2016 base socioeconomic inputs.

Detailed in Table 4.5 are the methods used to implement 2045 LRTP forecasts in producing forecasts for socioeconomic variables at the TAZ level, and other processes completed to finalize the 2045 socioeconomic inputs. The purpose of producing inputs at the TAZ level is for their use in the trip generation phase of the network model. They additionally serve as an insightful baseline for discussions around existing trends and potential alternative scenario's that would shift the trajectory outlined here.

Table 4.5: Socioeconomic Variable Adjustment by Municipality, Explanation, and Source

Socioeconomic Variables	Explanation of Adjustment	Source
Population	Distributed population from forecasts by Region down to their respective municipalities using the shares established in the base year 2016 socioeconomic inputs. After 2030, in the constrained forecasts, population is tied to forecasted employment growth.[60]	SDG Population Forecast
Households	Utilizing the average year over year growth rates from 2005-2016 for the Island of Puerto Rico, household size by municipality from the 2016 base year socioeconomic inputs was forecasted out until 2030, at which point rates were frozen.[61]	Forecast – Produced from ACS, Public Use Microdata Sample (PUMS) and SDG analysis
Total Employment	Applied growth rates by Region from the employment forecasts to the base 2016 socioeconomic inputs, distributing growth rates to the municipalities and TAZ corresponding to their associated Region.	Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW), BLS Local Area Unemployment Statistics (LAUS)
Retail, Service, Manufacturing, Government, and Other Employment Industries	With the basis of historical trends at industry level employment the technical team assumed a 10% decline by 2045 in manufacturing and government employment. This employment was redistributed to the retail, service, and other employment sectors, based on each TAZ's relative loss and the breakdown of employment in the retail, service and other employment sectors. Because of this, total municipality employment is left unaffected.	SDG Analysis
Income	Growth rates stemming from wage rate forecasts produced as part of the population and employment econometric models, were applied uniformly across incomes by municipality in the Base Year 2016 dataset, to adjust income out to 2045.	SDG Analysis and Forecast
Students	Student to population rates were forecasted and applied uniformly across the # of students by municipality in the base year 2016 dataset, to realize the impact of population loss and birth rate decline in Puerto Rico.	SDG Analysis and forecast

[60] The constrained forecast methodology is discussed further in the technical forecasting note in Appendix B.

[61] After analysis of the declining birth rate in Puerto Rico, the assumption of constant household size, population/household ratio, did not reasonably hold. Forecasts were developed for household size using their historical trend, carrying out the final year over year growth rate between 2015 and 2016. It was assumed that at 2030, birth rates would not continue to decline, as they are approaching a floor, being already one of the lowest in the world. Which is why the decline in household size is discontinued at 2030 levels as the forecasts continue.

Socioeconomic Variables	Explanation of Adjustment	Source
College	College students to population rates were forecasted and applied uniformly across the # of college students by municipality in the base year 2016 dataset, adjusting the college student population to forecasted 2045 levels.	SDG Analysis and Forecast
Dorms	Unchanged from Base Year 2010 (not used as inputs in trip generation model)	N/A

Source: SDG

Networks and Analysis

TAZ Urban Density

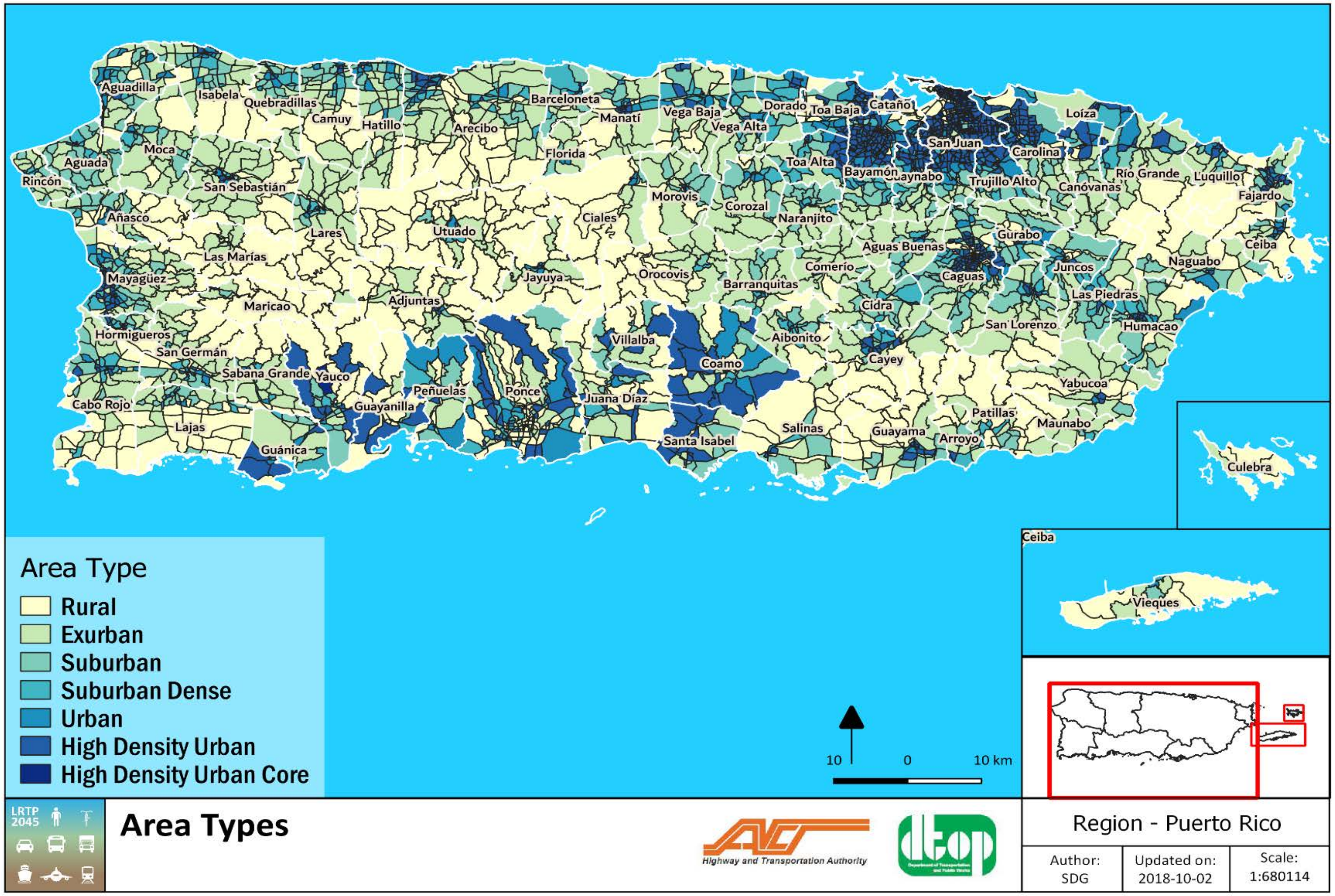
Figure 4.10 represents population density by square mile, allowing a visual distribution of population throughout municipalities and larger Regions. With public transportation's ridership base generally focused and made sustainable by high population densities, this can be a helpful and guiding graphic to identify corridors or areas to be assessed. The designations described in the graphic were guided by the U.S. Census Bureau's urban and rural classifications, and it is important to note that the map does not distinguish between land use, being strictly defined by population density. The ranges of the designations are defined in Table 4.6 below.

Table 4.6: Urban Density Area Types

Area Type	Population by Square Mile
Rural	(0-300)
Exurban	(300-1000)
Suburban	(1000-2000)
Suburban Dense	(2000-3000)
Urban	(3000-5000)
High Density Urban	(5000-20000)
High Density Urban Core	(20000+)

Source: 2016 population from Bureau of Census estimates, distributed to TAZ by SDG. Ranges produced by SDG guided by Bureau of Census definitions.

Figure 4.10: Area Types – Puerto Rico



Source: 2016 population from Bureau of Census estimates, distributed to TAZ by SDG. Ranges produced by SDG guided by Bureau of Census definitions.

Trip Generation

This section describes the modifications made to the trip generation component of the 2045 LRTP Model. The effects of those modifications are illustrated on the end-result of trip generation, i.e. the balanced productions and attractions by trip purpose. The modifications consisted of:

- Updates to some of the source data;
- Re-estimation of the models that support the population synthesizer with the updated data; and
- Miscellaneous changes to the general methodology which the technical team considered were appropriate.

Data Source Updates

The data sources that serve as input to the population synthesizer component of the trip generation models were updated, but no changes to the production or attraction models were introduced.

Table 4.7 shows the components of the trip generation model, the purpose of each component, and the nature of the updates made, if any.

Table 4.7: Components of Trip Generation Model

Model(s)	Dataset	Estimation Method	Purpose	Update
Household size and income group models	Census Tract	Linear regression of average household size / income on size / income group distribution	Disaggregate households into the 384 types by size, income group, numbers of workers, children, and seniors	Replaced 2010 Census with 2016 ACS 5-Year Data
Household composition models	PUMS	Cross-classification with household size and income group		Replaced 2006-08 with 2012-16 PUMS Data
Household auto ownership model	PUMS	Logit	Estimate probability of having 0, 1, 2 or 3+ autos per household for each household type	
Production models for each trip purpose (other than truck trips)	2011 Puerto Rico Household Travel Survey (HHTS)	Linear regression of trips generated on household characteristics derived from PUMS / IPF process	Generate productions by TAZ	None
Attraction models for each trip purpose (other than truck trips)	NCHRP 365[62]	n/a	Generate attractions by TAZ	None
	External Models	n/a	Generate truck productions and attractions by TAZ	None

Source: SDG

[62] National Cooperative Highway Research Program (NCHRP) Report 365: Travel Estimation Techniques for Urban Planning, 1998 (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_365.pdf)

As described in the prior section, the TAZ data from the prior model base year 2010 to 2016 was updated. This data serves as the backbone to trip generation.

Re-estimation of Population Synthesizer Models

Since the census tract and PUMS data serve as inputs to the models which support the population synthesizer, those models were re-estimated to reflect changes in demographics. These models estimate:

- The distribution of household sizes as a function of a zone's average household size;
- The distribution of income groups as a function of a zone's average household income;
- Numbers of workers, children and seniors as a function of a household's average size and income group; and
- Auto ownership as a function of household demographics.

Detailed information on the re-estimation of the population synthesizer process is included in Appendix F.

Changes to Trip Balancing Methodology

In addition to updating the data and re-estimating the population synthesizer models as discussed above, a full review of the methodology was conducted finding several items to be addressed, all related to balancing productions and attractions. These included:

- A "validation factor" of 1.45 for home-based work attractions;
- The balancing alternative (balancing to productions vs attractions) for several trip purposes; and
- Trip balancing within each Region individually.

Detailed information on the changes to trip balancing is included in Appendix F.

Validation Factors in Model Update

After applying all of the above changes, the resultant Island-wide average number of trips per household had decreased from 5.29 in the 2040 LRTP Model to 4.34 in the 2045 LRTP Model update. This is, by most sources, a very low number – the Florida Department of Transportation Travel Demand Model Validation Standards[63], used to validate the prior LRTP model's trip generation output, suggests a range of 8 to -10 person-trips per household. Although Puerto Rico travel per household may be lower, it seems unlikely that it would only be 50% as much as in Florida. To corroborate that difference, initial runs of the model produced traffic volumes that were generally significantly lower than observed traffic counts across the whole Island.

Thus, Region-specific factors to increase all trips were implemented (both productions and attractions), based on the general level of modeled traffic volumes, as compared to traffic counts. Table 4.8 presents those factors.

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[63] Florida Travel Demand Model Validation Standards, Cambridge Systematics, Inc. for Florida Department of Transportation, 2009.

Table 4.8: Region-Specific Trip Generation Factors

Region	Factor
Aguadilla	1.960
East	1.843
North	1.940
San Juan	1.186
South	1.323
Southeast	1.303
Southwest	1.803

Source: SDG

Truck Trip Generation

Due to the lack of the survey data, the production or attraction models for commercial and truck trips in the 2045 LRTP model were not updated, although global factors to adjust the trip productions and attractions based upon the general level of modeled truck volumes, as compared to the observed counts, were introduced. See Table 4.9. The resulting medium and heavy truck demand in 2016 increased by approximately 40,500 and 1,200 from the 2010 traffic conditions, respectively.

Table 4.9: Truck Trip Generation Factors

Vehicle Type	Factor
Commercial Vehicles	1.00
Medium Truck	1.31
Heavy Truck	1.10

Source: SDG

Validation of Trip Generation Output

Table 4.10 presents a comparison of the trip shares within each trip purpose, for the 2040 LRTP model (prior to any of the changes discussed in this report), and for the 2045 LRTP Model update, prior to and after the regional validation factors from Table 4.8.

Table 4.10: Comparison of Person Trip Shares and Total Trips per Household to Florida DOT Validation Standards

	Florida DOT Standard	2040 LRTP Model	2045 LRTP Model Update –	
			Before Regional Validation Factors	After Regional Validation Factors
Home-Based Work	12%-24%	31%	27%	27%
Home-Based Retail	10%-20%	17%	20%	20%
Home-Based School	5%-8%	18%	7%	7%
Home-Based Other (includes University)	23%-40%	20%	28%	28%
Non-Home Based	20%-33%	15%	18%	18%
	8.0 – 10.0	5.29	4.34	5.87

Source: SDG

Table 4.10 shows that in the 2040 LRTP Model, both work and school trips were a much larger share of overall trips than in the validation standards, while home-based other and non-home-based trips had shares below the lower ends of their ranges. Balancing home-based school trips to attractions rather than productions and making school enrollment control the total trips addressed that inconsistency and brought the share of home-based school trips into the recommended range. Reductions to home-based work trips due to the census data update helped bring the share of home-based work trips closer to the recommended range, albeit still slightly above. Finally, the regional validation factors did not affect relative shares between trip purposes, but increased the number of trips per household to 5.87, a level still below the Florida standard, but much closer, as opposed to 50% below the low end of the range.

Overall, the trip generation updates bring both the relative numbers of trips between purposes and the total numbers of trip generated closer to well-established standards.

Trip Distribution

This section focuses on the updates and the calibration of the trip distribution component of the 2045 LRTP Model. Trip distribution links trip productions in the model Region with trip attractions to create matrices of inter and intra-zonal travel flows. The results of trip distribution will be used as inputs to mode choice and later assigned to highways and/or transit systems to determine the travel demand constrained by the supply capacities of the underlying facilities.

Gravity Model

The LRTP Model uses a standard gravity model to distribute trips from each origin zone to each destination zone in the model Region. The number of trips between zones is a function of the attractiveness of a zone and the travel impedance between zones:

$$Tij = Pi\,\frac{AjF(Cij)Kij}{\sum_{\mathrm{j=1}}^{\mathrm{n}} AjF(Cij)Kij}$$

Where:

- T_{ij}: trips from zone i to zone j;
- P_i: trips produced from zone i;
- A_j: trips attracted to zone j;
- $F(C_{ij})$: generalized cost friction factor; and
- K_{ij}: zone-to-zone calibration factor, which adjusts the attractiveness from zone i to zone j.

Travel Impedances

The trip distribution uses the minimum travel impedances among the generalized costs of auto trips, transit trips, and non-motorized trips from an origin zone to a destination zone. The travel impedances of auto, transit and non-motorized travel are functions that convert all measures, namely vehicle journey time, operating costs, highway tolls, transit fares, and walk distances, into equivalent minutes.

To accurately estimate the travel cost, it is essential to use the up-to-date value of time (VOT) to calculate the travel impedance. The 2040 LRTP Model assumed the VOTs at $12 and $21 per hour for a car trip and a truck trip, respectively. These values seemed slightly high related to the median household income of the Island[64]. Based upon US Department of Transportation (USDOT) revised VOT Guidance 2016[65], the VOT of a business traveler is assumed to be equal to a median hourly gross wage, while the VOT of local personal travel is typically estimated at 50 percent of hourly median household income. The VOT of both passenger car and truck travelers were re-estimated, resulting in values presented in Table 4.11.

Table 4.11: Value of Time ($/hour, in 2016$)

Vehicle Class	2040 LRTP	2045 LRTP
Auto	12.0	10.10
Truck	21.0	17.68

Source: SDG analysis of value of time

The auto operating cost (AOC) was set at $0.20/mile based upon the American Automobile Association (AAA) 2016's Your Driving Costs[66] for gas, maintenance, and tires, with adjustment to the average gas price in Puerto Rico in 2016. This value is comparable to the auto operating costs implemented in the Southeast Florida Regional Planning Model (SERPM 7.0)[67]. For trucks, it was assumed a truck operating cost (TOC) of $0.80/mile. The truck value comes from a combination of trucking industry interviews, which suggested a cost range from $0.80 to $1.75, and the fuel, maintenance, and tires costs published in American Transportation Research Institute (ATRI) 2012 Cost of Trucking[68]. Table 4.12 shows the vehicle operating costs used in the 2040 LRTP Model and the updated values.

Table 4.12: Vehicle Operating Cost ($/mile, in 2016$)

Vehicle Class	2040 LRTP	2045 LRTP
Auto	0.1625	0.20
Truck	0.5833	0.80

Source: SDG analysis of vehicle operating cost

[64] Median household income and Gini Index in the past 12 months in 2016 in Puerto Rico is $20,078 (https://www.census.gov/content/dam/Census/library/publications/2017/acs/acsbr16-02.pdf).

The BLS's third quarter (2016) county employment and wages in Puerto Rico is $524/week. (https://www.bls.gov/Regions/new-york-new-jersey/news-release/countyemploymentandwages_puertorico.htm).

[65] The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations Revision 2 (2016 Updates), September 2016 (https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-valuation-travel-time-economic).

[66] Available at https://exchange.aaa.com/wp-content/uploads/2017/05/2016-YDC-Brochure.pdf.

[67] SERPM 7.0 uses an assumed auto operating cost of 19.80 cents/mile, including 13.50 cents/mile of fuel cost, and 6.30 cents/mile of maintenance cost (in 2009 dollars).

[68] American Transportation Research Institute, "An Analysis of the Operational Costs of Trucking: A 2012 Update".

The highway costs did not include parking costs in the 2045 LRTP Model since uniform data was not available for the entire Island.

Friction Factors

The gamma function from the 2040 PR LRPT Model to calculate friction factions was adopted:

$$FF = t^b \times e^{ct}$$

Where t is the travel impedance, and b and c are parameters to be calibrated.

During the calibration process, due to the lack of observed data, only the coefficients of gamma function for the home-based work trips were re-estimated, in order to keep the average travel time and travel time distribution close to that of the 2040 LRTP Model. Table 4.13 presents the changes of coefficients made for the 2045 LRTP Model.

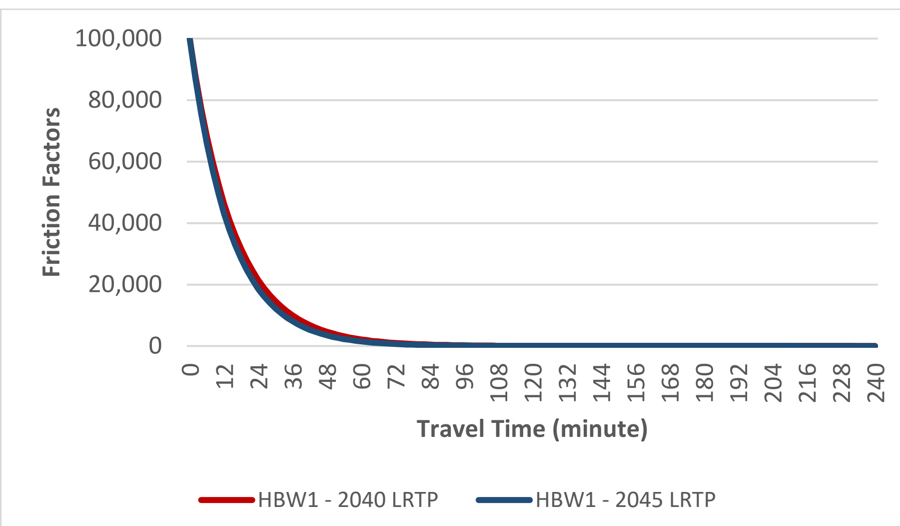
Table 4.13: Coefficient of Gamma Functions of HBW Trips

Trip Purpose	2040 LRTP Model		2045 LRTP Model	
	b	c	b	c
HBW Low Income	0	(0.064)	0	(0.07)
HBW Medium Income	0	(0.048)	0	(0.056)
HBW High Income	0	(0.04)	(0.01)	(0.055)

Source: SDG 2045 LRTP model update

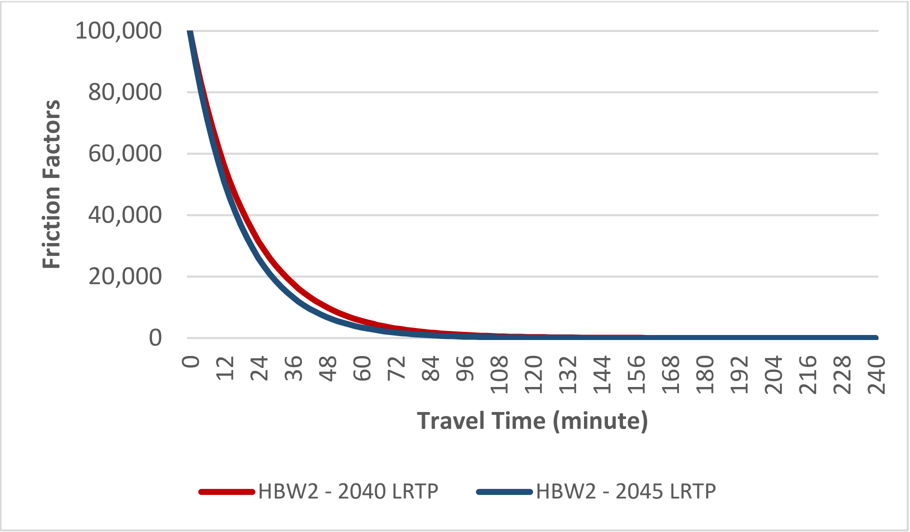
The resulting friction factors of the HBW trips and the comparison between the 2040 and 2045 LRTP models for low, medium, and high income travel are presented in Figure 4.11, Figure 4.12, and Figure 4.13 respectively.

Figure 4.11: Comparison of Friction Factors of Low Income HBW Trips (2040 LRTP vs. 2045 LRTP)



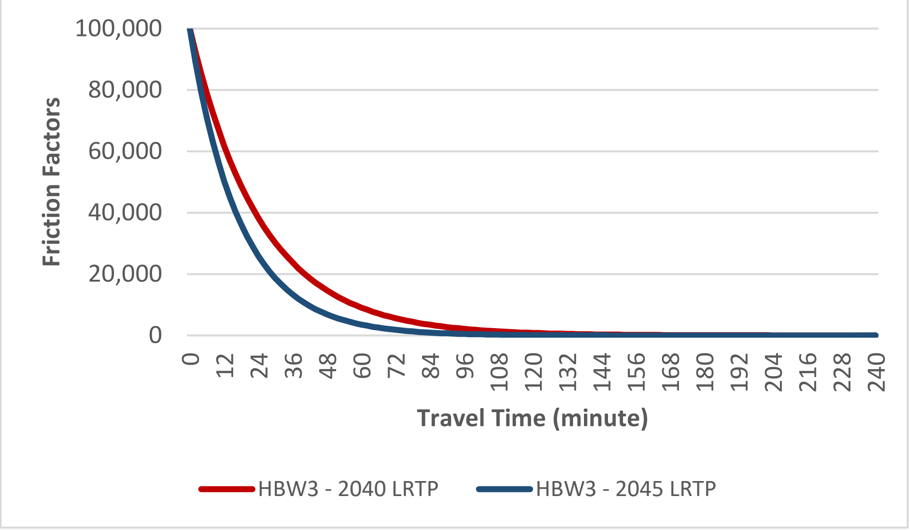
Source: SDG analysis of friction factors

Figure 4.12: Comparison of Friction Factors of Medium Income HBW Trips (2040 LRTP vs. 2045 LRTP)



Source: SDG analysis of friction factors

Figure 4.13: Comparison of Friction Factors of High Income HBW Trips (2040 LRTP vs. 2045 LRTP)



Source: SDG analysis of friction factors

K Factors

The K factor is a zone-to-zone trip adjustment coefficient that modifies the attractiveness of one trip attraction to trip production. Normally, the use of K factors helps to capture certain characteristics that influence travel patterns, from which a gravity model cannot directly estimate. Examples of these characteristics include tax policies that reduce or support travel to certain Regions, travel time reliability that affects the likelihood of travel, and geographic and/or topographical features, namely large water bodies, reserved/restricted areas, and mountain ranges as intermediate stops which may prevent travel. These limitations introduce an inconsistency into the distribution process and may further justify the use of k factors for some situations.

The 2040 LRTP model did not have K factors in place. After reviewing the 2016 traffic flows from highway assignment on screenlines, new coefficients were introduced to the 2045 LRTP Model to adjust the municipality-to-municipality trip flows. Table 4.14 presents the K factors developed for home-based work, home-based other, home-based retail, and non-home-based trips. With them, the attractiveness of travel within San Juan and between North Region and San Juan was increased, while reduced between Aguadilla and San Juan.

Table 4.14: K Factors for 2045 LRTP Model

Region	Aguadilla	East	North	San Juan	South	Southeast	Southwest
Aguadilla	1.00	1.00	1.00	0.85	1.00	1.00	1.00
East	1.00	1.00	1.00	1.00	1.00	1.00	1.00
North	1.00	1.00	1.00	1.10	1.00	1.00	1.00
San Juan	0.85	1.00	1.10	1.10	1.00	1.00	1.00
South	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Southeast	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Southwest	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Source: SDG 2045 LRTP Model update

Model Validation

The trip distribution of 2040 LRTP Model was calibrated by the average trip lengths and the trip length frequency distributions calculated from the 2011 Puerto Rico household survey. To examine the changes of travel patterns in the past 5-years (2011 – 2016), it was proposed to conduct a new household survey for information on origin-destination travel data for all trip purposes. However, due to Hurricane Irma and Hurricane María in Summer 2017 causing great damage to the Island, the planned Island-wide household survey was postponed. Because of this delay, it was not possible to update the trip length frequency distribution calculation, or re-estimate coefficients of the gamma function from the survey results.

A limited validation to the trip distribution step with three measures was conducted:

- Region-to-Region travel patterns;
- Average trip length; and
- Trip length frequency distribution.

Detailed information on this validation process is included in Appendix F.

Time of Day Choice

This section describes the methodologies available to segment the daily demand into peak and off-peak periods in preparation for mode choice, and after mode choice, further disaggregate the auto and truck trips into finer time periods for highway assignment.

Both trip generation and trip distribution were developed on a daily basis. In the 2040 LRTP Model, the mode choice was also performed on a daily basis. As the outputs of mode choice process, the daily vehicle trips were then disaggregated into four periods (AM Peak, midday, PM Peak, and night) for highway assignment. In reality, the choice of travel mode made by individuals would vary by time due to the changes of level of service and congestion. Thus, in the 2045 LRTP Model, the mode choice model was modified from daily basis to peak and off-peak periods.

Pre-Mode Choice Time-of-the-Day Trip Distribution

In preparation for mode choice, diurnal factors were applied to subdivide the daily trips by purpose into peak and off-peak trips. These factors, as presented in Table 4.15, were initially adopted from the 2040 LRTP Model, by combining the AM and PM peak factors to derive peak period, and midday and night factors to derive off-peak factors. During the model calibration, these were adjusted upon the observed traffic data.

Table 4.15: Daily to Peak and Off-peak Factors

Trip Purpose	Peak	Off-Peak
HBW – Low Income	0.500	0.500
HBW – Medium Income	0.500	0.500
HBW – High Income	0.500	0.500
HBO	0.201	0.799
HBR	0.100	0.900
HBS	0.720	0.280
HBU	0.420	0.580
NHB	0.190	0.810
COM	0.400	0.600
MTK	0.330	0.670
HTK	0.350	0.650

Source: SDG 2045 LRTP Model update

Time of Day Distribution for Highway Assignment

The transit trips estimated by the mode choice process were retained in peak and off-peak designations for purposes of assignment. The highway assignment was performed by finer time-of-day breakdowns to account for congestion effects and the subsequent diversion of trips caused by that congestion. The 2045 LRTP Model adopts four periods covering the AM and PM peak, the Midday period, and the other off-peak periods.

Peak periods comprise of multiple hours. Since link capacity is normally defined hourly, peak period factors were developed to convert hourly capacities to period capacities. Table 4.16 presents the period definition, the length of each period, and the hourly-to-period capacity factors.

Table 4.16: Hourly to Period Capacity Factors

Period	Timeframe	Number of Hours	Period Capacity Factor
AM Peak	7am – 9am	2	2.0
Midday	9am – 3pm	6	5.8
PM Peak	3pm – 6pm	3	2.9
Other Off-peak (Night)	6pm – 7am	13	6.2

Source: 2045 LRTP Model

The peak and off-peak auto trips generated by the mode choice process were in production/attraction (P/A) format, except for the non-home-based purposes which were estimated in an origin/destination (O/D) format. The commercial vehicles and truck trips were in the O/D format too. In preparation for highway assignment, the peak and off-peak P/A trip tables were converted to period-specific O/D trip tables using time-of-day and direction split factors. These factors are presented in Table 4.17 and Table 4.18.

Table 4.17: Peak to AM and PM Factors

Trip Purpose	AM		PM	
	P-to-A	A-to-P	P-to-A	A-to-P
HBW – Low Income	0.389	0.059	0.008	0.544
HBW – Medium Income	0.389	0.059	0.008	0.544
HBW – High Income	0.389	0.059	0.008	0.544
HBO	0.376	0.211	0.014	0.399
HBR	0.178	0.283	0.034	0.505
HBS	0.437	0.042	0.092	0.429
HBU	0.526	0.078	0.050	0.346
NHB	0.179	0.321	0.179	0.321
COM	0.213	0.287	0.213	0.287
MTK	0.200	0.300	0.200	0.300
HTK	0.216	0.284	0.216	0.284

Source: SDG 2045 LRTP Model update

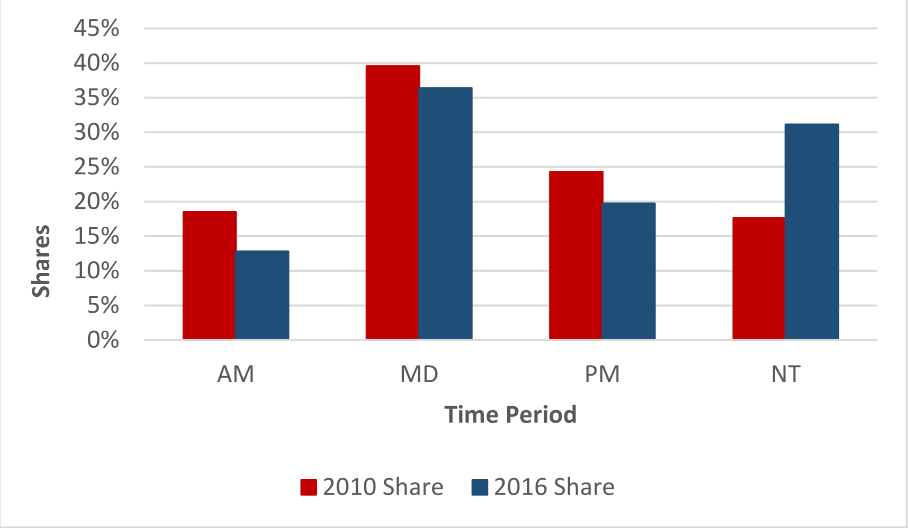
Table 4.18: Off-peak to MD and NT Factors:

Trip Purpose	MD		NT	
	P-to-A	A-to-P	P-to-A	A-to-P
HBW – Low Income	0.128	0.435	0.12	0.317
HBW – Medium Income	0.128	0.435	0.12	0.317
HBW – High Income	0.128	0.435	0.12	0.317
HBO	0.252	0.214	0.267	0.267
HBR	0.316	0.193	0.262	0.229
HBS	0.333	0.233	0.333	0.101
HBU	0.169	0.238	0.366	0.227
NHB	0.348	0.152	0.348	0.152
COM	0.367	0.133	0.367	0.133
MTK	0.280	0.220	0.280	0.220
HTK	0.290	0.210	0.290	0.210

Source: SDG 2045 LRTP Model update

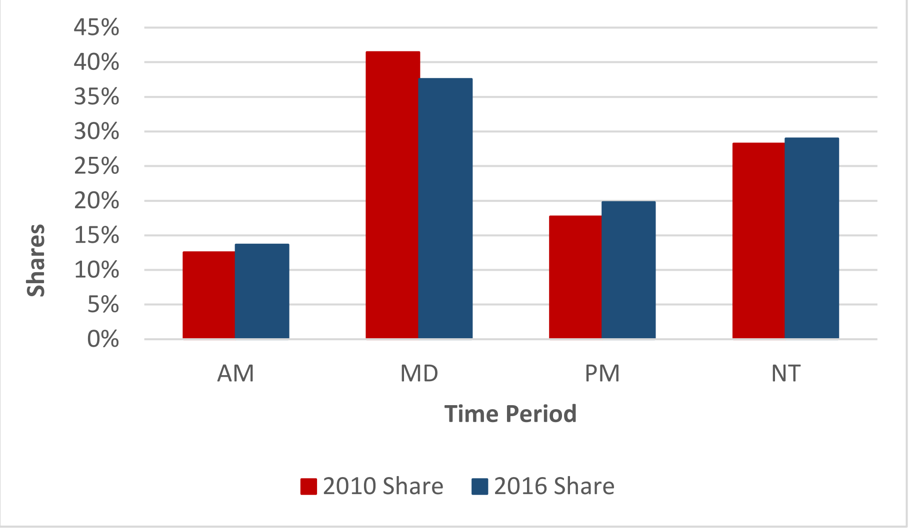
During the model calibration, the time-of-day factors based upon the traffic counts were adjusted. Figure 4.14 and Figure 4.15 compare the demand distribution by time-of-day between 2010 and 2016 for auto and trucks respectively. For auto trips, the 2016 model has significantly higher demand in the overnight period (NT) than the 2010 model. It seems reasonable since this period starts from 6pm when a lot of activities are still on-going.

Figure 4.14: Comparison of Time-of-Day Demand Distribution (2016 vs. 2010) - Auto Trips



Source: SDG analysis of auto trip shares by time period

Figure 4.15: Comparison of Time-of-Day Demand Distribution (2016 vs. 2010) - Truck Trips



Source: SDG analysis of auto trip shares by time period

Mode Choice and Transit Assignment

In this section the update to the mode choice and transit assignment is presented. Following this introduction, the section continues with a brief review of the mode choice framework established for 2040 LRTP, including a summary of the level of validation reported for the 2040 RP LRTP Model development. Improvements and updates undertaken for the 2045 LRTP are presented, followed by the calibration and validation of these improvements. The Appendix F includes a final part for this section presenting a range of sensitivity tests to show how responsive the model is to changes in input assumptions.

The 2040 LRTP model includes a complicated three-tiered nested multinomial mode choice model. The structure of the model, which is used for each of the eight trip purposes, is shown in Figure 2.1.

Note, however, that no data collection was undertaken for the estimation of the model with all parameters instead based on US benchmark values extracted from various Transportation Research Board (TRB) publications.

All-purpose target mode shares for each of the 10 modes were estimated from the household travel survey data which was collected as part of the 2040 LRTP Model, infilled with observed transit ridership and on-board survey data. Constants were applied to the final outputs of the mode share model in order to align the mode share forecasts with 2040 LRTP' target.

The mode share of the 2040 LRTP Model shows a reasonably match to the HTS data which is to be expected as it was used to derive the target mode shares. The model is better at capturing the mode choice decision in the San Juan Region compared to the performance across the rest of Puerto Rico. No details have been provided by 2040 LRTP regarding the reasonableness of the model in "forecasting mode" or if there are any possible weaknesses which need to be accounted for in the future years.

Developments for the 2045 LRTP

As a result of Hurricane María, no data collection proposed as part of the original project scope would be available for the model updates. In particular, the household travel survey data would not be completed and analyzed in time to update the relevant model inputs. As such, model development was relatively limited in scope. The main tasks are summarized as follows.

- Updated inputs where new data is available;
- Updated hierarchy of PT modes within the transit assignment;
- Mode choice modelling of the peak and off-peak periods for each trip purpose; and
- Revalidation for Base Year 2016.

Each of these tasks is discussed further in Appendix F.

Mode Choice

The target mode share for Auto, Transit, and Nonmotorized modes was estimated using the combined dataset, as shown in Table 4.19.

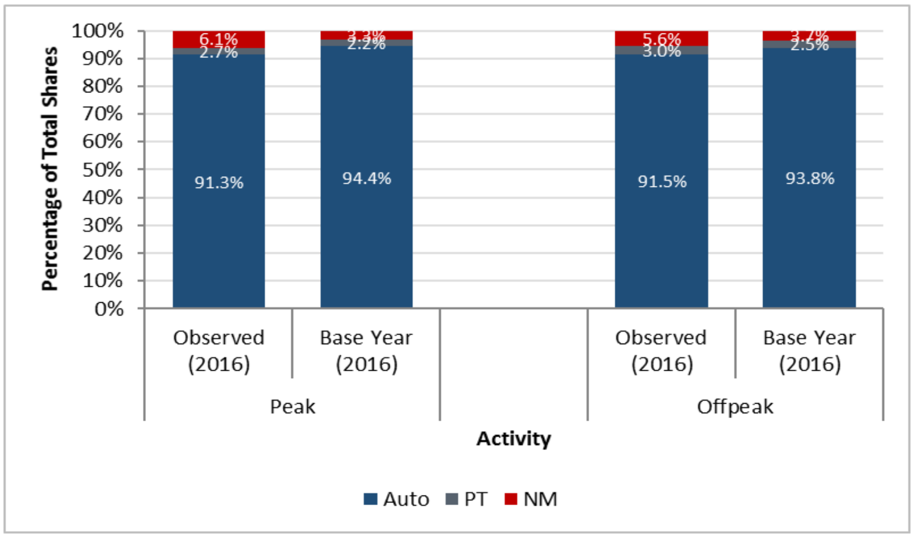
Table 4.19: Target Mode Share Evolution.

Scenario	HTS only	With On Board Transit Survey	And Journey to Work
Auto	90.2%	91.3%	91.4%
Transit	4.2%	3.0%	2.8%
Non-Motorized	5.6%	5.7%	5.8%

Source: SDG combined data set

Given the nature of the data, only limited information was available regarding mode choice at lower levels of the nested structure. In Figure 4.16 the mode choice model results are compared to the observed data at an Island wide level for both the peak and off-peak periods.

Figure 4.16: Mode Choice Validation – Island-wide by Time of Day



Source: 2045 P LRTP Model

Several data sources were combined to create a multimodal, island-wide 'observed' dataset for model calibration. The 2012-2016 American Community Survey Journey to Work data, the Atkins 2010 Household Travel Survey, and Atkins 2010 On Board Transit Survey were adjusted and compiled to form a representative set of trip matrices by TMA, split by journey purpose and mode of travel.

From Figure 4.16 it is observed that during both the peak and off-peak periods the mode share for auto is slightly high at the expense of non-motorized trips. Transit trips show a good match to observed data. The overallocation of auto trips is not considered to be a concern for the following reasons:

- Given that auto demand makes up over 90% of the observed travel demand, it is prudent to focus on this market segment. Indeed, a good match for auto trips is shown;
- The combined dataset represents one point of reference for travel demand. This dataset is made up of relatively subjective and sparse data when compared to other sources such as toll road transactions and other highway count data. The latter two data sources form the basis of the highway validation and insight from this stage of work indicated that the highway demand coming out of the mode choice was too low. Thus, there is a tradeoff to be made between the various data sources. For this reason, the mode choice was revised to increase the auto mode share to improve the highway validation at the expense of the mode choice validation; and
- The forecasting for the 2045 LRTP is focused on auto and transit schemes. The schemes to be tested are not expected to have a significant impact on non-motorized trips. As such the validation of non-motorized trips is not considered to be a priority.

The mode choice for the key trip purposes at an Island wide level is shown in Table 4.20.

Table 4.20: Island-wide Mode Choice Results by Purpose and by Period

Purpose	Peak			Off peak		
	Auto	Transit	Non-motorized	Auto	Transit	Non-motorized
Home-based work	95.6%	1.5%	2.8%	95.8%	1.4%	2.8%
Home-based other	93.2%	3.5%	3.3%	93.2%	3.5%	3.3%
Non-home based	94.6%	0.3%	5.2%	94.6%	0.2%	5.1%

Source: 2045 LRTP model

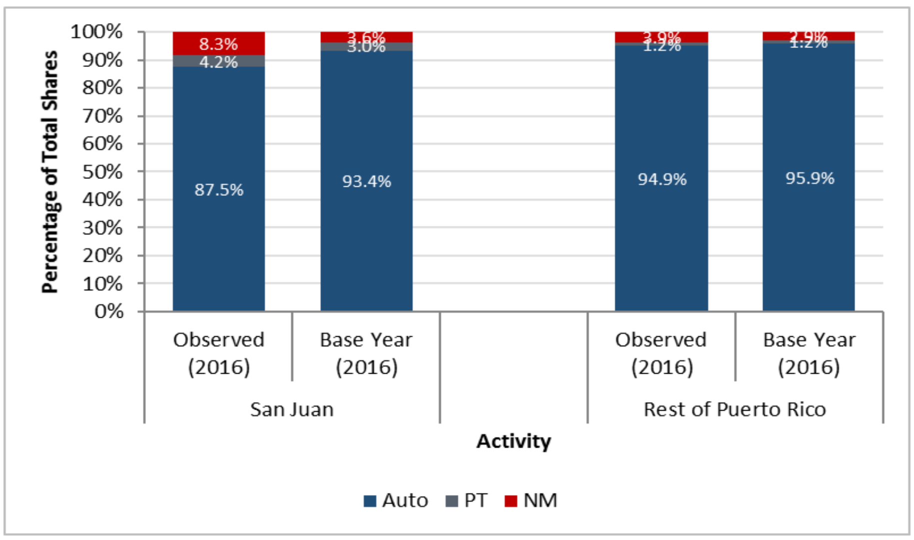
From Table 4.22 the following findings are observed:

- Auto share is high for all trip purposes and highest for home-based work trips;
- Home-based other trips are the most likely to use transit with a mode share of 3.5%, over double that of home-based work;
- Non-home based other trips are the most likely to use a non-motorized mode. This is likely due to the short distance of most of these trips; and
- As observed in other comparisons, the mode shares do not vary much between the peak and off-peak periods.

Overall these results make sense, with users with a higher value of time favoring the faster auto mode, while the shorter distance trips are more likely to walk or cycle.

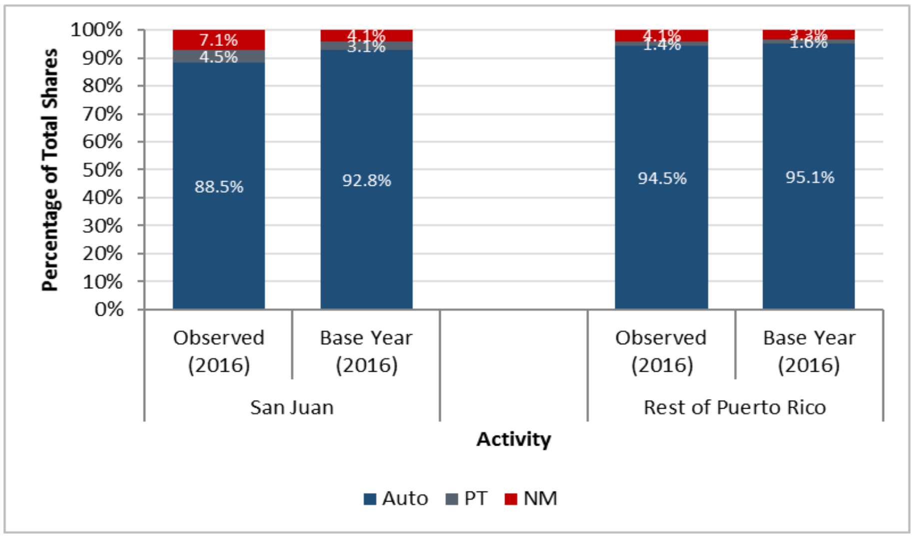
Given that transit is more widely available within San Juan Region, the mode shares are validated separately for San Juan and the Rest of Puerto Rico. These results are Figure 4.17 and Figure 4.18.

Figure 4.17: Mode Choice Validation – San Juan and Rest of Puerto Rico – Peak period



Source: SDG 2045 LRTP calibration of Mode Choice

Figure 4.18: Mode Choice Validation – San Juan and Rest of Puerto Rico – Off-peak period



Source: SDG 2045 LRTP calibration of Mode Choice

In general, the mode choice model is providing a good representation of the choices made between auto, transit, and nonmotorized modes. Consistent results are seen across each geography and each trip purpose with no erroneous behavior in the model.

Transit Boardings

Transit services exist across the entire Island of Puerto Rico. However, outside of San Juan these are limited to Públicos and local services (trolleys) only. The Puerto Rico multi-modal model uses a simple uncrowded transit assignment to allocate the Premium, Local, and Público transit demand onto the relevant services.

Only limited data is available regarding transit ridership in Puerto Rico. The sources available for this work are summarized below:

- AMA bus ridership extracted from April-May 2016 AMA report;
- Monthly Ridership for First Transit operated services for July 2016 to June 2017 – Metrobus, TU Conexión, Metro Urbano;
- Público ridership by time period (6-9am, 9am-3pm, 3pm-6pm) collected for National Transit Data Base. Final Report. October 2015; and
- Tren Urbano boardings by station for 2010 as used in the 2040 LRTP. This was cross checked against total boardings in 2016 Q4 American Transit Association report which had an identical total ridership.

Highway Path Building and Assignment

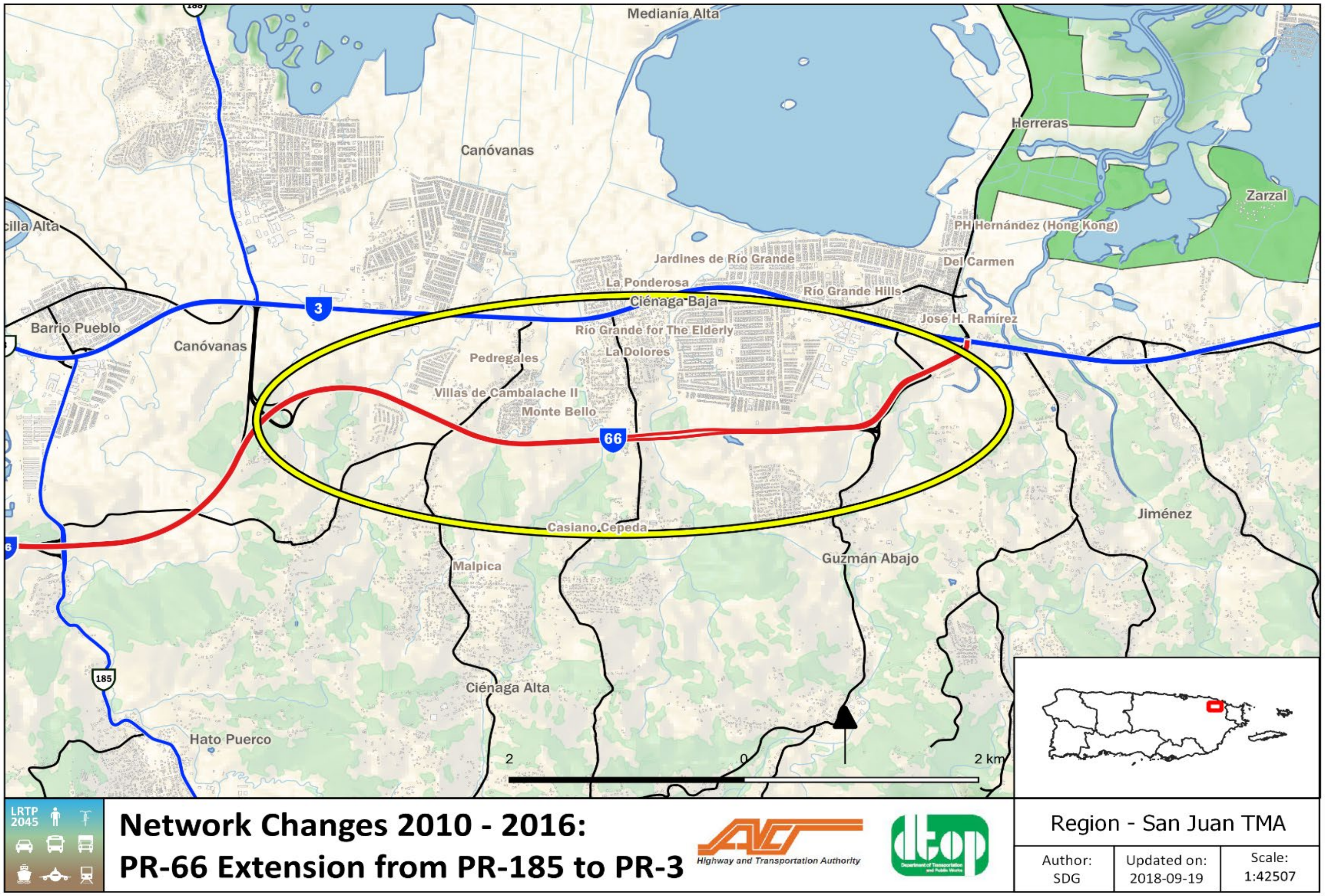
This section contains a description of the updates made in the highway network coding, the highway path building and assignment process, and summarizes the highway assignment calibration in the model base year of 2016. More detail is included in Appendix F.

Network Updates from 2010

- When creating the updated base year 2016 network, extensive review to examine network coding accuracy and to ensure proper network connectivity was conducted. The network was compared against Google Maps imagery and a list of recently completed projects from PRHTA. Two major roadway improvements that have been completed since the 2010 model version were identified and coded into the 2016 highway network. Figure 4.19 and Figure 4.20 show these new roadway segments in the 2016 network: PR-66 extension from PR 188 to PR-3, partially tolled; and
- PR-22 reversible toll lane with dynamic toll varied by time period (DTL) from PR-693 to PR-167.

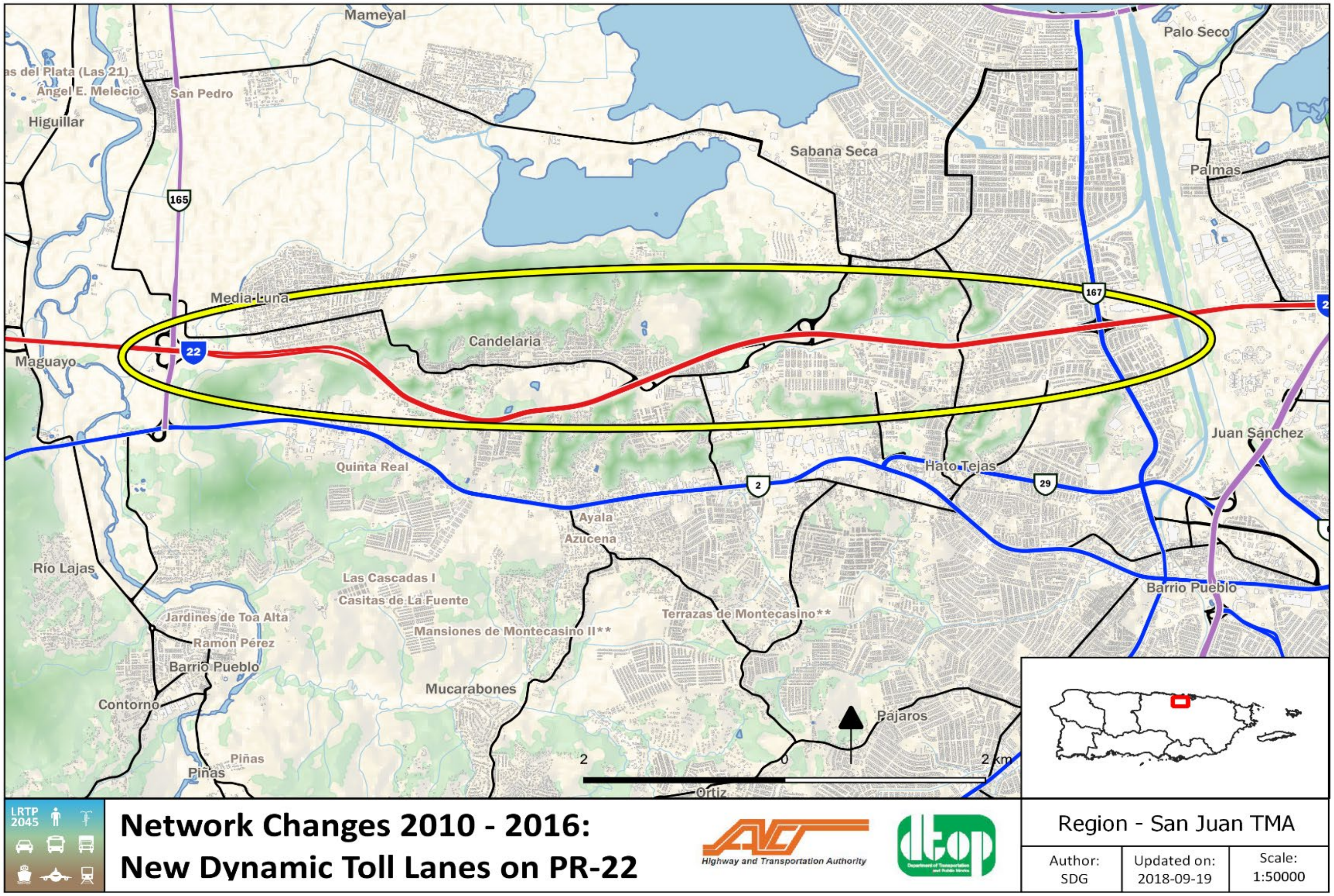
A detailed network comparison was shown in Appendix G.

Figure 4.19: PR-66 Extension from PR-188 to PR-3



Source: SDG

Figure 4.20: New Dynamic Toll Lanes on PR-22



Source: SDG

Speed and Capacity Estimation

Speed and capacity variables are two primary inputs of highway path building and assignment processes. During the course of the model update and calibration, the hourly lane capacities for the 2016 highway network were adjusted based upon professional judgement introducing only minor changes to previous values.

The uncongested speeds were updated using the average speeds in the night period from 2017 National Performance Management Research Data Set (NPMRDS) travel time data[69]. Note that these speeds represent theoretical upper limits before taking the road topographic features into account. Based upon the terrain classification, the following reductions to the uncongested speeds were applied:

- Level: 0%;
- Rolling: 5%; and
- Mountain: 30%.

The estimates of congested speeds were used as inputs to the very first iteration of the highway path building process. To create a pseudo congested condition (a so-called warm-up condition), the input speeds were assumed to be approximately 20 percent lower than the uncongested speeds during peak periods, and 10 percent lower than the uncongested speeds during off-peak periods.

The hourly lane capacities were defined by facility type and by area type. These initial hourly capacities per lane were adjusted to consider geometric constraints or other impedances along the link, such as number of lanes, and the condition of the approaching intersection or ramp configuration.

Toll Variables

The LRTP model network incorporates all toll facilities. Most of the toll roads in Puerto Rico have fixed toll rates throughout the day. The locations rates of toll plazas coded in the network were updated to 2016 conditions.

In April 2013, a new dynamic toll lane was opened between the Buchanan and Toa Baja toll stations on PR-22. The DTL comprises two reversible lanes located in the PR-22 median, which are opened for eastbound travel in AM peak, and for westbound travel in PM peak. During midday and night periods, the DTL is closed for a few hours to facilitate the switch of travel directions. The toll rates on the DTL are determined by traffic volumes, ranging from $0.50 to $6.00 per trip. To simulate the change of direction in DTL during the day, reductions of lane capacities in the off-peak periods were assumed to replicate the partial lane closure. To model the various toll rates on DTL, new link variables to the 2016 highway network were introduced to contain the average toll rates of passenger cars during each period.

[69] NPMRDS travel time data are in February, March, and April of 2017.

Highway Path Building

The highway path building process provides necessary travel time, distance, and cost estimates for several model components, such as trip distribution and mode choice. This process was performed for both peak and off-peak periods, based upon the minimum generalized cost between each zonal pair.

$$auto\ GC = congested\ time \times AVOT + distance \times AVOC\ \ + \text{auto toll}$$

$$truck\ GC = congested\ time \times TVOT + distance \times TVOC\ \ + \text{truck toll}$$

Where:

$auto\ GC$: *generalized cost of a passenger car ($)*

$truck\ GC$: *generalized cost of a truck ($)*

$AVOT$: *auto value of time ($/hour)*

$AVOC$: *auto vehicle operating cost ($/mile)*

$TVOT$: *truck value of time ($/hour)*

- $TVOC$: *truck vehicle operating cost ($/mile).*

The intrazonal time and distance were estimated in the final step of the highway path building process, using half of the sum of time from the two closest nonzero zones.

Highway Assignment

The 2045 LRTP model incorporates a multiclass assignment combining the passenger trip tables with truck trip tables. For use in the highway assignment, vehicles were converted into Passenger Car Equivalents (PCEs[70]), using the factors described in Table 4.21, commonly used in transportation modeling:

Table 4.21: Passenger Car Equivalents (PCEs) used in PR LRTP Model

Vehicle Class	PCE
Auto (SOV, HOV2, HOV3+)	1.0
Commercial Vehicle	1.0
Medium truck	1.5
Heavy truck	2.0

Source: PR LRTP Model

[70] PCEs are used in transportation modeling to reflect the greater amount of highway capacity utilized by trucks.

Travel times are estimated based on the volume-delay relationship, which is implemented through the volume-to-capacity (V/C) ratio on each link of the network. The 2045 LRTP model uses the traditional Bureau of Public Road (BPR) formula.

Calibration

The following section describes how the 2016 Base Year model's highway trip assignment has been validated to observed conditions.

Observed Data

Due to consequences of Hurricane Irma and Hurricane María, it was not possible to collect traffic counts on the roads in fall 2017 as originally proposed. The best available vehicle classification counts were gathered from various data sources. The observed data used for model calibration contained the following sets:

- 2015 – 2017 vehicle classification counts from various months;
- One month of transaction data by vehicle class in September of 2015 and 2016; and
- NPMRDS travel time data in February, March, and April of 2017.

Figure 4.21 depicts the distribution of traffic counts. Among 368 one-way count locations on the entire Island, more than 55% of counts were on freeways and expressways. Approximately 15% were on principal arterials and only about 26% were on minor arterials or local roads. These counts are not evenly distributed by road type.

Figure 4.22 highlights corridors on which travel time data was obtained from NPMRDS. Similarly, to traffic count data, most of the travel times were collected on freeways and expressways. On some road segments, the average travel speed during the night period is slower than peak periods. Therefore, travel time was not used as a primary calibration target.

Existing Traffic Counts and Travel Time Databases

This chapter provides an overview of the data collection databases on main roads in the Puerto Rico road network. Specifically, describing traffic counts and travel times collection efforts, which were essential inputs in the model development and calibration process.

Taking into consideration the recent events in Puerto Rico (i.e. Hurricanes Irma and María) and understanding that traffic patterns were not representative of pre-hurricane travel patterns; these historical datasets are the best source of information for this study. This chapter aims to describe the available traffic count and travel time data.

Traffic Counts

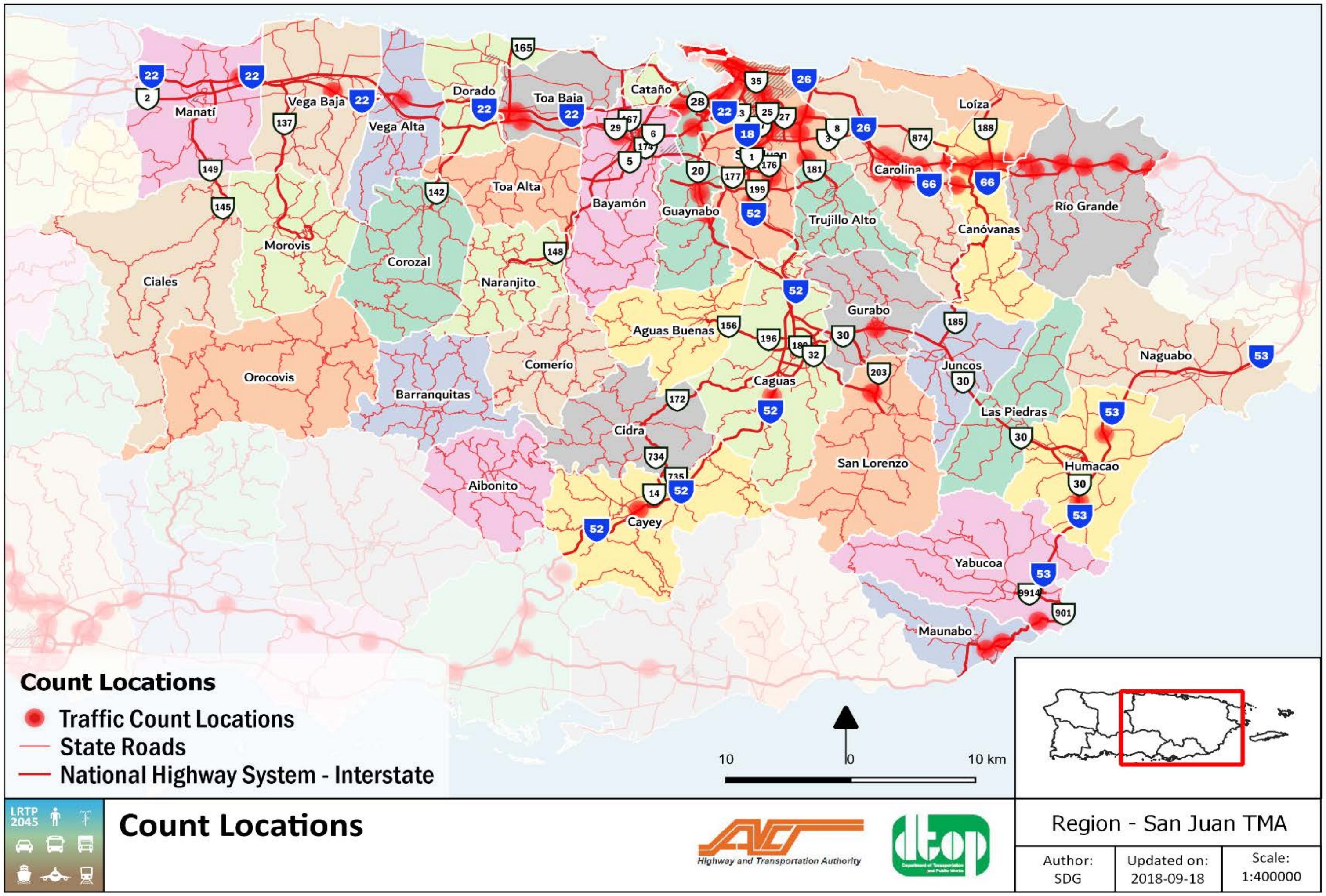
The traffic counts were performed by the PRHTA traffic data collection office thru their internal and subcontracted data collection resources. There were 133 counts locations identified in the San Juan TMA. The locations of each counts are presented in Figure 4.21.

Travel Times

The available travel time information was obtained from the National Performance Management Research Data Set (NPMRDS), through their analytics webpage. NPRMDS provides vehicle probe-based travel time data for passenger autos and trucks. The real-time probe data is collected from a variety of sources including mobile devices, connected autos, portable navigation devices, commercial fleet and sensors. NPMRDS includes historical average travel times in 5 minutes increments on daily basis covering the National Highway System (NHS). The data is provided in two parts. The first part is a Traffic Message Channel (TMC) static file that contains TMC information. The second part includes travel times and identifies roadways geo-referenced to TMC location codes. The two datasets need to be joined in Global Information System (GIS)-based software to provide the full picture.

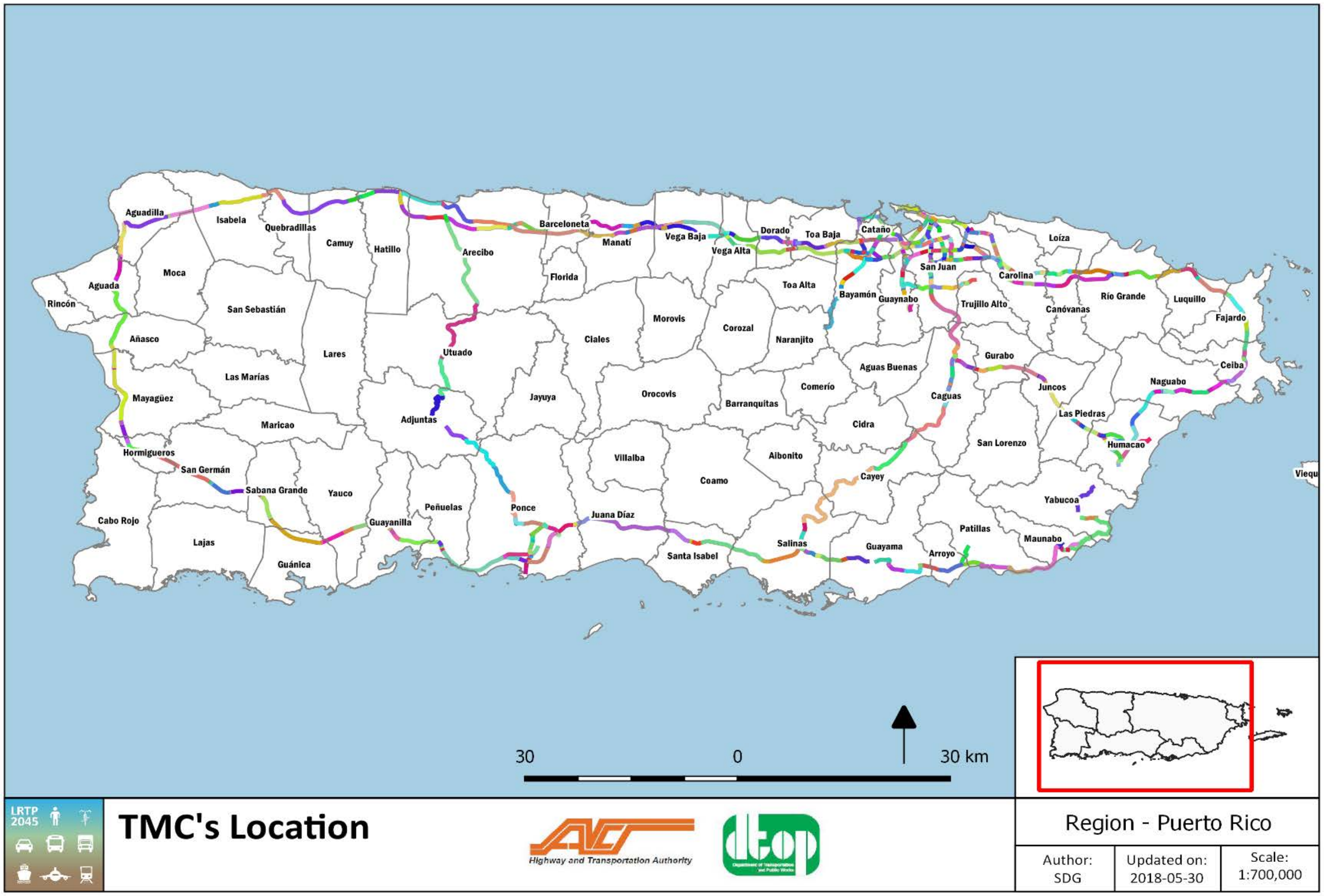
A total of 32 corridors are identified in the platform, as shown in Figure 4.22. Data was collected for pre-hurricane conditions for the months of February, March and April of 2017, for a period of 24 hours for 15-minute intervals.

Figure 4.21: San Juan TMA Counts Locations



Source: Traffic Count locations layer was provided by the Puerto Rico Highway and Transportation Authority (ACT by its spanish acronym)

Figure 4.22: TMC's Location



Source: Steer Davies Gleave, based on NPMRDS Analytics

Calibration Results

The calibration of highway assignment focused on the standard comparison of the modeled volumes to the observed counts by using various classifications and statistical measures of fit such as Percent Error (%Error) and Percent Root Mean Squared Errors (%RMSE) by volume group. Both %Error and %RMSE are commonly used to determine how closely estimated volumes replicate observed count data.

The overview highway assignment statistics were summarized Appendix F to depict different aspects and levels of comparison, including:

- Volumes vs. counts by facility types;
- Volumes vs. counts by sub-Regions;
- Volumes vs. counts by area types;
- Volumes vs. counts on screen lines latter described; and
- Truck volumes vs counts by facility types.

5 CHAPTER 5 FINANCE

This chapter is divided into 5 sections:

1. Context;
2. Prioritization Strategy;
3. Financial Support for Disaster Recovery;
4. Sources of Funds; and
5. Capital Cost Estimates.

CONTEXT

The impact of Hurricane María on Puerto Rico was devastating and it seriously damaged much of the Island's critical transportation infrastructure. For the immediate future, the primary HTA and DTPW's focus must be on disaster recovery and repair. However, this is also the time to be planning and investing in mitigation measures, in order to be prepared for any future catastrophic natural events and ensure greater resilience of the Commonwealth's key infrastructure.

The critical nature of the local economic situation requires economic/financial analysis to help define the available budget and minimum spending obligations, prior to defining the alternatives to be modeled.

A strategic review of funding and financing options has been prepared to provide a prudent and realistic assessment of potential financial resources likely to be accessible to PRHTA over the coming years. The financial team have identified and reviewed the availability and eligibility of various capital grants and loan programs available for transportation infrastructure and transit initiatives, including both apportionment and discretionary/competitive funds.

The PRHTA and the DTPW jointly prepare a STIP, which sets out the proposed distribution by project of federal funds assigned to Puerto Rico, covering highways and transportation related funding from the FHWA, and transit related funding from the FTA.

PRHTA's also produces a 5-year Capital Improvement Program (CIP) which is the basis for preparation of TIP for FHWA federal aid-projects. PRHTA has evaluated the condition of its highways assets, allowing it to identify and prioritize major needs given the limitations on resources, and the associated construction costs. The CIP is subject to approval by the PROMESA Oversight and Management Board.

The CIP estimates the steady state costs for FY22+ amounting to $261.8M per annum, including $130M for pavement, $86M for bridges and $33M for safety. These CIP figures exclude soft costs (in the range 10-18.5% of capital expenditure (capex). There is a separate budget for transit CIP projects. The level of projected costs implies a more than doubling of expenditure on pavement and five-fold increase in the amount allocated for bridges compared with recent STIPs[71].

For operational expenditure and construction in progress, PRHTA relies on funds from toll revenues, transit revenues, federal funds from the FHWA and FTA, and a transfer from the central Government of Puerto Rico (part of which is earmarked).

PRIORITIZATION STRATEGY

The high-level prioritization of projects, as shown in Figure 5.1, follows the PRHTA objectives set out in the Fiscal Plan[72] (page 21), to address immediate needs and backlog, and is further informed by stakeholder consultation.

Figure 5.1: Overview of capex prioritization

Source: SDG analysis

[71] Source: PRHTA Initial Transportation Asset Management Plan; April 2018; PRHTA.

[72] PRHTA Revised Financial Plan 2018-2023; As certified by the Financial Oversight and Management Board for PR; Revised HTS Fiscal Plan; June 29, 2018.

The initial focus is on emergency repairs, developing resilient infrastructure to modern standards, and meeting FHWA targets for condition of interstate and NHS pavements and bridges. Many federal programs require some degree of local match. This could be provided by drawing on toll revenue credits, although there will also be a need for actual funding in order to achieve key targets for state of good repair.

In view of the lack of access to bond markets (due to default on existing bond issues), combined with the government's clawback arrangements for tax streams previously dedicated to transportation, there is no alternative source of funds to provide the local contribution other than specific government transfers.

Demand for construction and project management resources are likely to drive up costs in short term. This is already being reflected in levels of construction cost inflation, which will inevitably reduce the amount of work possible within a fixed, finite budget. Timescales for project start dates may therefore be extended.

A number of possible P3 (Public-Private Partnership) projects have been identified, but their scope for covering financing charges and cost recovery through user fees is limited, which implies a requirement either an upfront capital contribution from the Government or commitment to on-going availability payments. The former is likely to be a more attractive option for investors but would depend on the ability of PRHTA to secure a project specific, discretionary federal loan, which will require time to process and with an uncertain degree of success.

FINANCIAL SUPPORT FOR DISASTER RECOVERY

The Central Office of Recovery, Reconstruction and Resiliency was created to coordinate all sources of federal funding approved for Hurricane María recovery. It estimates that the reconstruction process will take around 10 years.

Preliminary damage assessment for highways totals $652M, of which $642M is expected to be covered by federal funds. There are further costs of $114M for damage to non-highway and transit assets, of which $108M are expected to be covered by a combination of federal funds and insurance claims. It should be noted that the funding allocation is based on a preliminary damage assessment, which may need to be updated. In addition, the costs of repairs could increase, given inflationary trends, and timescales be extended.

Nationally available funding sources are set out in Table 5.1.

Table 5.1: Sources of funding for disaster recovery

	Approved/ obligated funds $M	Local match required	Notes	Allocation to highways and local transportation	Potential contribution $M
FEMA Public Assistance grants	2,432	25%	May use HUD CDBG-DR[73] funds as match	Contribution to non-Federal aid road infrastructure	59.5 (authorized) - 220* (implied)
FHWA Emergency Relief Assistance	142.5	0%	100% Federal funding authorized by Bipartisan Budget Act of 2018	100%	142.5
FTA Emergency Relief	198	10%	Authorized to use Toll Credits as match	100%	198
FTA Resilience	26	20%	Authorized to use Toll Credits as match	100%	26
HUD CDBG-DR	18,438	n/a	Estimated allocation to infrastructure repairs	0.3%	55
Treasury Disaster Relief Loan	2,065			Unknown	
Total	**23,231**				

* Value implied by local match assumed from HUD CDBG-DR
Source: SDG analysis

[73] U.S. Department of Housing and Urban Development's (HUD's) Community Development Block Grant for Disaster Recovery (CDBG-DR).

FEMA Public Assistance Grants

Public Assistance (PA) grants typically represent the largest disbursement of federal funds for short- and long-term disaster recovery. They are the primary form of assistance offered by FEMA (Federal Emergency Management Agency) for the repair, replacement, or restoration of public infrastructure.

FEMA obligates funds for PA projects based on detailed cost estimates derived from damage assessments. FEMA's PA program has (up to July 16, 2018) obligated $2.6 billion in total funding departments and municipalities for debris removal and emergency protective measures related to Hurricane María.

Usually FEMA provides 75% of estimated costs, with the remaining 25% from local sources, although the local contribution may be covered by funds from other federal grant programs, including the U.S. Department of Housing and Urban Development's (HUD's) Community Development Block Grant for Disaster Recovery (CDBG-DR).

Public Assistance funds are intended to be applied to restore facilities to their pre-disaster state and function, and only allow for upgrades where necessary to meet applicable codes and standards.

Hazard mitigation add-on funding (designated as PA 406 program funds) may be sought for improvements designed to make the facilities more resilient and better able to withstand equivalent hazardous events, subject to a cost-benefit analysis to demonstrate cost effectiveness.

FHWA Emergency Relief Assistance

FHWA provides emergency relief (ER) assistance for repair of roads and bridges on federal-aid highways. These funds can be used for improvements that increase resilience of the infrastructure, if the additional costs can be justified based on the potential/expected future damage arising from a similar disaster.

ER funds are normally made available at the normal pro-rata share for federally funded assets: 90% for interstate highways and 80% for other highways the requirement for a local share has been waived in this instance under the terms of the Bipartisan Budget Act of 2018, which authorizes 100% Federal share for projects in construction within 2 years of the Hurricane. This covers both emergency and permanent repairs.

A total of $142.5M has so far been allocated to Puerto Rico in respect of damage caused by Hurricanes Irma ($2.5M) and María ($40M on September 27, 2017, followed by another $30M on November 16, 2017, and $70M in April 2018) as ER13 and quick release funds. "Quick release" funds are applied to restoring essential traffic and repairs to bridges, guardrails, traffic signal systems and to address mudslide and flooding damage. An additional $130M has been requested.

In addition, in response to a request from PR DTOP, FHWA received $59.5 million in reimbursable authority from FEMA to assist DTOP in completing emergency repairs to road infrastructure not eligible for Federal aid. FTA Emergency Relief Program (Statute 49 USC, s 5324).

The FTA's program provides grant funding for capital projects to repair, reconstruct or replace transit equipment and facilities which have suffered serious damage as a result of an emergency, or to protect the same if they are in danger of serious damage. Allocation of Emergency Relief is based upon review and validation of preliminary damage assessment.

The federal share is 90% of permanent or emergency repairs incurred more than 270 days after the disaster declaration date. The funds can also be applied to 100% of transit operating costs of evacuation services and temporary emergency service in the area affected by the emergency.

Funding for resilience – including flood protection, covered storage or power line protection – is available with an 80% federal share. These projects can include elements to bring facilities up to a state of good repair.

Costs already reimbursed by FEMA (or other federal agency) are not eligible, and any FEMA PA Grants approved or in progress which relate to transit costs will be transferred to the FTA Emergency Relief Program.

In response to Hurricane María, FTA allocated to Puerto Rico:

- $197.8M for emergency relief; and
- $25.7M for resilience, subject to approval of the program of projects.

Repair costs incurred within 1 year of the disaster do not need to be included in the TIP/STIP, but resilience projects must be.

HUD Community Development Block Grant for Disaster Recovery

HUD awarded a total of $18.44 Billion (B) to Puerto Rico in April 2018 under the CDBG-DR for the purposes of addressing unmet housing needs, economic development, and infrastructure repair (including bridges and roads). Of the total, $10.2B was allocated for meeting remaining 2017 unmet needs, and $8.3B is for mitigation activities designed to limit future damage. A key priority is the resilience of the electrical power supply system which is nominally apportioned $2B within the total.

The CDBG-DR allocation should be read in the context of the Government's preliminary damage estimate of $31.5B (Nov 27, 2017), and its request for $94.4B to rebuild the Island's infrastructure with adequate resilience to cope with future natural disasters[1].

CDBG-DR funds can be applied only to address needs created as a direct result of a disaster, not for general improvements. 80% of these recovery funds must also be spent in the "most impacted" areas.

PRHTA's Fiscal Plan for 2018-2023 (published April 20, 2018) indicates that it intends to target a 0.3% share of these funds, with potential to generate over $50M over 6 years (at a run rate of up to $15M). Given the importance of road infrastructure and public transportation to economic development and access to employment, it is arguable that the potential claim on available funding could be higher. However, it must be recognized the range of competing demands and the modest scale of funding available relative to the assessed needs.

As a prudent assumption, it is assumed that CDBG-DR funds will, as a minimum, be made available to provide local match for FEMA PA grants related to transportation[74].

Liquidity Funds: Treasury Disaster Loans

The U.S. Treasury initially made available $4.9B in disaster loans, although this was subsequently cut back to $2.06B. Terms have been under negotiation since October 2017 and the proposed conditions prevent access to the facility until the PR Government's cash balance falls below $1.1B.

The Treasury has indicated that it expects the loan to be paid ahead of other creditors, with reporting, collateral and security requirements made explicit. Although historically 90-95% of such debt has ultimately been forgiven, there is no guarantee that this precedent will be followed in the case of Puerto Rico.

For the purposes of this review it is assumed that these funds will not be applied to transportation projects.

Disaster Recovery and Emergency Relief

Access to disaster recovery and emergency relief funding requires satisfying strict conditions and making appropriately evidence-based applications. Although the majority of the expenditure on disaster recovery is expected to be covered by a combination of federal funds or insurance, there will be a requirement for some local funding. The gap may be closed by drawing on other Federal allocations but this would effectively imply reduction in funds notionally allocated to capital improvements and addressing the maintenance/renewal backlog.

For the purposes of preparing the 2045 LRTP Financial Plan the disaster recovery components of funding and expenditure over the next 4 years have been treated as ring-fenced. This approach is intended to provide greater clarity around the long-term capital expenditure required to achieve and sustain minimum asset condition thresholds, address the backlog of renewals and fund a prioritized program of enhancements, given the potential availability of funds. See Table 5.2.

[74] Source: 1. www.aafaf.pr.gov/assets/newfiscalplanforpuerto-rico-2018-04-05.pdf.

Table 5.2: Disaster recovery funding and expenditure FY-2018 - FY2021

		2018 $000	2019 $000	2020 $000	2021 $000	Total $000
Funding						
	Federal Emergency Revenues	175,553	265,565	145,201	55,135	641,454
	Hurricane Loss Assessment - Insurance and FEMA	27,002	54,004	27,002		108,008
	State contribution/transfer	8,498	10,884	4,792	2,484	26,658
	Total funding	**211,053**	**330,453**	**176,995**	**57,619**	**776,120**
Capital Expenditure[1]						
	Federal Emergency Repair Program	175,553	265,565	145,201	55,135	641,454
	Local Emergency Repair Program	6,946	7,780	3,240	2,484	20,450
	Hurricane Loss Assessment - Insurance and FEMA covered	27,002	54,004	27,002		108,008
	Hurricane Loss Assessment - Local Funding Needs	1,552	3,104	1,552		6,208
	Total Capex	**211,053**	**330,453**	**176,995**	**57,619**	**776,120**

1: Including soft costs and matching funds for FEMA ER program
Source: SDG analysis on Disaster Funds data

SOURCES OF FUNDS

Figure 5.2 sets out the outlook for long range funding of operations and capital expenditure.

There are several sources of funds available to the PRHTA:

- Federal Funds;
- State Funds;
- Local Taxes;
- Tolls and farebox income; and
- P3 project Investment

The formal documents that define the shorter-term investment regarding the PRHTA available funds are:

- The Capital Improvement Plan (CIP);
- The Statewide Transportation Improvement Program (STIP); and
- The TAMP.

Federal Funds

FHWA Fixing American Surface Transportation Act (FAST-Act)

As mentioned in Chapter 3; the FAST-Act establishes and funds new programs to support critical transportation projects to ease congestion and facilitate the movement of freight on the Interstate System and other major roads. It requires improvements to the resilience and reliability of the transportation system, storm water mitigation, and enhancements to travel and tourism.

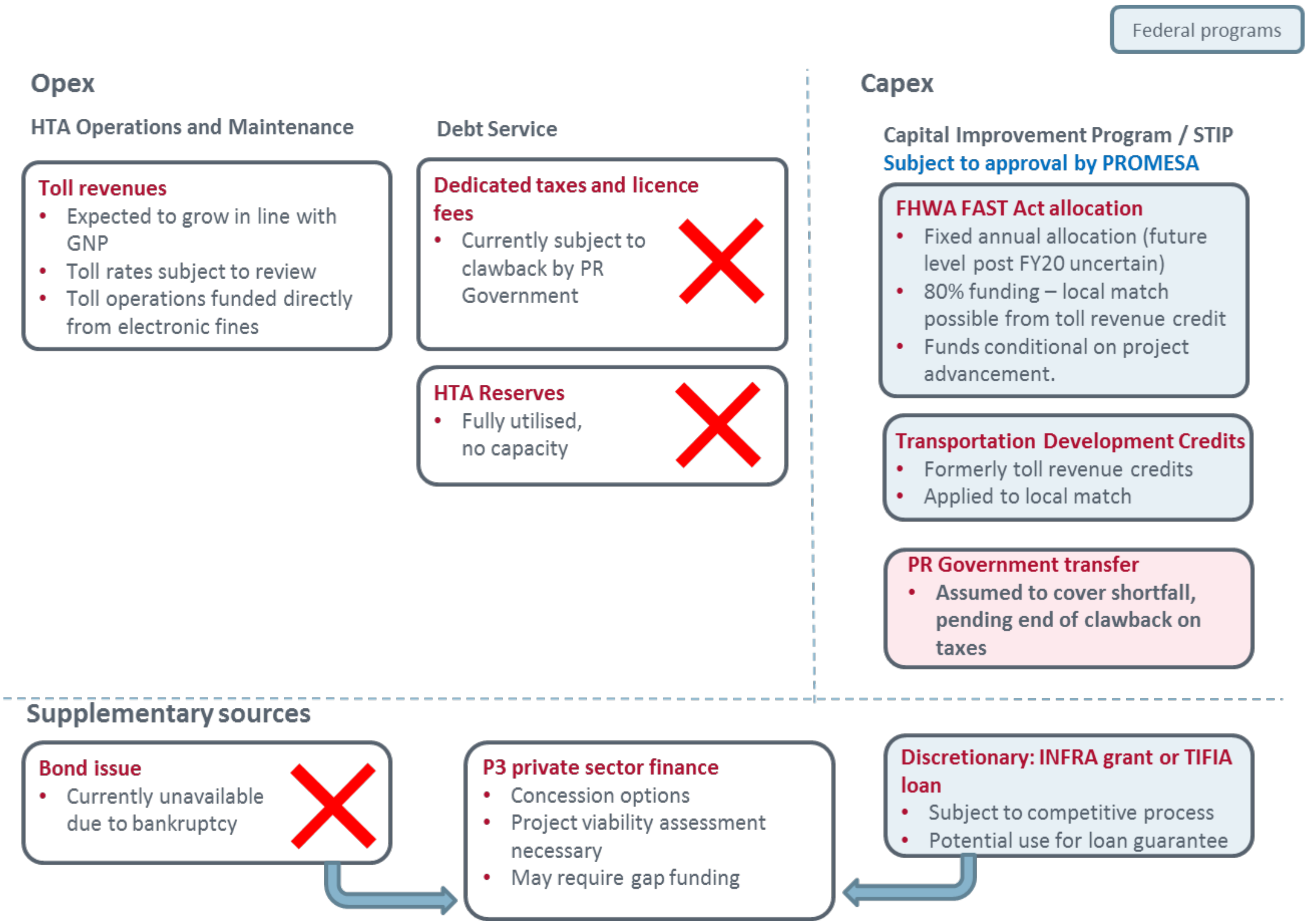
The FAST-Act provides apportioned funding to states/territories for federal-aid highway programs over a 5-year period (at the time FY-2016 through FY-2020). The Highway Trust Fund is the source of funding for most of the programs in the act. However, the FAST-Act also transfers additional funds to the Highways Trust Fund to keep it solvent.

Although Puerto Rico is included in the definition of “state” for most purposes under title 23, it is not eligible to receive funds apportioned among states. Specific authorization for the Puerto Rico Highway Program (PRHP) is provided, with an allocation of $158M annually for fiscal years 2016 through 2020. Penalties are imposed because of the lower minimum drinking age and minimum penalties for repeat offenders due to driving while intoxicated, reducing the available funds to $138.8MM. Section 1115 of the FAST-Act amends the PRHP under 23 U.S.C. 165, which sets out program requirements.

The lump sum payments for each year cover all the apportioned highway programs combined, including pre-defined allocations to:

- National Highway Performance Program (NHPP) [under 23 U.S.C. 119] 50%;
- Highway Safety Improvement Program (HSIP) [under 23 U.S.C. 148] 25%;
- Puerto Rico Highway 25%

Figure 5.2: Funding Sources: Long Range Outlook



Source: SDG analysis

The Federal share of funding for projects is governed by 23 U.S.C. 120. Although generally limited to 80 percent, it can be up to 100 percent in the case of traffic control signalization, pavement marking, commuter carpooling and vanpooling, installation of traffic signs, traffic lights, guardrails, impact attenuators, concrete barrier end treatments, breakaway utility poles, or priority control systems.

Funds are available for obligation for a period of 3 years after the last day of the fiscal year for which the funds are authorized. Any authorized funds that exceed the amount of obligation will be deducted for re-distributed to the States for Surface Transportation Block Grant Program funded projects[75].

A condition of funding is that the grantee demonstrates specific and well defined technical, financial and organizational capabilities. Historically, more than $400MM in available funding was not deployed due to delayed processes for project advancement, project completion and provider payments. PRTHA and FHWA signed a Memorandum of Understanding (MoU) in February 2016 with the objective of implementing enhancements to PRTHA's Project and Program Delivery capabilities.

The default by PRHTA in terms of bond debt obligations could potentially raise questions as to its financial capacity and could put federal funding at risk if the debt restructuring process should breakdown[76].

FHWA Allocation - Asset Management and 10-year Financial Plan

Federal grant funding typically falls into two categories: apportioned and allocated, depending on the manner in which the funds are distributed. The federal aid provided to Puerto Rico is not determined by the standard formula apportionment (which applies to states), but instead by a fixed term allocation.

The FHWA requires a (minimum) 10-year financial plan to be developed which sets out how the authority expects to fund future work and investment as set out in the asset management plan. The plan is to be based on funding levels that can be expected to be "reasonably available" by year, with the planning process required to address the anticipated sources of funding.

The FHWA acknowledges that future funding amounts may be uncertain, and in these circumstances, allows the financial plan to use estimates based on historical values. In the case of apportionment, the potential variance is reasonably limited, with the base allocation to each state typically reflecting their respective share of prior year funding[77]. With a fixed allocation (rather than a formula-based apportionment) it is extremely difficult to predict the future level of funding

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[75] Sources**:** www.fhwa.dot.gov/fastact/summary.cfm.

www.fhwa.dot.gov/specialfunding/prhp/160224.pdf.

www.aafaf.pr.gov/assets/fiscal-plan---pr-highway-and-transportation-authority.pdf..

[76] Source: www.aafaf.pr.gov/assets/fiscal-plan---pr-highway-and-transportation-authority.pdf.

[77] Initial Transportation Asset Management Plan; April 2018; PRHTA.

beyond the current commitments. The fiscal plan assumes that funding for the period up to 2023 will continue at the current level of $138.8M per year net of penalties.

For the purposes of the 2045 LRTP Financial Plan, it has been assumed that the level of funding will be maintained at its current level in real spending terms. In practice this could imply an uplift of 20% to allow for the surge in construction prices post Hurricane María. Much of this could be covered simply by removing penalties. The available transportation development (toll revenue) credits would be adequate to provide the required 20% local match, allowing projects to be fully federally funded.

Discretionary Federal Loan: Transportation Infrastructure Financing and Innovation Act (TIFIA) Discretionary Federal Loan

The TIFIA loan program was established to provide federal credit assistance to eligible transportation projects. The objective is to provide access to funding for large scale transportation projects which are dependent on user (toll) revenues, but where the future revenue stream is subject to uncertainties which would make alternative financing options expensive.

The FAST-Act authorized $1.43 billion in capital over the five years 2016-20 for the program. Direct loans can be for a period of up to 35 years, with repayments starting up to 5 years after opening, to allow for ramp up. TIFIA can also provide loan guarantees for non-Federal financing. The FAST-Act also authorizes payment of subsidy cost (similar to a commercial bank's loan reserve requirement) of supporting Federal credit.

Given that dynamic toll lanes are already in the spending program, and that other funding sources are potentially committed to achieving a state of good repair and improving resilience, this type of loans could be aimed at supporting P3 projects, although the principal amounts of credit assistance are generally limited to 33% of eligible project costs[78].

Discretionary Federal Grant: INFRA Grants

The Nationally Significant Freight and Highway Projects (NSFHP) program was established by the FAST-Act to provide competitive grants, known as INFRA grants, to support regionally significant highway, bridges and freight projects that align with the program goals which include:

- improving the safety, efficiency, and reliability of the movement of freight and people;
- generating national or regional economic benefits;
- reducing highway congestion and bottlenecks;
- improving connectivity between modes of freight transportation;
- enhancing resiliency of critical highway infrastructure and help protect the environment.

An INFRA grant may not exceed 60% of the total eligible project costs, although a further 20% of project costs may be funded with other Federal assistance.

Of the $1 billion funding available in FY-2020, 90% will be allocated to projects which represent more than 30% of the Federal highway aid apportionment, and 10% for smaller projects (with a

[78] Sources: www.fhwa.dot.gov/fastact/summary.cfm.

minimum value of $5 million). It is also stipulated that there should be access to additional stable and dependable source(s) of funding and financing to support the construction, maintenance and operation of the project.

PRHTA was unsuccessful in its application for INFRA grants to support several Dynamic Toll Lanes projects in FY-2017-2018. Successful applicants typically sought a smaller percentage grant contribution, but this approach would not be viable given the financial situation of Puerto Rico.

Matching contribution – Toll Transportation Development Credits (Formerly Toll Revenue Credits)

Section 120(i) of Title 23 of the United States Code permits states to substitute certain previous toll-financed investments for state matching on current Federal-aid projects. The non-federal share of a project's cost may be met through a "soft match" of toll credits. This means the federal share can effectively be increased to 100 percent of the total project cost. The credits can be applied for the construction of new infrastructure, or the maintenance or improvement of existing public highways, including those which have received federal-aid funding in the past.

It should be noted that although these credits are often referred to as a source of funding, they do not represent actual available funding. They are typically applied in order to free local funds (which would otherwise need to be committed), allowing the flexibility to fund other transportation projects (which may not themselves be eligible for federal funds), or to support operating costs.

Toll credits may be claimed only for the share of a project’s capital expenditures which are supported by toll revenues accruing to a toll authority (public agency or private entity). The allowable credit excludes revenues needed for debt service, returns to investors, or the operation and maintenance of toll facilities.

In addition, an annual maintenance of effort (MOE) test is applied, which must certify that the toll facilities are being properly maintained in the year to which the credit relates before excess revenues can be credited. The actual level of maintenance spend in relation to initial estimates is also monitored and any shortfall will result in a requirement to replace federal funds with local funds on projects where the credit was applied. Future ability to accrue additional credits will therefore depend on meeting the MOE requirements.

The amount of credit earned equals the amount of excess toll revenues spent on Title 23 highway capital improvement projects. However, if federal funds were used for the project which generates the tolls, then the available credit is reduced by the percentage of the total project cost sourced from federal funds, i.e. if 80% of the original project was federally funded, the toll credit is reduced by 80%. Once approved the credit remains available until used.

In the PRHTA Fiscal Plan 2017-2023 it was stated that there was an outstanding balance of $665M toll credits. In Q1 2016, PRHTA validated compliance with FHWA guidance. The use of these credits as matching contributions is estimated at approximately $30M per year based on the current level of allocated funding, implying potential for these credits to be applied over the next 20 years[79].

Local Taxes Dedicated to Transportation and Government Transfers

The Authority's funding originally included a range of pledged tax and licence revenue streams. However, starting in 2016 these revenues have been subject to government clawback, being used instead to make payments on bonds of the Government Development Bank (GDB), guaranteed by the government. The clawback covers: Gasoline tax; Diesel tax; Petroleum products tax; Vehicle license fees; and Cigarette tax.

However, in Puerto Rico these allocations are not constitutionally dedicated and the funds can be re-purposed by the government, as is the case under the "clawback" arrangement now applied. At the present time there is no end date for the clawback and, as a prudent and conservative approach, it has been assumed that these funds will not be available over the term of the 2045 LRTP.

The net result of the clawback to date is that PRHTA has been unable to make interest or principal payments on bonds, or interest payments due to the former GDB. PRHTA initially continued to make bond payments using reserve funds, but they were unable to do so beginning in July 2017. The result has been PRHTA filing for bankruptcy under Title III of PROMESA.

The clawback has also resulted in an overall shortfall against approved expenditures. To address the shortfall there is expected to be transfer payments from the Commonwealth, amounting to 26% of the clawback in FY-2017-18 but averaging 30% over the term of the current Fiscal Plan and projected to rise to over 40% by FY-2022-23. The advice from DTOP is that this it should be assumed that such transfers will continue at a similar rate after the Fiscal Plan period ends[80].

State Funds Earmarked for Capex

PRHTA has received a one-off appropriation of $75M for capital expenditure from the Central Government. This includes a contribution to local construction and other projects beyond the limit of federal funding. It expects to receive $475M from state funds for matching of federal funds, for maintenance related activities and to cover soft costs (although notionally earmarked for Capex) during the period of the fiscal plan. However, the profile of payments shows a fall from $160M in 2017-18 to $53M in the last two years of the plan[81].

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[79] Sources: www.fhwa.dot.gov/fastact/summary.cfm.

[80] Sources: PRHTA Initial Asset Management Plan, April 2018.

[81] Sources: PRHTA Revised Financial Plan 2018-2023; As certified by the Financial Oversight and Management Board for PR; Revised HTS Fiscal Plan; June 29, 2018.

Toll Rates and Additional Tolling Opportunities

Toll revenues

The level of tolls in Puerto Rico is low in absolute terms but at upper levels in relation to incomes, in comparison to US states (Fiscal Plan 2018 p.49[82]).

Toll revenue estimates included in the Fiscal Plan are based on a tiered catch-up of historical CPI since the last toll raise, plus an average CPI of 1.62% to account for current year(s), over the 5 years to FY2023. Subsequent years assumed tolls would continue to be increased by CPI plus 1.5%. The revenue was expected to contribute $167M in FY2023, up from $120M in FY-2018.

However, plans to increase tolling above CPI have been abandoned, for at least the next five years, as being inconsistent with the public policy of PRHTA and the Government of Puerto Rico. Future increases are now seen as conditional on improving road conditions.

Toll Highway Administration and Maintenance

Toll highway administration and maintenance costs are estimated at around $35M per year. This was largely offset by electronic toll fines in FY-2018, but this contribution is expected to decline to $19M per year subsequently, only partly compensated by rising ancillary revenues (for example, advertising signage). This will leave a cumulative shortfall of around $41M by FY-2023.

Potential for Additional Tolling

Federal law limits the imposition of tolls on existing highways which have been built or maintained using federal funds. Tolls can be imposed for single occupant use of HOV lanes or with the objective of congestion pricing. In other circumstances, tolls can only be levied on existing roads following reconstruction (e.g. for capacity expansion or other improvements).

If the authority certifies that the facility is being adequately maintained, and generating sufficient revenue to pay for operations, the surplus can be applied to contribute to the cost of other highway activities or support public transportation operations, provided that the application would not be in violation of the authority's bond covenants.

The fiscal plan includes a $5M contribution up to FY-2023 but opportunities may be limited unless the approach included ways to protect residents with no other access routes.

P3 Project Investment

Encouraging private sector capital investment would appear to offer a means of implementing projects whilst minimising the dependence on government funding. The Puerto Rico Government is proposing to further strengthen the P3 legal framework to facilitate critical infrastructure investments.

[82] PRHTA Revised Financial Plan 2018-2023; As certified by the Financial Oversight and Management Board for PR; Revised HTS Fiscal Plan; June 29, 2018.

The P3 Authority is focused on developing critical infrastructure projects, and unsolicited private sector proposals can be submitted. The success of toll road concessions for PR-22 and PR-5 would appear to provide a successful precedent. Current priority projects in development include a concession to modernise, operate and maintain government-owned parking facilities.

New Projects

Any investor in a P3 will have expectations of a return over the duration of a concession, either from user fees or availability or service fees payable by PRHTA or the PR Government. A complicating factor is that there is considerable uncertainty associated with forecasts of future usage of any infrastructure, given the outlook for the macro-economic environment and a decline in population through continued net migration.

At the same time, PRHTA is unlikely to be able to provide cast iron assurances with regard to providing either a minimum revenue guarantee or making availability and service payments without access to additional funds. The Government is equally unlikely to be able to offer such guarantees as a backstop given other demands on its finite resources. Similarly, there may be concern about the ability of PRHTA to fund the construction or maintenance of essential related infrastructure (e.g. roads which feed or distribute traffic using the tolled facilities).

The potential return for investors could be improved by an upfront government contribution to offset capital costs. This might be recovered in the longer term by a revenue sharing mechanism. In these circumstances, it may be possible to apply for a discretionary TIFIA loan with appropriate grace period (during construction) and a 35-year repayment term, as discussed earlier. The credit contribution from a TIFIA loan is typically limited to 33% of eligible project costs which may prove a significant constraint, given the relatively low levels of revenue generated by potential highway projects identified by PRHTA.

In these circumstances, the potential to secure P3 investment is likely to be a binary option, depending on whether an application for a TIFIA loan is granted (or not). Given the time required to make an application, and for its evaluation, it is suggested that any associated projects cannot begin before FY2024.

P3 Covering Existing Assets

The option of transferring existing highway infrastructure assets with a proven history of toll revenue generation is subject to uncertainty in view of the associated direct loss of a revenue stream supporting PRHTA's activities, and because of potential competing claims to the associated cash flow from PRHTA's creditors. However, there would be more certainty if the proposed transactions and associated asset transfers as part of a P3 were to be included in a fiscal plan certified by the PROMESA Board.

Capital Improvement Program (CIP)

The Fiscal Plan approved and certified by the Financial Oversight and Management Board (FOMB) on June 29, 2018 covers anticipated revenues and capital and operating spending through to FY-2023. It includes completion of current projects and a projected level of transfers from the Government, in addition to state funds already earmarked for capex.

The construction program reflects the Capital Improvement Program (CIP) budget produced by PRHTA. The projected "steady state" run rate of $261.8MM in hard costs per year, which reflects the level of spending deemed necessary to keep the National Highway System (NHS) and Interstate system in a state of good repair compliant with federal standards, but only a minimal level of intervention on non-NHS roads. An average of $129.6M is allocated to pavement works, $85.5M to bridges, $33.5M to safety and $13.2M to traffic signalling (in 2018 USD).

The implied breakdown by highway classification is shown in Table 5.3.

Table 5.3: Notional Allocation of CIP Budget by Highway Classification

Highway classification	Lane-kms	Anticipated spend per annum $M	Equivalent spend/km $000
Toll roads	874	35	40.0
Primary roads	2225	32	14.4
Urban Primary	2052	29	14.1
Secondary	5936	61	10.3
Tertiary	8049	85	10.6
All highways	19136	242	12.6

Source: Based original CIP budget of $242MM (the validated version of CIP totals $262MM and includes a higher allocation to bridges with reduction in funds for pavements and safety).

Transportation Asset Management Plan (TAMP)

The TAMP is designed to provide a comprehensive management program to address the backlog of pavements and bridges in poor condition, bringing them up to standards which meet FHWA targets and sustaining a state of good repair.

Development of TAMP is a federally mandated requirement: failure to produce a plan would have resulted in substantial penalties, increasing the local match for use of Federal funds.

In view of the expected levels of available financing, PRHTA is only seeking to meet the minimum standards for pavements and bridges. Even before Hurricane María, the condition of interstate pavements was well below target, and bridges close to the maximum permitted level in poor condition as shown in Table 5.4.

Table 5.4: Target Standards and Actual Condition (Pre-María)

	Poor condition - FHWA target	Poor condition - PRHTA target	Poor condition - actual (2016)
Interstate Pavement	<5%		16.2% (19.4% lane miles)
Non-Interstate NHS Pavement		<20%	7.4% measured (+12.9% non-measured)
NHS Bridges (by deck area)	<10%		9.5%

Source: PRHTA Initial Asset Management Plan, April 2018

Failure to meet the standards over 2 consecutive years for pavements (and 3 years for bridges) will lead to penalties which are likely to restrict the potential obligation of NHPP and STP funds, forcing their allocation to remedial works to bridges and pavements. The reality is that PRHTA expects to take over 10 years to bring the interstate pavements up to standard, and is already proposing to allocate all the available federal funds in this manner, plus meeting the obligation with respect to the funding allocation to safety projects.

The backlog of highway pavement work is estimated at $185M for interstates and $342M for NHS.

A number of scenarios were considered as part of the TAMP, reflecting more or less aggressive strategies for the replacement, rehabilitation and renewal of assets, from an unconstrained budget case with a 5-year time horizon, through to less expensive, longer term options intended to allow an alternative distribution of available finance. All cases imply a higher level of spending than historic levels, and spending will peak before reverting to a level necessary to sustain steady state condition.

The TAMP did not settle on any scenario, as it needed to align with the CIP, which was not yet accepted at the TAMP date of publication (April 2018).

For bridge works TAMP Scenario 5 (Table 7.5) was applied for the purposes of the financial plan, reflecting the “preferred” scenario which spent the allocation in the fiscal plan as quickly as reasonably possible, starting with light rehabilitation and allowing time to develop more ambitious projects. Within this total, the allocation to non-NHS bridges follows TAMP Scenario 4 (Table 7.10). For pavements, the profile of spending followed the balanced scenario set out in PRHTA 2019-2028 Capital Improvement Program Validation (June 22, 2018) report.

Allocation of Funds - Highways

Illustrative Allocation of Funds: State of Good Repair (SGR)

The 2045 LRTP assumes that the first priority, post disaster recovery, will be to meet federal targets for the interstate and NHS bridges. Failure to meet the targets will, in any case, oblige all Federal funding would be directed towards these efforts. The assume spending profile is based on PRHTA’s “balanced” scenarios, which seek to apply a realistic approach to a ramp up of work. 25% of the available FHWA funds also need to be committed to safety projects. See Table 5.5.

There are sufficient toll revenue credits available as local match over the next 20 years, so the available level of federal funding should not be available in full, irrespective of the level of local contribution. However, the level of funding currently provided by FHWA is below the level of expenditure required to deliver the state of good repair (SGR) program over the next 10 years. This means there will be a continuing need for Government of Puerto Rico to transfer funds to balance the books, beyond the period covered by the present fiscal plan.

Illustrative Allocation of Funds: Highways, Bridges

Post-2028 there is expected to be a levelling off in expenditure on SGR for interstate and NHS pavements, and reduction in allocation to NHS bridges, assuming the catch-up is largely completed. However, the initial funding allocation had a minimal allocation to the non-NHS network, which also faces a substantial renewal backlog. It is envisaged that an increase of 25% in the allocation to non-NHS pavements and bridges is likely to be required, as a minimum, going forward.

In overall terms, the allocation to interstate and NHS highways and bridges is projected to continue at around $128M per year in real terms, which is above the notionally available FHWA funding of $102M (after deducting the $37M which must be allocated to safety measures). A continuing level of state contributions is therefore inevitable if SGR targets are to be met.

Any additional capex on non-SGR projects is going to depend on the ability of the government to either relax the clawback on taxes/license fees, or willingness to continue to make funds available via a transfer payment.

As an illustrative case, a prioritized list of capex projects has been developed, with estimated start dates, indicative timeline (1-5 years depending on project scope) and cost profiles to arrive at a broadly even rate of annual spend. Expenditure on safety related projects, bike and pedestrian interventions and resilience studies was excluded, as these are assumed to be covered by specific allocations from within the FHWA budget.

The net result is project spending in the immediate post Fiscal Plan period FY 2024-2028, rising from $10M in 2025 to $20M by 2028. Spending is then assumed to ramp up to an average of $25M per year through to 2045. This illustrative scenario implies transfers from Government at a broadly consistent rate of $200M per year in real terms (2018 prices) through to the end of the LRTP, which is less than half of the amount of clawback of taxes and fees. It should be noted that the affordability of priority projects is based on cost estimates at 2018 prices with 20% inflation, and makes no allowance for further cost inflation.

Source and Allocation of Capital: Highways FY-2018-2028

Table 5.6 sets out the anticipated level of funding and capital expenditure during the period of the current fiscal plan (to FY-2023) and the following 5 years, based on the TAMP balanced scenarios to achieve target state of good repair.

Source and Allocation of Capital: Highways Projections FY-2029-2045

Table 5.7 sets out the anticipated level of funding and capital expenditure in the period FY-2029 to FY-2045, assuming continued expenditure to sustain SGR on interstates and NHS, and start to address the backlog on non-NHS highways. Modest levels of funding are allocated to identified priority projects. It is recognized that there is potential for some slippage in the planned timeline for project start and completion, particularly in view of construction community capacity and resource constraints.

Table 5.5: State of Good Repair and Safety Project FY-2019-2028 – Balanced Scenario (Costs in $000)

	FY	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Interstate Pavement Asphalt	SGR	14,228	6,693	6,693	66,93	6,693	6,693	30,681	30,681	30,681	30,681
Interstate Pavement Concrete	SGR	16,940	16,613	3,271	44,171	44,171	44,171	44,171	44,171	27,416	27,416
NHS Pavement Asphalt	SGR	53,758	53,233	51,152	51,152	51,152	51,152	28,685	28,685	28,685	28,685
NHS Pavement Concrete	SGR	12,610	16,058	12,611	12,611	12,611	12,611	2,205	2,205	2,205	2,205
Non-NHS Pavement	SGR	28,784	30,238	28,396	28,396	28,396	28,396	28,396	28,396	35,209	35,209
All Pavement		126,320	122,835	102,123	143,023	143,023	143,023	134,138	134,138	124,196	124,196
NHS Bridges (Scen 5-Scen 4 non-NHS)	SGR	10,000	28,000	26,000	41,000	61,000	52,000	52,000	52,000	52,000	52,000
Non-NHS Bridges (TAMP Table 7.10, Scenario 4)	SGR	17,000	17,000	24,000	24,000	24,000	34,000	34,000	34,000	34,000	34,000
All Bridges (TAMP Table 7.5, Scenario 5)	SGR	27,000	45,000	50,000	65,000	85,000	86,000	86,000	86,000	86,000	86,000
TAMP - Interstate and NHS Pavements & Bridges	SGR	107,536	120,597	99,727	155,627	175,627	166,627	157,742	157,742	140,987	140,987
TAMP - Non-Interstate Pavements & Bridges	SGR	55,784	75,238	78,396	93,396	113,396	114,396	114,396	114,396	121,209	121,209
Traffic signals	SGR				13,229	13,229	13,229	13,229	13,229	13,229	13,229
Safety projects					36,649	36,649	36,649	36,649	36,649	36,649	36,649
Total		**163,320**	**195,835**	**178,123**	**298,901**	**338,901**	**330,901**	**322,016**	**322,016**	**312,074**	**312,074**

Source: PRHTA 2019-2028 Capital Improvement Program Validation (June 22, 2018)

Table 5.6: Highways – Source and Application of Funds 2018-2028 (All Figures in $000 at 2018 Prices)

			Fiscal Plan						TAMP scenarios (balanced)				
		FY	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Funding sources													
	FWHA - after penalty		132,766	401,926	313,922	168,768	138830	138,830	138,830	138,830	138,830	138,830	138,830
	State Funds Earmarked for Capex		159,963	82,073	67,334	59,067	53020	53,761					
	Transfer from PR Govt (balancing item)		31,288			109,898	145075	144,031	203,253	194,368	203,253	203,768	206,368
	Total Capex Funding - Highways		324,017	483,999	381,256	337,733	336925	336,622	345,198	344,256	342,344	323,256	323,256
Capital Expenditure													
FHWA	FHWA Construction Spend		95,768	340,801	255,567	140,769	120009	117,156					
	FHWA Construction Soft Costs		36,260	51,315	49,614	22,967	18821	21,674					
	FWHA Capex projects												
	FHWA contribution to SGR Pavements & Bridges								102,181	102,181	102,181	102,181	102,181
	FHWA Safety projects (based on req funding allocation)								36,649	36,649	36,649	36,649	36,649
State	Non-Federal Construction Projects		111,750	20,796	27,606	129,169	152734	152,734					
	Non-Federal Construction Soft Costs		14,153	6,800	6,481	22,556	24989	24,686					
	Construction Local		23,160	9,190	9,190	9,190	9190	9,190					
	State Capex projects												
	State contribution to Interstate and NHS SGR								64,446	64,446	55,561	55,561	38,806
	State contribution to non-NHS SGR								114,396	114,396	114,396	121,209	121,209
	Prioritized highways projects (excl safety)											9,400	12,000
	Traffic signals SGR								13,229	13,229	13,229	13,229	13,229
	Design		23,000	7,769	10,716	7,882	7882	7,882	7,882	7,882	7,882	7,882	7,882
	Right of Way		3,300	3,300	3,300	3,300	3300	3,300	3,300	3,300	3,300	3,300	3,300
	Right of Way Payments		16,626	12,736	7,068	1,900							
	Total Capital Expenditure - Highways		**324,017**	**452,707**	**369,542**	**337,733**	**336925**	**336,622**	**342,083**	**342,598**	**345,198**	**344,256**	**342,344**

Source: SDG analysis

Table 5.7: Highways – Source and Application of Funds 2029-2045 (All Figures in $000 at 2018 Prices)

		Projections											Average year
		2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040-45
Funds													
	FWHA - after penalty	138,830	138,830	138,830	138,830	138830	138,830	138,830	138,830	138,830	138,830	138,830	138,830
	State Funds Earmarked for Capex												
	Transfer from PR Govt allocated to Capex (balancing item)	195,962	198,557	198,208	200,448	203,686	198,870	203,284	200,237	197,416	199,167	204,597	201,798
	Total Capex Funding - Highways	**334,792**	**337,387**	**337,038**	**339,278**	**342,516**	**337,700**	**342,114**	**339,067**	**336,246**	**337,997**	**343,427**	**340,628**
Capital Expenditure													
FHWA	FHWA Construction Spend												
	FHWA Construction Soft Costs												
	FWHA Capex projects												
	FHWA contribution to SGR Pavements & Bridges	102,181	102,181	102,181	102,181	102181	102,181	102,181	102,181	102,181	102,181	102,181	102,181
	FHWA Safety projects (based on req funding allocation)	36,649	36,649	36,649	36,649	36649	36,649	36,649	36,649	36,649	36,649	36,649	36,649
State	Non-Federal Construction Projects												
	Non-Federal Construction Soft Costs												
	Construction Local												
	State Capex projects												
	State contribution to Interstate and NHS SGR	25,806	25,806	25,806	25,806	25,806	25,806	25,806	25,806	25,806	25,806	25,806	25,806
	State contribution to non-NHS SGR	125,511	125,511	125,511	125,511	125,511	125,511	125,511	125,511	125,511	125,511	125,511	125,511
	Prioritized highways projects (excl safety)	20,234	22,829	22,480	24,720	27,958	23,141	27,556	24,509	21,687	23,439	28,868	26,069
	Traffic signals SGR	13,229	13,229	13,229	13,229	13,229	13,229	13,229	13,229	13,229	13,229	13,229	13,229
	Design	7,882	7,882	7,882	7,882	7,882	7,882	7,882	7,882	7,882	7,882	7,882	7,882
	Right of Way	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300
	Right of Way Payments												
	Total Capital Expenditure - Highways	**334,792**	**337,387**	**337,038**	**339,278**	**342,516**	**337,700**	**342,114**	**339,067**	**336,246**	**337,997**	**343,427**	**340,628**

Source: SDG analysis

Transit Funds and Capex

Transit capital funding comes principally through the FTA 5339 allocation for bus and bus facilities. The associated capex can therefore be treated separately from highway expenditures. See Table 5.8

A series of service expansion projects are envisaged with associated investment in buses, route infrastructure and terminal facilities. The level of expenditure is presented in five-year intervals from the end of the current Fiscal Plan.

There also needs to be continued investment in renewal of the existing fleet and refurbishment of facilities.

Table 5.8: Transit – Source and Application of Funds (All Figures in $000 at 2018 Prices)

				Fiscal Plan						Projections		
			FY	2018	2019	2020	2021	2022	2023	2024-2028	2029-2033	2034-2038
Funds												
FTA 5339 funds (bus & bus facilities + statewide allocation)				4,890	5,007	5,124	5,000	5,000	5,000	25,000	25,000	25,000
FTA additional capex funding allocation (disaster recovery)				45,110	44,994	44,876						
	Total			**50,000**	**50,000**	**50,000**	**5,000**	**5,000**	**5,000**	**25,000**	**25,000**	**25,000**
Capital Expenditure												
Transit CIP				31,000	50,000	50,000	5,000	5,000	5,000			
Transit Prioritized projects (service expansion)										15,797	14,362	5,859
Other fleet renewal and SGR										9,203	10,638	19,141
	Total			**31,000**	**50,000**	**50,000**	**5,000**	**5,000**	**5,000**	**25,000**	**25,000**	**25,000**

Source: SDG analysis

CAPITAL COST ESTIMATES

Context

A list of potential projects for inclusion in the LRTP was prepared based on:

- Needs of the Municipalities to comply with their land use and transport plans;
- Existing projects requiring further investments; and
- Projects included in 2040 LRTP that are in the pipeline.

As explained earlier, the list of potential projects was analysed based on the priorities defined for the Goals and Objectives of this 2045 LRTP. The projects were then ranked (the methodology applied is described in Appendix H). The project identification and ranking process were discussed in detail with the Technical Committee and the leadership of the PRHTA.

Approach

Capital costs were calculated for each individual investment being considered, reflecting the key project characteristics regarding the scope and scale of the project (for example, the extent and length of highway widening).

The project phasing was based on the combination of rankings with the expected availability of funds, and the combination of anticipated construction periods and assumed spread of costs by construction year. Projects were added up to the level of funding assumed be available in each year.

Source Data

Project Details

A wide range of projects have been included in the LRTP, covering investments in the following categories:

- Operations;
- Reconstruction;
- Technologies;
- Improvements;
- Capacity Increases;
- New Construction;
- Congestion Management; and
- Preservation.

In each case, information is provided including a description of the project, and key statistics regarding the scale and scope of the project.

Costs

Estimated costs associated with the project metrics have been developed based on:

- Estimates of capital costs associated with projects included within the PRHTA Capital Improvement Program (CIP) database, June 2017;

- Costs associated with project metrics included within the PRHTA Initial Transportation Asset Management Plan (TAMP), April 2018;
- Unit costs associated with project metrics included within the PRHTA 2019-2028 Capital Improvement Program Validation report, June 22, 2018;
- Estimates of capital costs associated with projects included within the State-wide Transportation Improvement Program (STIP), Fiscal Years 2017-2020, Amendment #2 report, February 23, 2018.

The reference costs are intended to reflect latest estimates at 2018 prices, allowing for 20% cost inflation, post Hurricane María, which reflects the combination of a relatively small Island, limited construction community and rapid increase in demand for services. Full project cost tables are included in Appendix H.

6 CHAPTER 6 2045 PLAN

This chapter presents the 2045 LRTP. It is divided into three main sections that include the conclusion of the scenarios analysis, the definition of project priorities and the modelling results for the future 2045:

1. Tested Scenarios:
   a. Freight Network Extension;
   b. Transit Service Extension;
   c. Roadway Network Vulnerability Assessment; and
   d. Bottleneck Analysis.
2. Cost Feasibility Plan Scenarios:
   a. Transportation Funding Summary; and
   b. 2045 Models.

TESTED SCENARIOS

As part of the development of this 2045 LRTP, 4 scenarios were analyzed based on the planning approach discussed earlier. These scenarios are:

- Freight network extension;
- Transit service extension;
- Roadway network vulnerability assessment; and
- Bottle neck identification.

The results from these scenarios are discussed in more detail in the next sub-sections.

Freight Network Extension

The planning factors include the priority of increasing accessibility and mobility of freight and the integration and connectivity of the transportation system, across and between modes, for people and freight.

Based on this planning factor, the 2045 LRTP model was tested considering an extended truck network system defined beyond the FHWA network presented in Figure 6.1, the map represents suggested key freight network roads based on inputs from the Freight Committee members as part of the engagement process of the Plan. This scheme includes access to/from port zones and major cargo mobility areas as well as the completion of the strategic roadway system based on the results Freight Advisory Committee meetings discussions. Table 6.1 and Table 6.2 list the new freight corridors and other roadways that were coded as freight corridors within the Island-wide model. This analysis was performed with the travel demands under the condition of 2016 population and employment.

Table 6.1: New Freight Corridors

Name	Distance (mile)	Facility Type
PR-22 Extension	27.63	Freeway
PR-53 Extension Patillas to Maunabo	8.38	Freeway
PR-2 convert to Freeway	17.83	Freeway
PR-10 Extension	4.52	Principal Art
PR-5 Extension from Humacao and Maunabo	3.54	Freeway

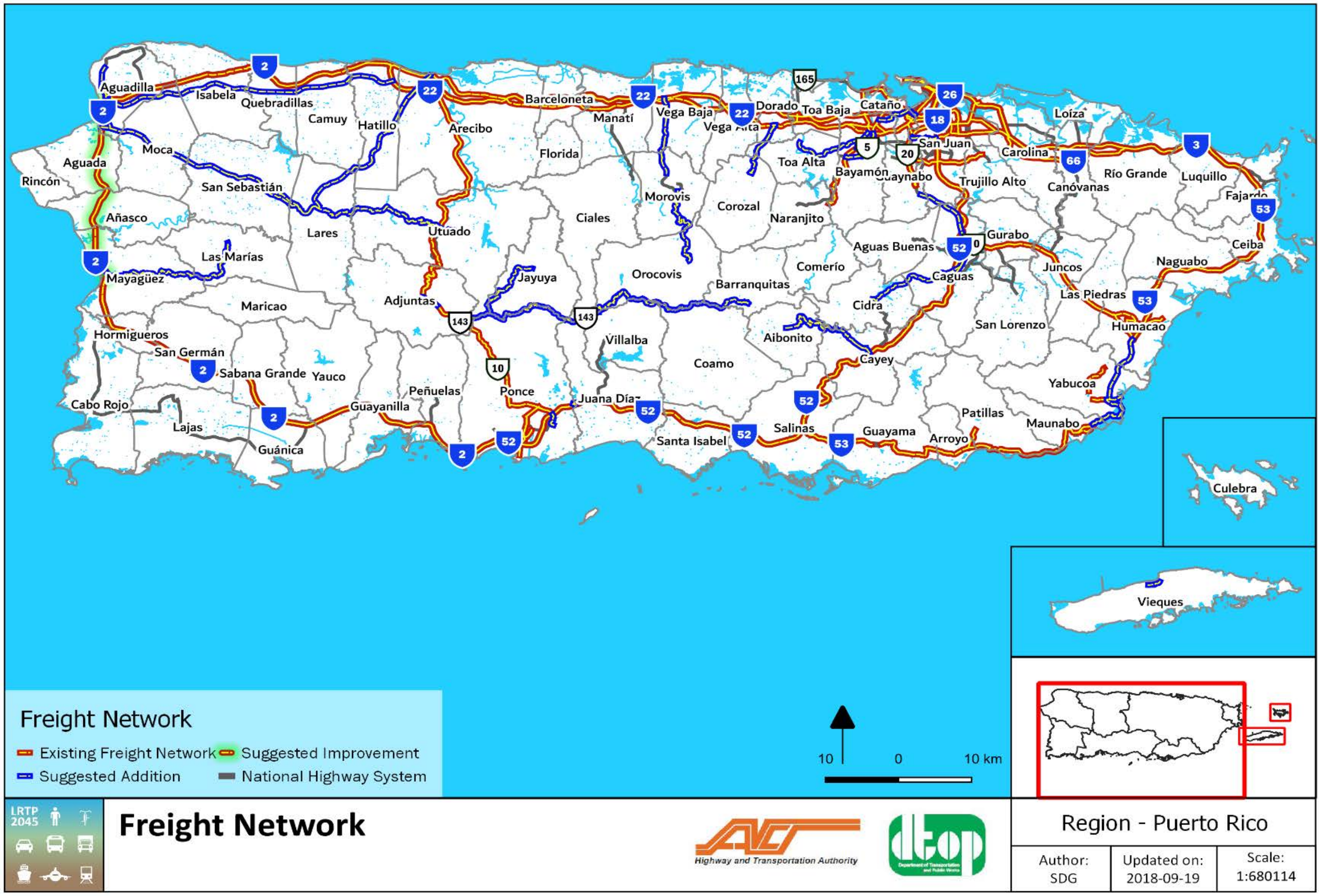
Source: SDG analysis

Table 6.2: Improved Freight Corridors

Name	MPO
PR-2	Aguadilla
PR-111	Aguadilla/North
PR-129	Aguadilla/North
PR-106/PR-120	Southwest/Aguadilla
PR-137	San Juan
PR-155	San Juan
PR-142	San Juan
PR-839/PR-861	San Juan
PR-5	San Juan
PR-28	San Juan
PR-21	San Juan
PR-172	San Juan
PR-1	San Juan
PR-14	San Juan
PR-143	South/San Juan
PR-140	North

Source: SDG analysis

Figure 6.1: Freight Network



Source: The existing Freight Network information layer was obtained form the Federal Highway Administration (FHWA)

Presented in Table 6.3 through Table 6.5, the resulting statistics were compared to the 2016 base condition, namely the Base Case. The Base Case can be described as the 2016 population and employment operating on the 2016 transportation system. The truck vehicle mile traveled (VMT) and truck vehicle hours traveled (VHT) on freeways have minor increases from the Base Case, while VMTs and VHTs on the expressways have slightly decreased. Since some minor arterials are upgraded to principal arterials and added to the freight corridor, the truck VMTs and VHTs increased significantly on the principal arterials. The speeds are slightly increased in the San Juan TMA in the freight scenario.

As presented in Table 6.5, the tested scenario results in a slight reduction of trips and road usage in terms of time spent by drivers on the network. At the same time a marginal increase of miles traveled is observed.

As expected, no material changes in terms of cost or accessibility are seen with the introduction of the freight scenario. The most significant benefit that results from this proposal is an optimized distribution of trucks on roadways; according to Table 6.3 and Table 6.4, freight related vehicles are moving from minor, local roads to those offering better and most suitable capacity as expressways and major arterials. It is likely that this spreading of heavy traffic could result in positive effects on other road users, resulting in better LOS, more reliable travel times and ideally, improved road safety. Not all of these effects are reflected in previously mentioned statistics.

Table 6.3: Island-wide Truck VMT by Vehicle Class and by Road Type

Road Type	Medium Truck			Heavy Truck			Total Truck		
	Base Case	Freight Scenario	% Change	Base Case	Freight Scenario	% Change	Base Case	Freight Scenario	% Change
Freeway	498,026	602,850	21.0%	174,786	208,502	19.3%	672,812	811,352	20.6%
Expressway	290,439	264,466	(8.9%)	116,713	112,723	(3.4%)	407,152	377,189	(7.4%)
Principal Arterial	239,952	300,809	25.4%	91,836	113,050	23.1%	331,788	413,859	24.7%
Minor Arterial	509,851	442,848	(13.1%)	178,223	154,328	(13.4%)	688,074	597,176	(13.2%)
Ramps	37,499	39,977	6.6%	13,254	13,901	4.9%	50,753	53,878	6.2%
Local Roads	727,440	711,164	(2.2%)	227,165	221,089	(2.7%)	954,605	932,253	(2.3%)
Total	**2,303,207**	**2,362,113**	**2.6%**	**801,976**	**823,593**	**2.7%**	**3,105,183**	**3,185,706**	**2.6%**

Source: SDG on PRHTA Island-wide Model

Table 6.4: Island-wide Truck VHT by Vehicle Class and by Road Type

Road Type	Medium Truck			Heavy Truck			Total Truck		
	Base Case	Freight Scenario	% Change	Base Case	Freight Scenario	% Change	Base Case	Freight Scenario	% Change
Freeway	13,420	16,134	20.2%	4,744	5,660	19.3%	18,164	21,795	20.0%
Expressway	12,444	11,140	(10.5%)	4,963	4,640	(6.5%)	17,407	15,780	(9.3%)
Principal Arterial	10,163	12,864	26.6%	3,818	4,758	24.6%	13,981	17,622	26.0%
Minor Arterial	22,028	19,256	(12.6%)	7,640	6,659	(12.9%)	29,669	25,914	(12.7%)
Ramps	1,645	1,765	7.3%	590	622	5.5%	2,235	2,387	6.8%
Local Roads	32,389	31,561	(2.6%)	10,065	9,763	(3.0%)	42,454	41,324	(2.7%)
Total	**92,089**	**92,719**	**0.7%**	**31,820**	**32,102**	**0.9%**	**123,909**	**124,821**	**0.7%**

Source: SDG on PRHTA Island-wide Model

Table 6.5: Island-wide Summary of Measures of Effectiveness for Freight Scenario

Measures of Effectiveness	Base Case	Freight Scenario	% Change (Freight vs. Base)
System Performance			
Average network speed (mph)	25.0	25.5	2.0%
Total transit passengers per route mile	6.4	6.4	0.6%
% non-motorized trips	3.6%	3.6%	(0.4%)
% transit trips	2.4%	2.4%	0.6%
Average highway trip cost	$2.02	$2.07	2.5%
Average transit trip cost	$1.88	$1.90	1.3%
% Population within 0.5-mile walk to transit	17.0%	17.0%	0.0%
% Employment with 0.5-mile walk to transit	35.1%	35.1%	0.0%
Vehicles hours of delay	341,997	342,840	0.2%
Vehicle hours of travel/1000 vehicle miles of travel	40.1	39.3	(2.0%)
VMT above capacity	1,177,739	1,319,565	12.0%
Speed on limited access roads and expressways	30.8	32.2	4.5%
Gallons of fuel consumed[83]	2,723,659	2,774,272	1.9%
System Usage			
Vehicle miles of travel	62,916,521	64,085,689	1.9%
Vehicle hours of travel	2,520,563	2,517,244	(0.1%)
Average network speed	25.0	25.5	2.0%
Person trips	7,640,633	7,640,181	0.0%
Vehicular trips[84]	5,730,818	5,730,560	0.0%
Truck trips3[85]	280,917	280,669	(0.1%)

Source: SDG analysis of freight scenario on Island-wide Model

[83] Gallons of fuel consumed were calculated using AAA miles per gallon in 2016 at 23.1 mpg.

[84] Vehicle trips exclude commercial vehicles, medium trucks and heavy trucks.

[85] Truck trips include medium trucks and heavy trucks.

Transit Service Extension

The planning factors include the priority of enhancing the integration and connectivity of the transportation system, across and between modes, for people and freight; the goals and objectives of the 2045 LRTP consistently indicate the importance of accessibility, connectivity, mode choice. Considering the importance of strengthening the local transit services in Puerto Rico, multiple scenarios were tested using the Island-wide model.

Two transit scenarios were tested under the 2016 travel demand situation. One scenario looked at the impacts of introducing a Caguas BRT connecting between Caguas and San Juan along PR-52 (see Figure 6.2). The other scenario tested an enhanced San Juan local bus network together with the Caguas BRT route.

Results of the 2016 scenarios are presented in Table 6.6. Since the improvements of transit service are all inside the San Juan TMA, and no changes are made to Público service on other regions, only a noticeable mode shift away from cars were observed and transit passengers per route mile were increased by 2.2%. This means that the new BRT service will be busier than the existing transit network on a per mile basis. The BRT also improves transit accessibility to residential areas and jobs by 0.6% and 1.3%, respectively.

A revised bus network in San Juan TMA was also specified to complement the BRT service in the scenario of BRT plus enhanced bus network. Adding the local bus service further improves the coverage the transit coverage on the island, primarily San Juan TMA. Compared to the Base Case, the impacts of these changes on transport provision increase the accessibility to residence areas by 0.7% and to jobs by 3.1%. This also makes the public transit more attractive and therefore the share of transit trips increased from the Base Case.

Table 6.6: Island-wide Summary of Transit Scenarios

Measures of Effectiveness	Base Case	BRT Service	% Change (BRT vs. Base)	BRT + Local Bus Service	% Change (BRT + Local vs. Base)
System Performance					
Average network speed (mph)	25.0	25.0	0.0%	25.0	0.1%
Total transit passengers per route mile	6.4	6.5	2.2%	6.6	3.1%
% non-motorized trips	3.6%	3.6%	0.0%	3.6%	(0.1%)
% transit trips	2.4%	2.4%	2.0%	2.5%	3.2%
Average highway trip cost	$2.02	$2.02	0.0%	$2.02	0.0%
Average transit trip cost	$1.88	$1.92	2.3%	$1.92	2.1%
% Population within 0.5-mile walk to transit	17.0%	17.1%	0.6%	17.1%	0.7%
% Employment with 0.5-mile walk to transit	35.1%	35.6%	1.3%	36.2%	3.1%
Vehicles hours of delay	341,997	341,154	(0.2%)	340,406	(0.5%)
Vehicle hours of travel/1000 vehicle miles of travel	40.1	40.1	0.0%	40.0	(0.1%)
VMT above capacity	1,177,739	1,194,948	1.5%	1,192,309	1.2%
Speed on limited access roads and expressways	30.8	30.8	0.1%	30.8	0.1%
Gallons of fuel consumed	2,723,659	2,722,964	0.0%	2,722,437	0.0%
System Usage					
Vehicle miles of travel	62,916,521	62,900,469	0.0%	62,888,287	0.0%
Vehicle hours of travel	2,520,563	2,519,232	(0.1%)	2,518,019	(0.1%)
Average network speed	25.0	25.0	0.0%	25.0	0.1%
Person trips	7,640,633	7,640,643	0.0%	7,640,638	0.0%
Vehicular trips	5,730,818	5,728,103	0.0%	5,726,400	(0.1%)
Truck trips	280,917	280,915	0.0%	280,918	0.0%

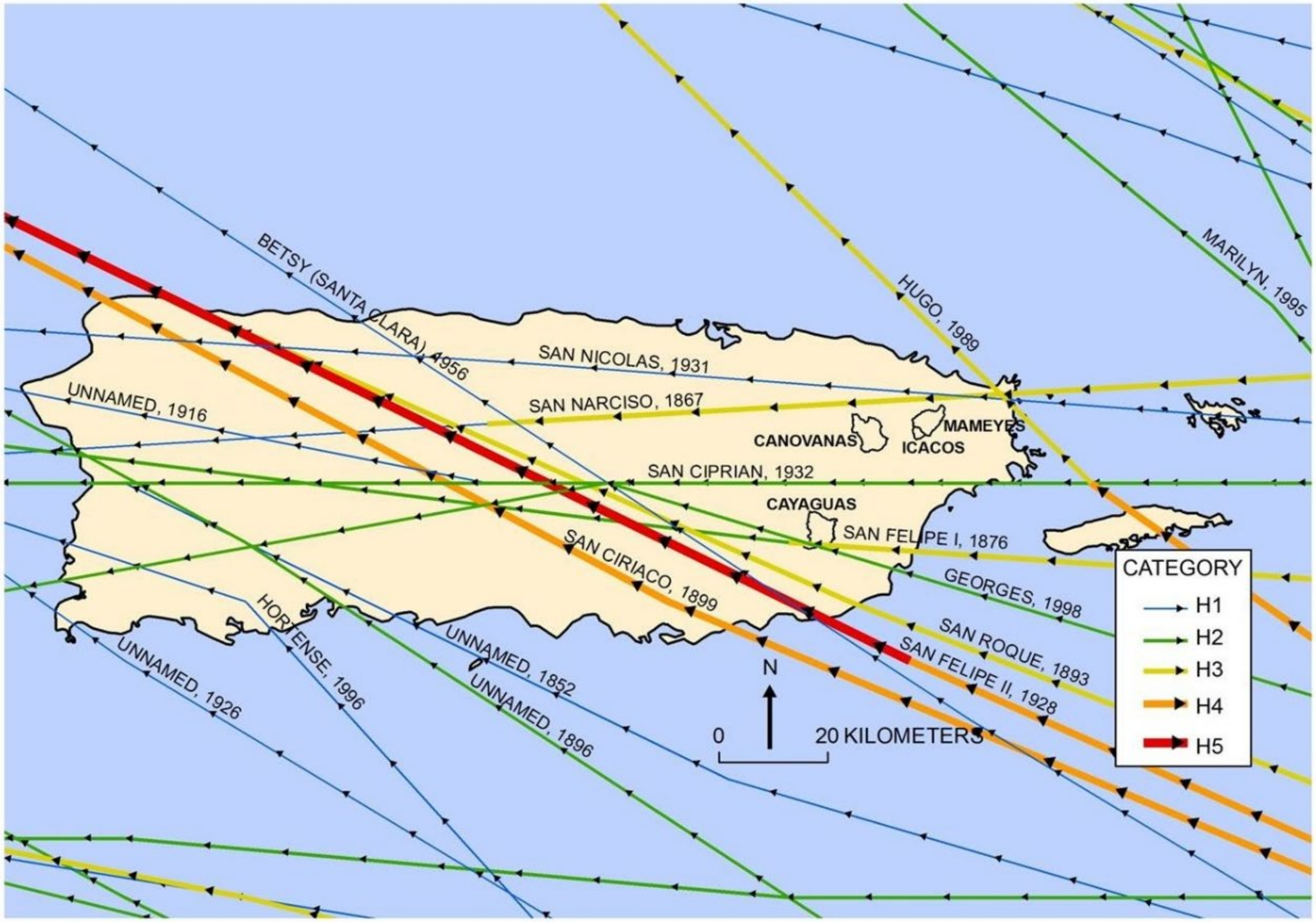
Source: SDG analysis of transit scenarios on PRHTA Island-wide Model

Roadway Network Vulnerability Assessment

Resilience Component for The Long-Range Transportation Plan

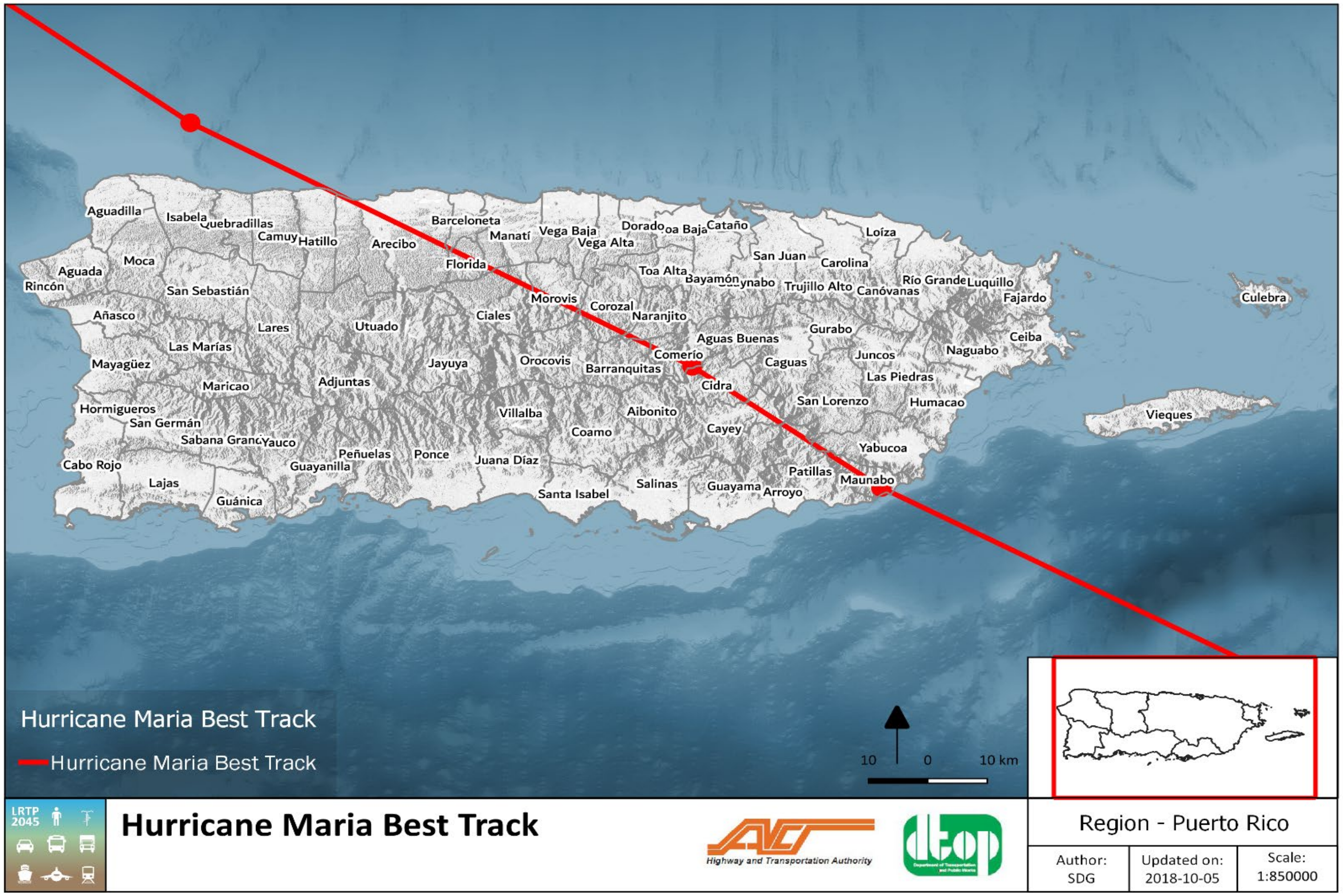
Due to its location, Puerto Rico is highly exposed to hurricanes passing by the island every year usually between July and November. The hurricane season is characterized by heavy rain, high-velocity winds and storm surge, causing flooding and landslides in different areas of the island. However, the extent of damage varies depending on different variables such as track, intensity, size, forward speed of the hurricane, geotechnical conditions of each area, land elevation, etc. Additionally, hurricane season presents different characteristics each year, for example shifts in track, as presented in Figure 6.2 and Figure 6.3, duration and intensity as it can be seen by the dispersion in the historical average shown in Figure 6.4.

Figure 6.2: Puerto Rico Hurricane Map



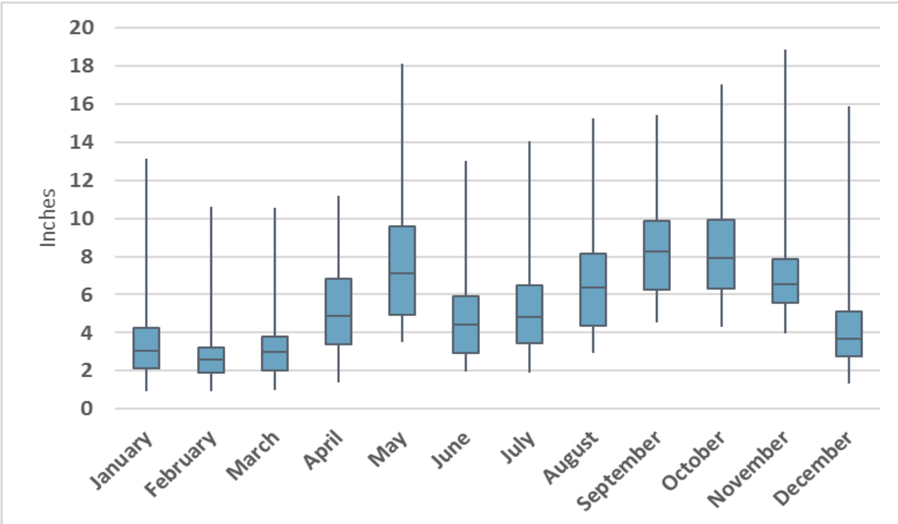
Source: USGS, Puerto Rico Hurricanes Map, 2018. https://www.usgs.gov/media/images/puerto-rico-hurricanes-map

Figure 6.3: Hurricane María Best Track



Source: SDG based on information from the National Hurricane Center. Hurricane Maria Best Track obtained from: https://www.nhc.noaa.gov/data/tcr/index.php?season=2017&basin=atl

Figure 6.4: Historical Monthly Precipitations (1981-2010) – All Stations



Source: SDG based on historical data in (National Weather Service, 2017)

The 2017 hurricane season was particularly intense, with two consecutive storms striking the island, Hurricane Irma and Hurricane María, the latter being the worst to hit Puerto Rico in over 80 years and the third costliest hurricane in United States history[86]. In terms of infrastructure, the electric power system, communication system and water supply system were left without service.

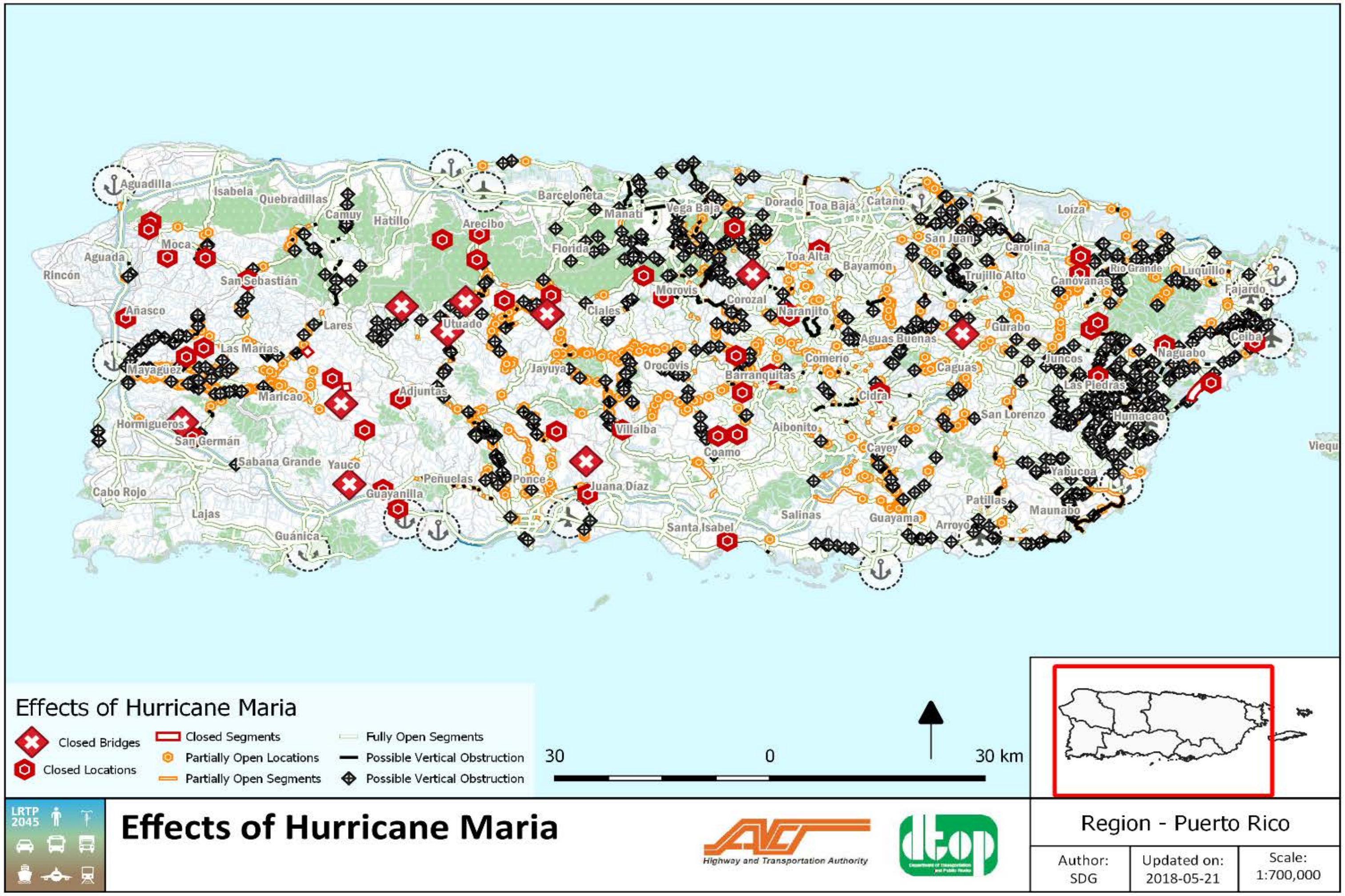
The transportation network did not suffer to the same extent as other infrastructure systems, however many roads were affected either by floods, landslides or storm surge, as it can be seen in Figure 6.6. The highest structural damage in the transportation system was in bridges, where river flooding due to rainfall caused total or partial failure.

The 2017 hurricane season in Puerto Rico follows the trend of climate-related events becoming more frequent and/or more intense. Therefore, incorporation of resilience and vulnerability of infrastructure systems into planning is paramount. In the following sections a vulnerability analysis for the transportation network is carried out following the vulnerability assessment and adaptation framework of the U.S. Department of Transportation[87].

[86] Richard J. Pasch, 2018.

[87] Federal Highway Administration, 2017.

Figure 6.5: Affected roads by María Hurricane



Source: Hurricane Maria impacts were geolocated with the aid of information obtained from multiple meetings with the Highway and Transportation Authority Regional Directors during the first quarter of 2018.

Figure 6.6: Examples Of effects of Hurricane María on the roadway network

Source: Federal Highway Authority, 2018

Vulnerability Analysis Methodology

According to (Proag, 2014), vulnerability is defined as "*the degree to which a system, or part of it, may react adversely during the occurrence of a hazardous event*", therefore, vulnerability analysis includes: a characterization of the system, its response to a hazard and, the "likelihood of occurrence" of such hazard. As it can be seen, this is a broad concept that involves different aspects of interaction between hazard and infrastructure.

On the other hand, resilience is a more specific characterization of a system and complements vulnerability in the context of hazard management and climate change. It can be defined as "[The systems'] *ability to reduce both the magnitude and duration of a deviation (caused by a disruptive event) as efficiently as possible to its usual targeted system performance levels*"[88]. Incorporation of resilience policies into transportation planning allows a long-range improvement of the system to respond to a hazard, which is part of the system's vulnerability.

In concordance with these definitions, the FHWA in 2017 released a Vulnerability Assessment and Adaptation Framework for carrying out vulnerability analysis in transportation infrastructure. The framework includes a five-step process:

1. Definition of objectives and scope
2. Data compilation
3. Vulnerability assessment
4. Analysis of adaptation options
5. Incorporation of results into decision-making

A description of each step is included in Appendix I. A complete explanation and examples are available within the framework's document.

Objective and Scope

The vulnerability assessment is a component of the 2045 LRTP and as a result of the plan's time horizon the vulnerability assessment is limited to a system-level decision-making context. Furthermore, the transportation infrastructure that can be analyzed from a system-level perspective is limited to roads, which are relevant for emergency response, distribution of goods and connectivity of municipalities.

The incorporation of a vulnerability assessment component into the 2045 LRTP was mainly triggered by the devastating effects of Hurricane María on the transportation infrastructure. Therefore, in terms of climate variables, this study focuses in hurricane-related hazards. It explicitly excludes other hazards such as earthquakes though they are also present in the Island.

As previously mentioned, hurricanes are characterized by high-speed winds, rain and storm surge. These features while not generally direct threats to roads pose a major hazard as they trigger landslides and floods. Specifically, rainfall is the most common trigger for both hazards. Large volumes of precipitations over a short period increases water levels in rivers, lakes and any other bodies of water leading to overflows that when combined with uneven topography lead to floods. Additionally, the accumulation of water in soil may result in landslides. This is especially dangerous in soil that is highly susceptible to landslides. As a result, the vulnerability assessment is mainly focused on the variables related to floods and landslides.

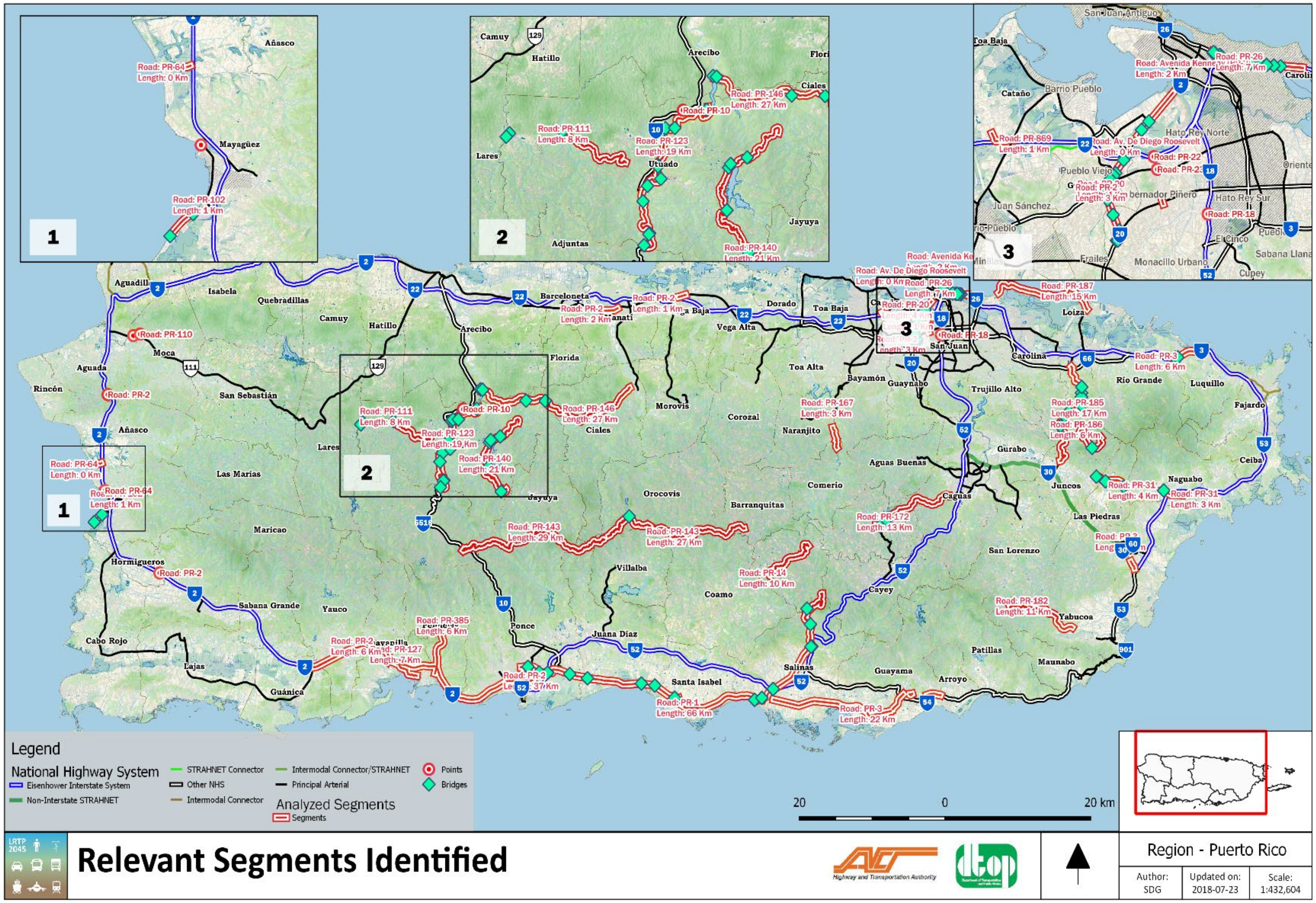
[88] Taken from (Proag, 2014).

The key climate variables identified for this analysis are:

1. Landslides in Hurricane María
2. Flooding data
3. Weather stations
4. Rainfall historic data
5. Slope
6. River map
7. Land use
8. Susceptibility to landslides
9. Infrastructure damage due to Hurricane María
10. Coastal floods

Regarding infrastructure, a stakeholders-input methodology was sought (see Appendix I for details) and through a series of workshops with several participants, 49 segments were identified as the most critical assets, as seen in Figure 6.7. The vulnerability assessment focused on identifying the vulnerability components of these facilities.

Figure 6.7: Relevant Segments Identified by Stakeholders

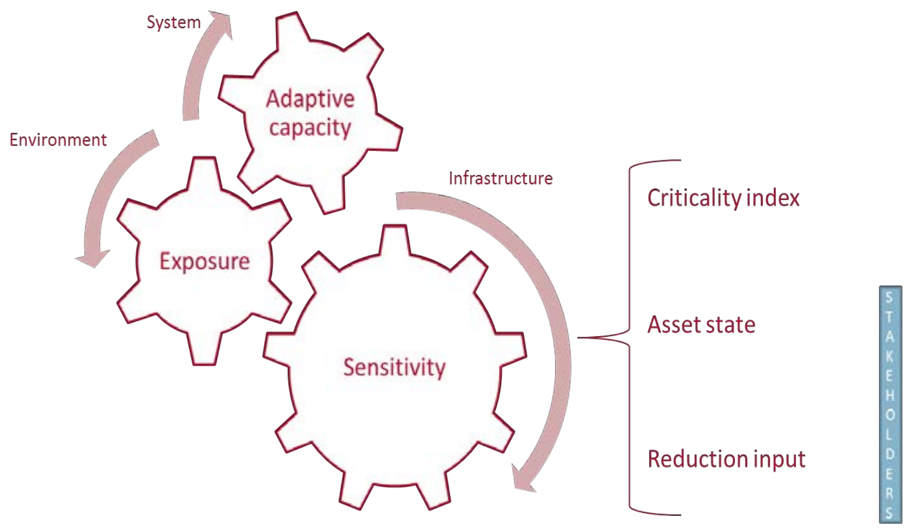


Source: SDG

Vulnerability Assessment

According to the FHWA, vulnerability can be expressed in terms of: Exposure, Sensitivity, and Adaptive capacity. Exposure is the representation of hazard and can be obtained from the hazard maps and hazard information available. Sensitivity should reflect the asset's state and resistance to failure; this information is represented mainly by stakeholder input. Finally, Adaptive capacity is a system-level indicator and can be calculated from data given by the transportation model. Figure 6.8 summarizes the three components of the vulnerability assessment.

Figure 6.8: Components of vulnerability



Source: SDG

The following sections explain the procedure to calculate each component of the vulnerability assessment for the 2045 LRTP.

Exposure

- Trigger: Rainfall

As the precipitation levels are not constant over the year, neither periodical between years, due to climate change, it is paramount to examine multiple hazard scenarios. For this analysis three scenarios were defined according to their corresponding level of hazard to reflect an average scenario, a critical scenario and the worst-case scenario (from historical data). The three scenarios, from minimum to maximum, are (all in inches per day):

1. Average scenario: Corresponds to the average annual precipitation for Puerto Rico obtained from an historical data in a 1981 to 2010 period[89].
2. Intensive scenario: Corresponds to the cumulative precipitation of the months with the higher levels of rainfall during the 1981 – 2010 period: September, October and November[103].

[89] National Weather Service, 2017.

3. Hurricane María scenario: Corresponds to the precipitation levels estimated during the Hurricane María, obtained from a 48-hour total data from September 19 to 21, 2017[103].

The precipitation data for each weather station was georeferenced and using an inverse distance weighted (IDW) process, the precipitations level for the entire island were obtained (the resulting maps and detailed procedure is explained in Appendix I for details).

- Floods

The flood hazard is based on precipitation levels and the flood zones identified by FEMA's Flood Insurance Rate Map (FIRM). Rainfall is the critical trigger for the occurrences of flooding. Therefore, each of the rainfall scenarios were intersected with the FIRM layer, resulting in three flood hazard scenarios, as seen in Figure 6.9 through Figure 6.11.

These maps show the level of flood hazard for each area in Puerto Rico, joining the exposure of flood (i.e., FIRM map) with the amount of water in each scenario. Each area is susceptible to flooding according to flooding data from FEMA and the severity of the flooding is obtained from the rainfall scenario that is being evaluated.

The coastal flood maps were adapted from the coastal flood frequency produced by the National Oceanic and Atmospheric Administration (NOAA, 2017), in which the potential impact associated with coastal flood advisories for the 3 ft. and 6t. sea level rise were obtained; the resulting hazard map is shown in Figure 6.12.

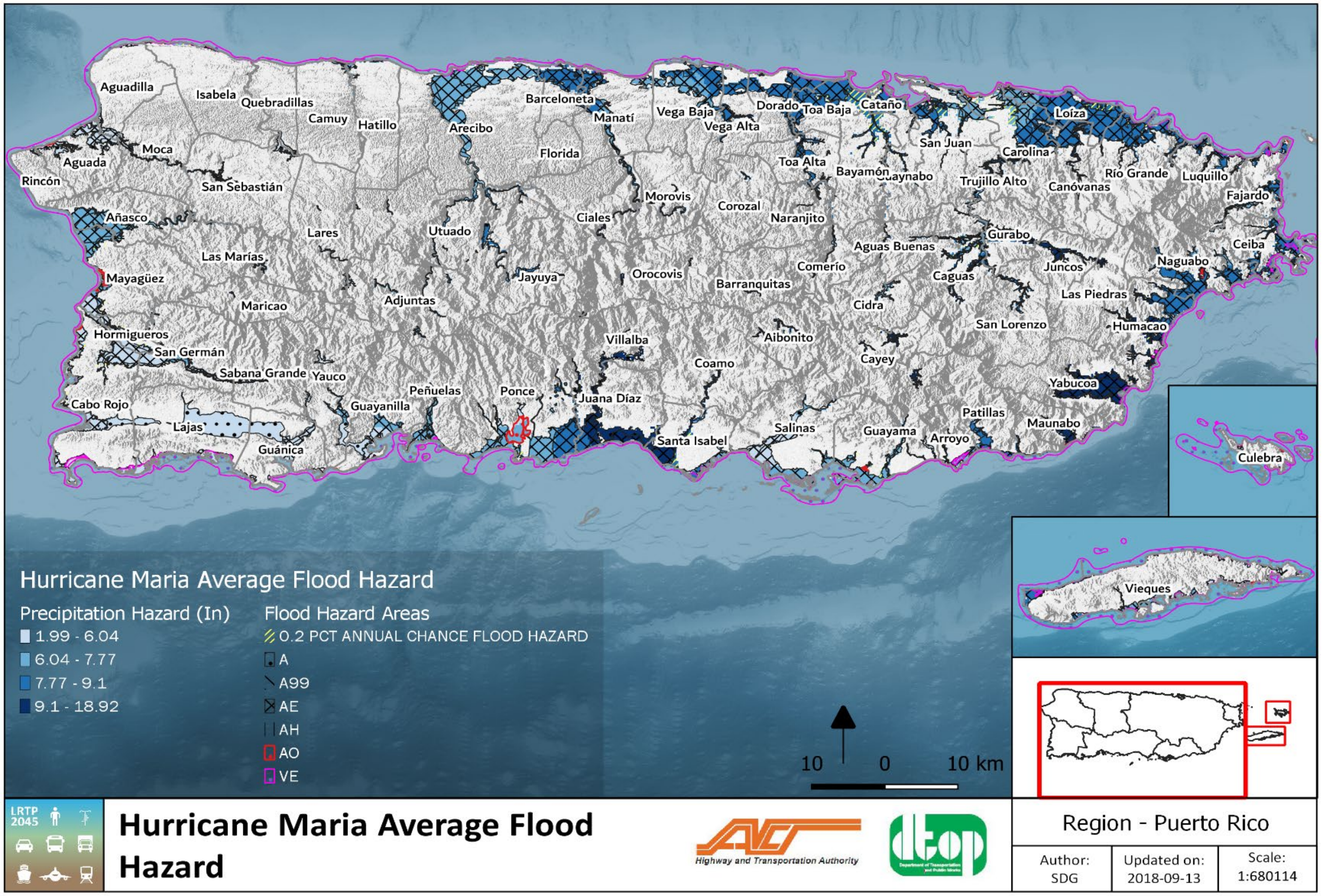
- Landslides

The landslide analysis was based on the creation of a model that can model the landslides that occurred during Hurricane María, using the listed variables as triggers:

- Slope;
- Proximity to rivers: Binary variable that indicates if within a unit of analysis (100m X 100m) there is a relevant water body;
- Land use data: Categorical variable indicating the areas of each land use classification;
- Landslide susceptible zones from the Planning Board: Categorical variable that indicate the level of susceptibility for a landslide event ranging from 1 (the lowest susceptibility) to 4 (the highest susceptibility); and
- Precipitation levels for Hurricane María and Average seasons in inches.

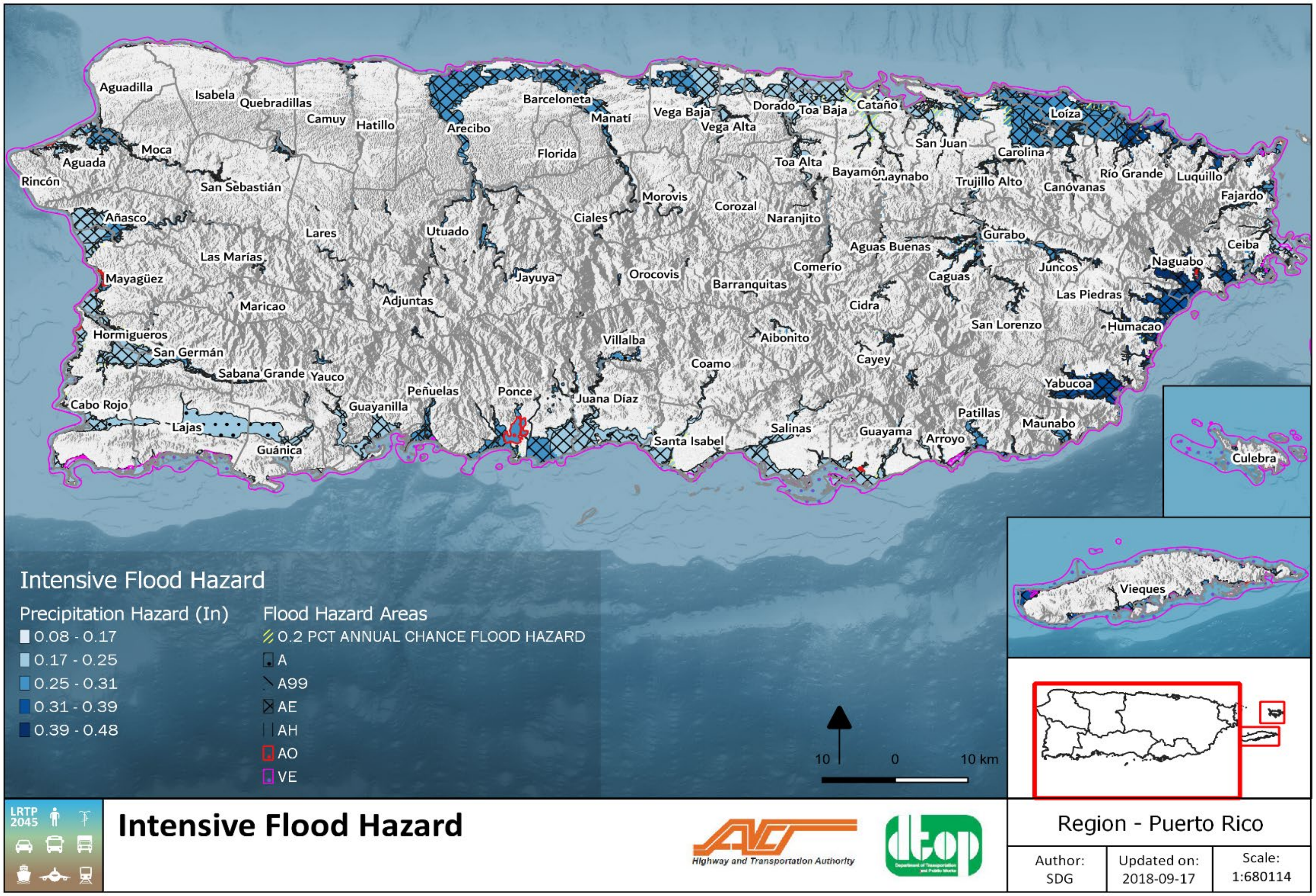
A binomial logistic regression model was used to predict the concentration of landslides for the Hurricane María rainfall scenario. The accuracy obtained with this model was 0.741 (see Appendix I for details), which corresponds to a fair error rate given the scope of this study. After this model was developed, the precipitation levels were changed to the average rainfall scenario and a second landslide hazard map (i.e., concentration of landslides) was obtained, as shown in Figure 6.13 and Figure 6.14.

Figure 6.9: Hurricane María Average Flood Hazard



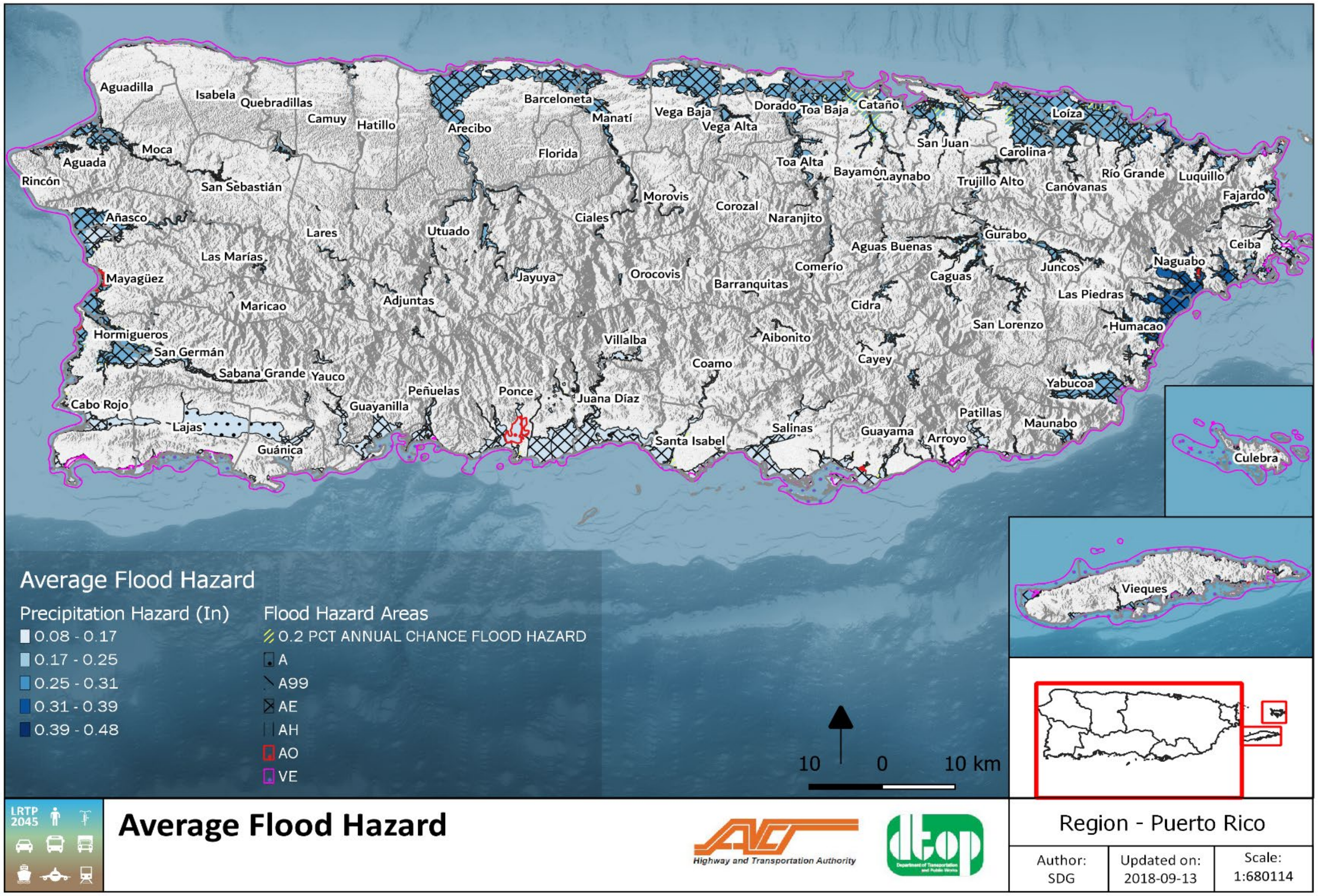
Source: SDG based on information from the National Weather Service

Figure 6.10: Intensive Flood Hazard



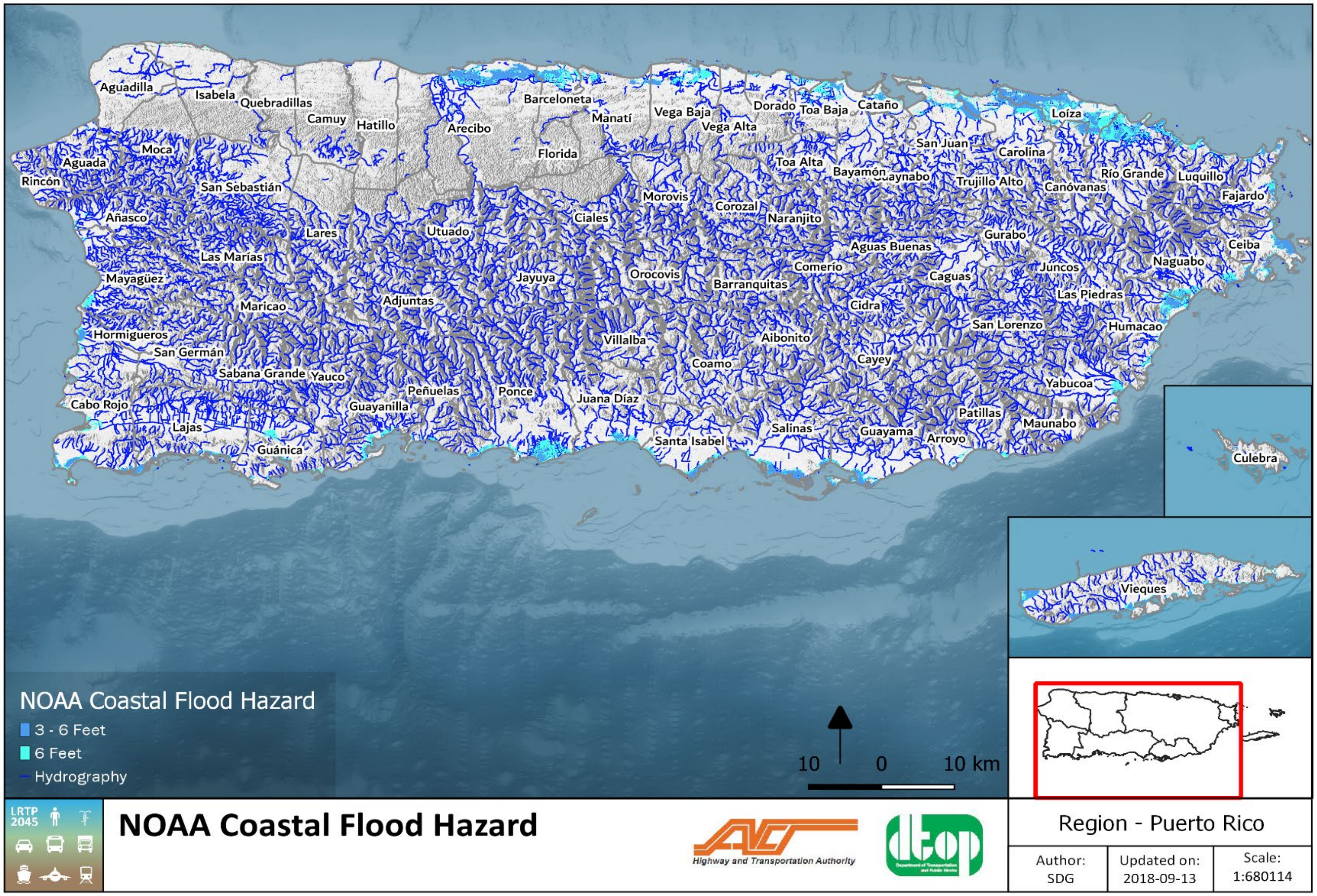
Source: SDG based on information from the National Weather Service

Figure 6.11: Average Flood Hazard



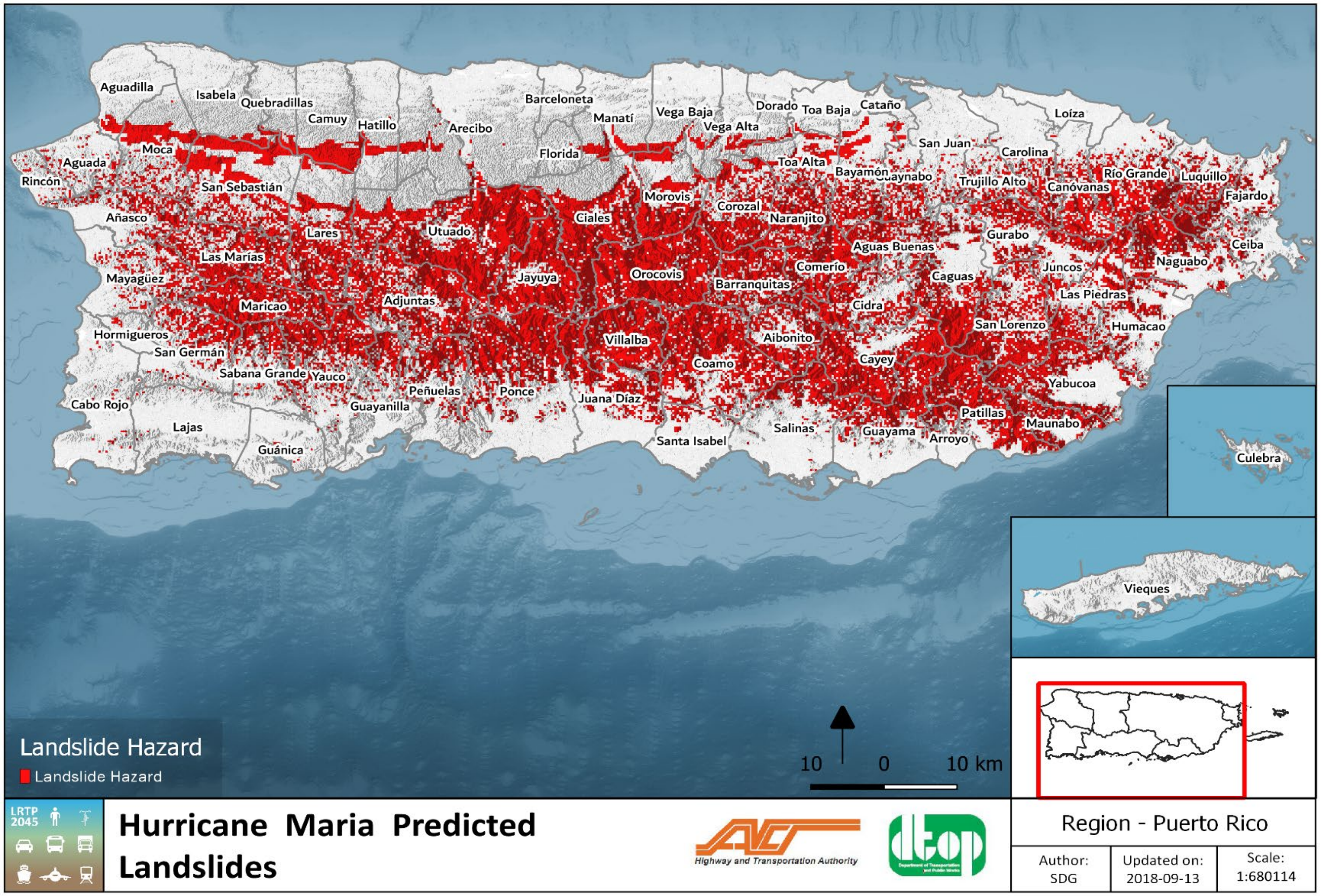
Source: SDG based on information from the National Weather Service

Figure 6.12: Coastal Flood Hazard Map



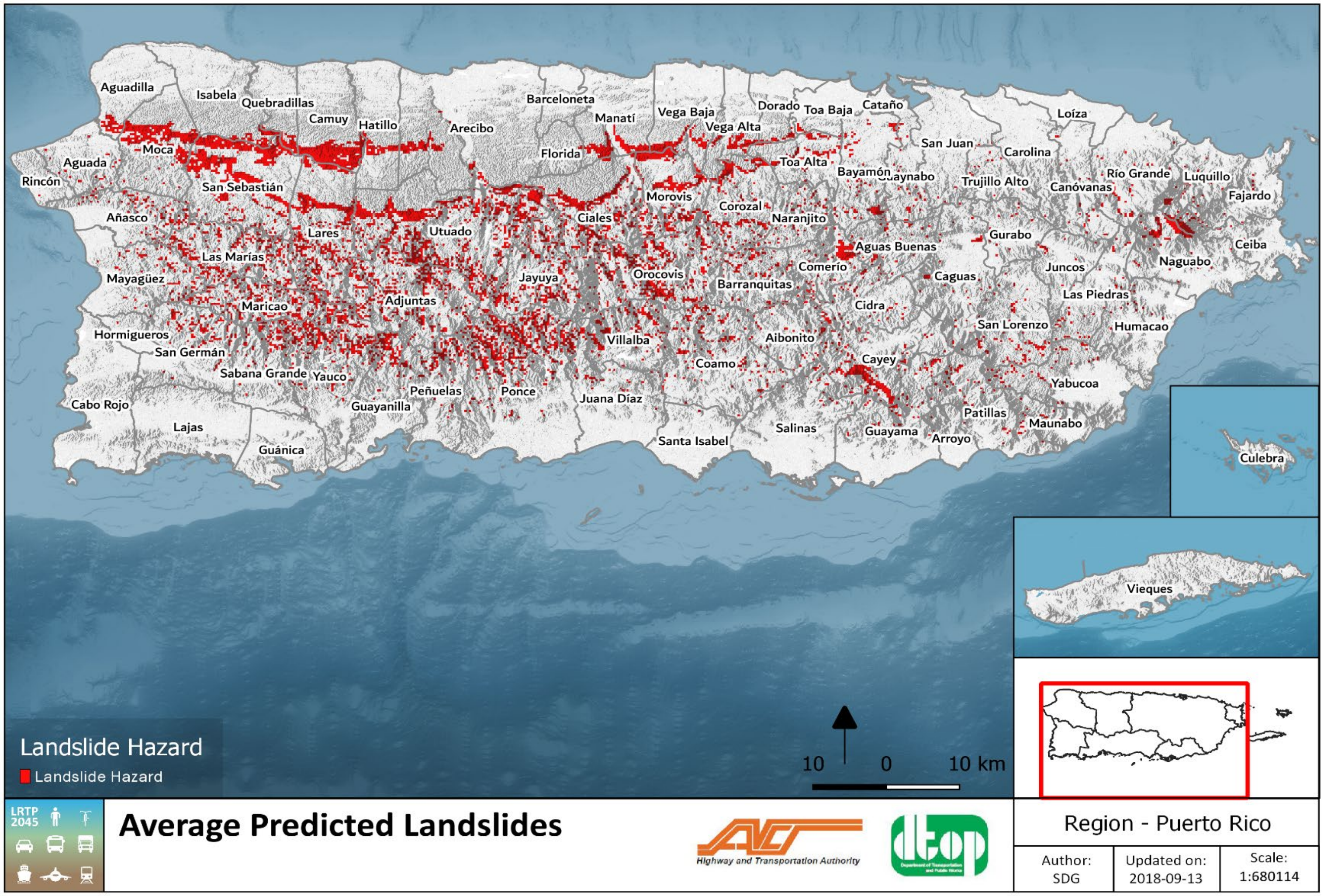
Source: SDG based on the National Oceanic and Atmospheric Administration information.

Figure 6.13: Hurricane María Predicted Landslides



Source: SDG

Figure 6.14: Average Predicted Landslides



Source: SDG

Sensitivity

According to FHWA, Sensitivity is defined as "*how the asset or system fares when exposed to a climate variable*". The response of the asset to certain climate variables can be expressed in terms of the probability of certain magnitudes of failure, given some magnitude of hazard. Since the scope of this analysis is not to characterize each segment of road in the Puerto Rico transportation system, but to give a broad assessment regarding vulnerability, this probability of failure will be broken down into three components: frequency of failure, magnitude of failure and criticality index.

For each segment analyzed. frequency of failure provides insights regarding asset state and where the segment is in its lifecycle. Typically, towards the end of design life, assets tend to have higher maintenance costs as their failure rate increases. Therefore, this measure, even in a qualitative scale, should quantitative measures not be available, gives a sense on the general state of the infrastructure.

The magnitude of failure provides information regarding how well the asset withstands a disturbance due to a climate event. The failure can be a result of the original design, where resistance to the identified hazard was not strongly included, or it might be related to the age of the asset, and it continuous exposure to the hazard. In most cases, this measure provides an insight on how the asset is affected each time it interacts with the hazard.

Finally, a criticality index is included in the study as a measure of the level of use of each analyzed segment and its importance in the overall network This allows the measure to differentiate between two assets in terms of how significant they are in terms of the networks dynamics. This index is developed for every link of the transportation network and was also used as part of the Adaptive Capacity analysis.

For each identified asset, stakeholders provided input in terms of frequency of failure and magnitude of failure. This data was transformed into a score between 1 and 5 depending on the level of each response. These two scores are averaged with the criticality index and for each asset a final score is given (see Appendix I for details).

Adaptive Capacity

The final component of the vulnerability analysis is the Adaptive Capacity analysis. This is a system-level measure and aims at measuring how a failure in one element of the system reflects in the overall performance. There are two possible approaches for this measure:

- Direct: Using the transportation model, each segment is removed from the network and the model demand is assigned again. Using performance statistics of the transportation model (e.g. average volume/capacity ratio), the effect of the removal of such link is measured.
- Indirect: Using graph theory, the transportation model is represented by a weighted-directed graph and a centrality statistic (before and after removal) is used to measure the effect of a link failure in the system.

The indirect measure was selected to measure adaptive capacity because it is less time intensive than the direct measure and the centrality measures successfully captures the global effect of removing a segment from the network. Detailed methodology can be found in Appendix I.

As a result, a score between 1 and 5 was developed for each asset depending on the resulting index.

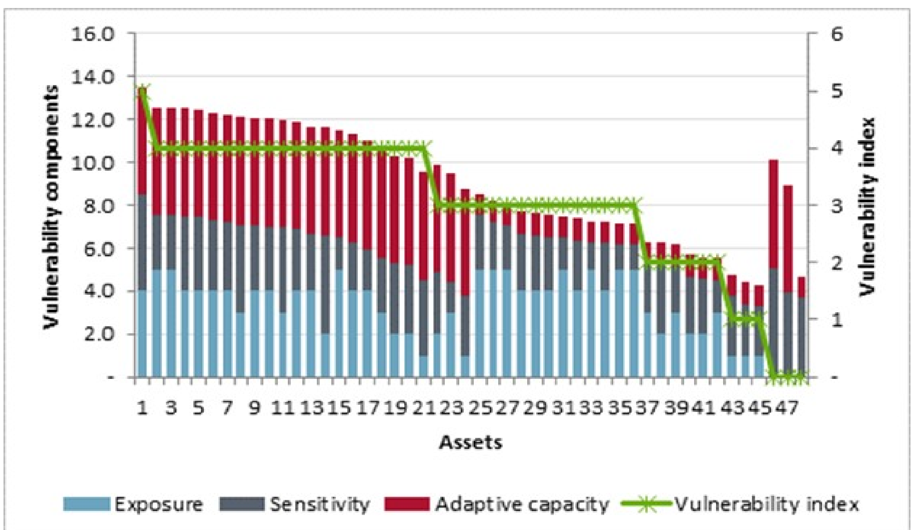
Results

The vulnerability index was obtained by combining the three components: Exposure, Sensitivity and Adaptive Capacity. A simple average might hide single-component criticalities that is why the scoring for vulnerability index followed these rules:

- Score=5: If the three components had score of 5
- Score=4: If two out of three had a score equal or higher than 4
- Score=3: If at least one of the components had score equal or higher than 4, or the average is above 3
- Score=2: If the average is above 2 and below 3
- Score=1: Any other case

The results for each component and the final vulnerability index for the selected segments is shown in Figure 6.15.

Figure 6.15: Vulnerability Index for Relevant Assets

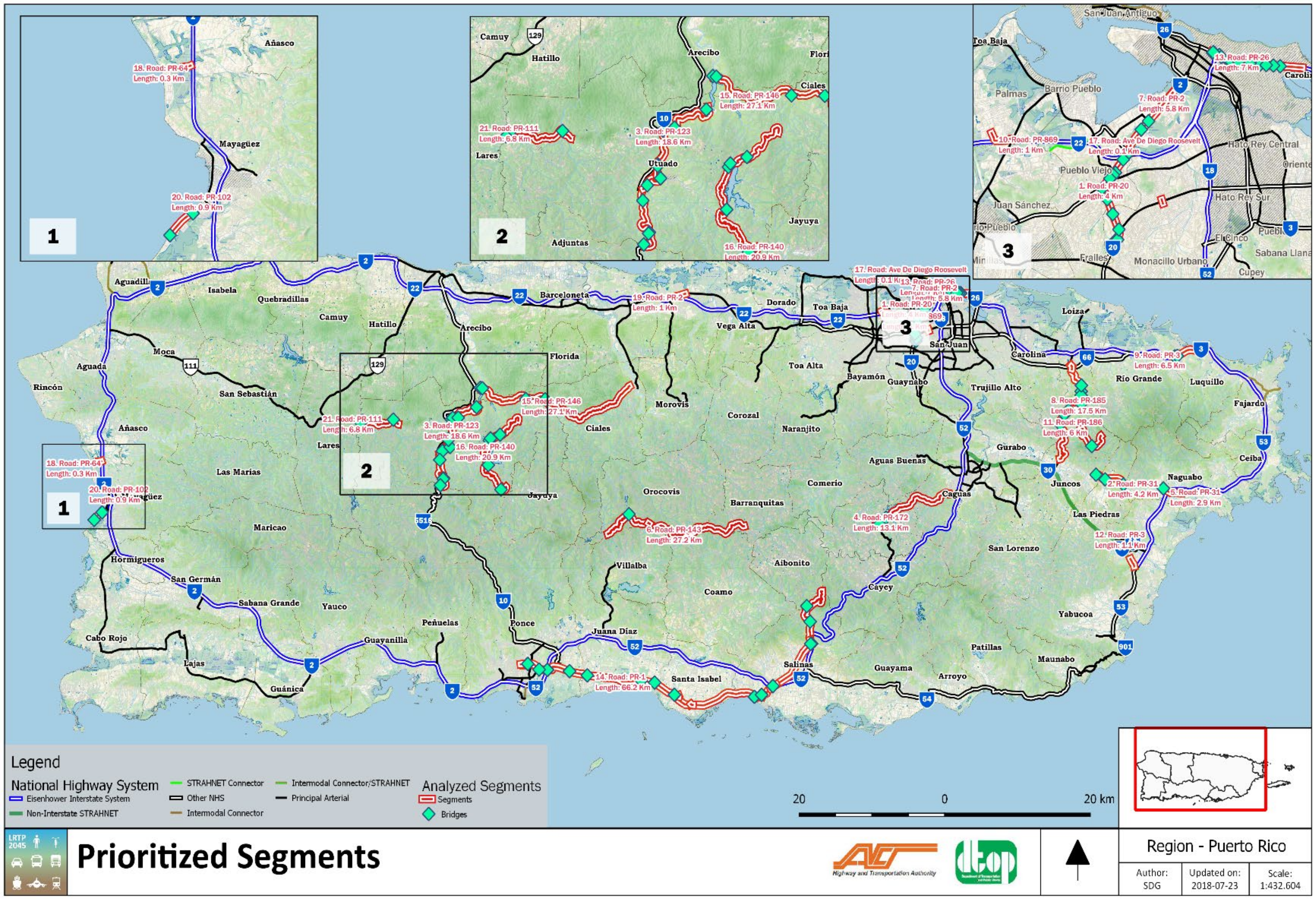


Source: SDG

Due to the level of detail defined in this analysis, the vulnerability index is defined as a discrete scale from 1 to 5, where "1" is the lowest score and "5" the highest. It is important to note that three of the selected segments where given a score of "0" because there was no evidence of Exposure and without it, there is no vulnerability. However, these might be due to uncertainties in the location or type of hazard responsible for failure. Therefore, it is important to re-visit these points and develop further hazard analysis.

These results were shared with the stakeholders in a final workshop, where the top 21 segments (i.e., score 4 and 5) were selected for further analysis and definition of mitigation analysis. The prioritized projects are shown in Figure 6.16 shows a brief description of each prioritized segment for the San Juan TMA. For all the identified segments a detailed study needs to be carried out to identify the appropriate adaptation option.

Figure 6.16: Prioritized Segments



Source: SDG

Table 6.7: Prioritized Segments Assessment

Road name	Location	AADT	Length (km)	Hazard	Vulnerability index
PR-20	Guaynabo	51,337	2	Floods	5
PR-31	Las Piedras	9,633	4	Floods	4
PR-123	Utuado	9,139	19	Landslides	4
PR-172	Cidra/Caguas	9,504	13	Landslides	4
PR-31	Naguabo	15,670	2.8	Floods	4
PR-143	Orocovis / Barranquitas	3,208	27	Landslides	4
PR-2	Guaynabo	51,337	4	Floods	4
PR-185	Canóvanas / Juncos	11,521	17	Landslides	4
PR-3	Luquillo	15,385	3.2	Floods	4
PR-869	Cataño	57,104	1	Floods	4
PR-186	Canóvanas	4,369	6	Landslides	4
PR-3	Humacao	14,985	2	Floods	4
PR-26	San Juan	75,190	3	Floods	4
PR-1	Ponce, Juana Díaz, Santa Isabel, Salinas	1,420	58.8	Floods	4
PR-146	Ciales	1,444	27	Landslides	4
PR-140	Utuado	2,181	20	Landslides	4
Av. De Diego Roosevelt	San Juan	8,536	1.1	Floods	4
PR-64	Mayagüez	8,112	0.3	Floods	4
PR-2	Vega Baja	34,127	1	Floods	4
PR-102	Mayagüez	6,164	1.9	Floods	4
PR-111	Utuado	5,081	6.8	Landslides	4

Source: SDG. Note: The AADT presented for each segment was estimated using an annualization factor and it is shown in Passenger Car Unit (PCU). This factor converts toll revenue from the weekday values derived from the study area forecast models to an equivalent annual total. SDG set this factor based on available observed toll transaction data and SDG estimate of the number of weekdays, weekends and a weekend day's share of weekday transactions in 2016. Assuming a weekend has one-third of a weekday's transactions, SDG Team estimated a revenue factor of 296 (261 weekdays plus 104 weekends * 1/3).

The description and location of the 21 prioritized segments is the following:

1. PR-20: Guaynabo, as seen in Figure 6.17:
   - AADT: 51,337;
   - Segment: km 0.0 a km 2.0;
   - Hazard: Floods; and
   - Vulnerability index: 5.
2. PR-31: Las Piedras, as seen in Figure 6.18:
   - AADT: 9,633;
   - Segment: km 14.9 a km 18.9;
   - Hazard: Floods; and

- Vulnerability index: 4.

3. PR-123: Utuado, as seen in Figure 6.19:
    - AADT: 9,139;
    - Segment: Km 48.0 a 67.0;
    - Hazard: Floods; and
    - Vulnerability index: 4.
4. PR-172: Cidra/Caguas, as seen in Figure 6.20:
    - AADT: 9,504;
    - Segment: km 13.0 to 26.0;
    - Hazard: Landslide; and
    - Vulnerability index: 4.
5. PR-31: Naguabo, as seen in Figure 6.21:
    - AADT: 15,670;
    - Segment: km 6.0 to 8.8;
    - Hazard: Floods; and
    - Vulnerability index: 4.
6. PR-143: Orocovis / Barranquitas, as seen in Figure 6.22:
    - AADT: 3,208;
    - Segment: km 30.0 to 57.0;
    - Hazard: Landslide; and
    - Vulnerability index: 4.
7. PR-2: Guaynabo/San Juan, as seen in Figure 6.23:
    - AADT: 51,337;
    - Segment: km 2 to 6.3;
    - Hazard: Floods; and
    - Vulnerability index: 4.
8. PR-185: Canóvanas / Juncos, as seen in Figure 6.24:
    - AADT: 11,521;
    - Segment: km 2.0 to 19.0;
    - Hazard: Landslide; and
    - Vulnerability index: 4.
9. PR-3: Luquillo, as seen in Figure 6.25:
    - AADT: 15,385;
    - Segment: Km 31.6 to 34.8;
    - Hazard: Floods; and
    - Vulnerability index: 4.
10. PR-869: Cataño, as seen in Figure 6.26:
    - AADT: 57,104;
    - Segment: km 0.0 to 1.0;
    - Hazard: Floods, and
    - Vulnerability index: 4.
11. PR-186: Canóvanas, as seen in Figure 6.27:
    - AADT: 4,369;
    - Segment: km 4.0 to 10.0;

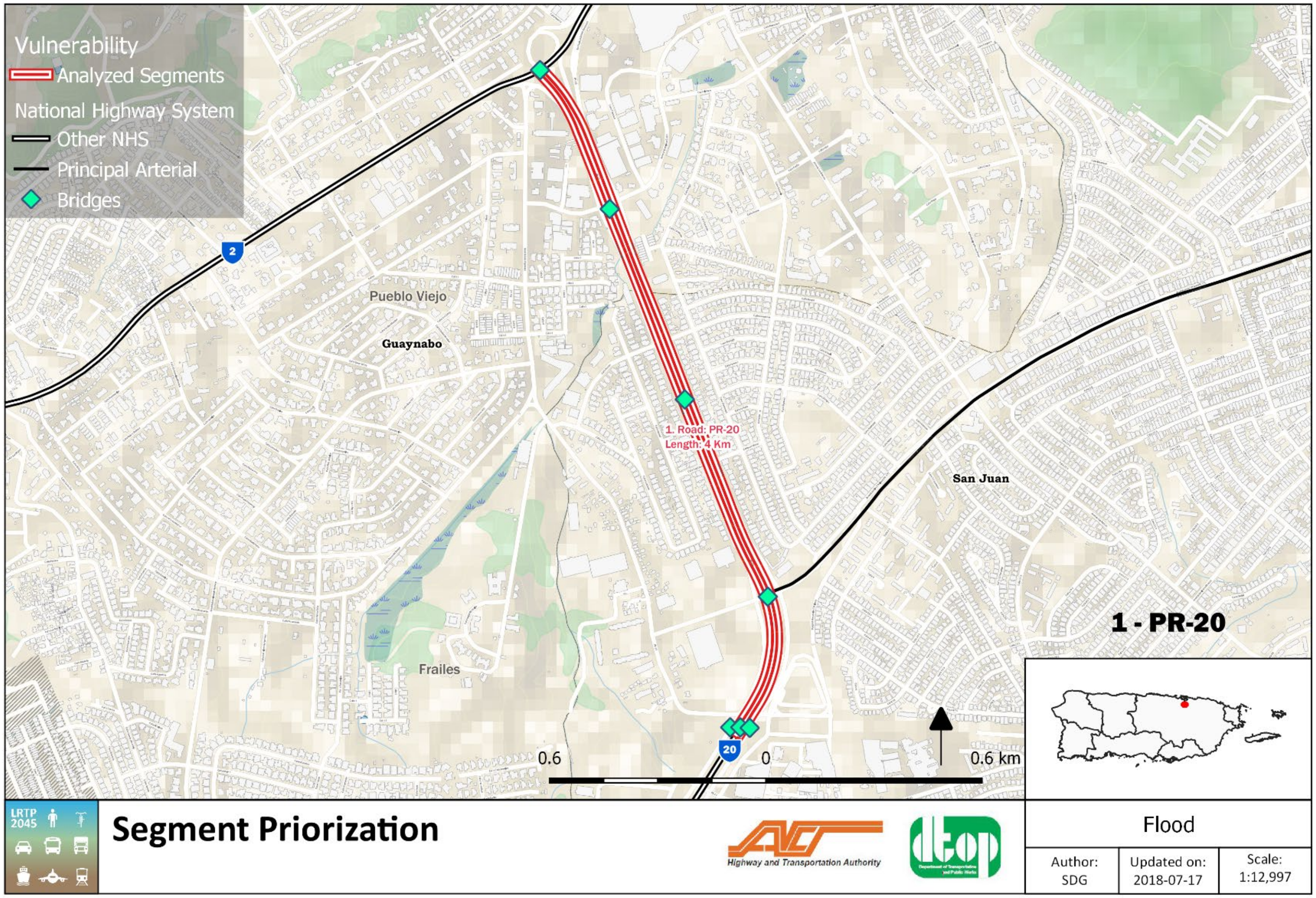
- Hazard: Landslide; and
- Vulnerability index: 4.

12. PR-3: Humacao, as seen in Figure 6.28:
    - AADT: 14,985;
    - Segment: km 82.9 to 84.0;
    - Hazard: Floods; and
    - Vulnerability index: 4.
13. PR-26: San Juan, as seen in Figure 6.29:
    - AADT: 75,190;
    - Segment: km 2.0 to 5.5;
    - Hazard: Floods; and
    - Vulnerability index: 4.
14. PR-1: Ponce, Juana Díaz, Santa Isabel, Salinas, as seen in Figure 6.30:
    - AADT: 1,420;
    - Segment: Km 69.1 to 127.98;
    - Hazard: Floods; and
    - Vulnerability index: 4.
15. PR-146: Ciales, as seen in Figure 6.31:
    - AADT: 1,444;
    - Segment: From Utuado to Ciales;
    - Hazard: Landslide; and
    - Vulnerability index: 4.
16. PR-140: Utuado, as seen in Figure 6.32:
    - AADT: 2,181;
    - Segment: Km 14.0 to 34.0;
    - Hazard: Landslide; and
    - Vulnerability index: 4.
17. Av. De Diego: San Juan, as seen in Figure 6.33:
    - AADT: 8,536;
    - Segment: Intersection Ave. De Diego and Ave. Jesús T. Piñero;
    - Hazard: Floods; and
    - Vulnerability index: 4.
18. PR-64: Mayagüez, as seen in Figure 6.34:
    - AADT: 8,112;
    - Segment: Km 5.2 to 5.5;
    - Hazard: Floods; and
    - Vulnerability index: 4.
19. PR-2: Vega Baja, as seen in Figure 6.35:
    - AADT: 34,127;
    - Segment: km 40.5 to 41.5;
    - Hazard: Floods; and
    - Vulnerability index: 4.
20. PR-102: Mayagüez, as seen in Figure 6.36:
    - AADT: 6,164;

- Segment: Km 4.6 a 5.5;
- Hazard: Floods; and
- Vulnerability index: 4.

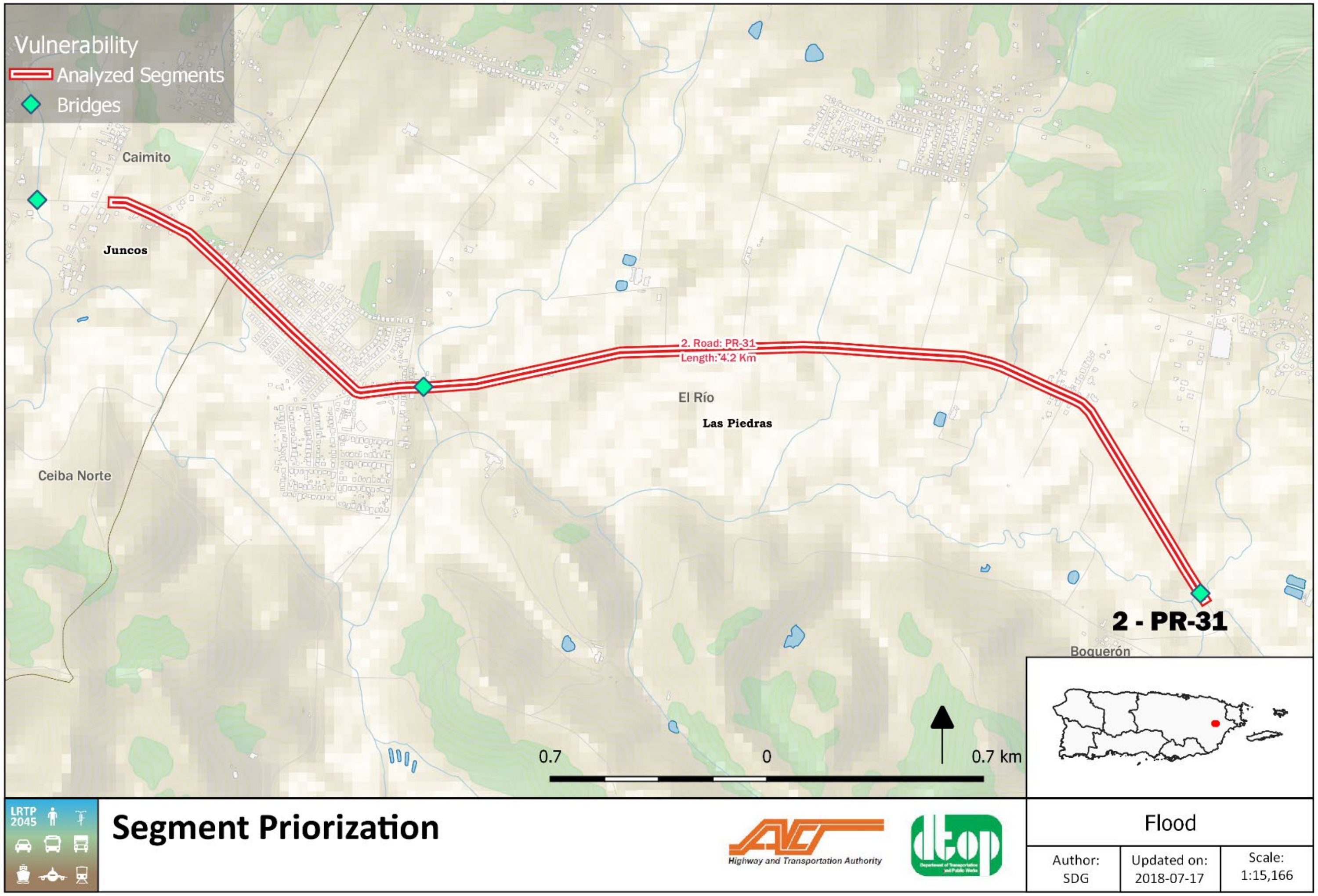
21. PR-111: Utuado, as seen Figure 6.37:
    - AADT: 5,081;
    - Segment: Km 48.6 a 55.4;
    - Hazard: Landslide; and
    - Vulnerability index: 4.

Figure 6.17: PR-20 Guaynabo



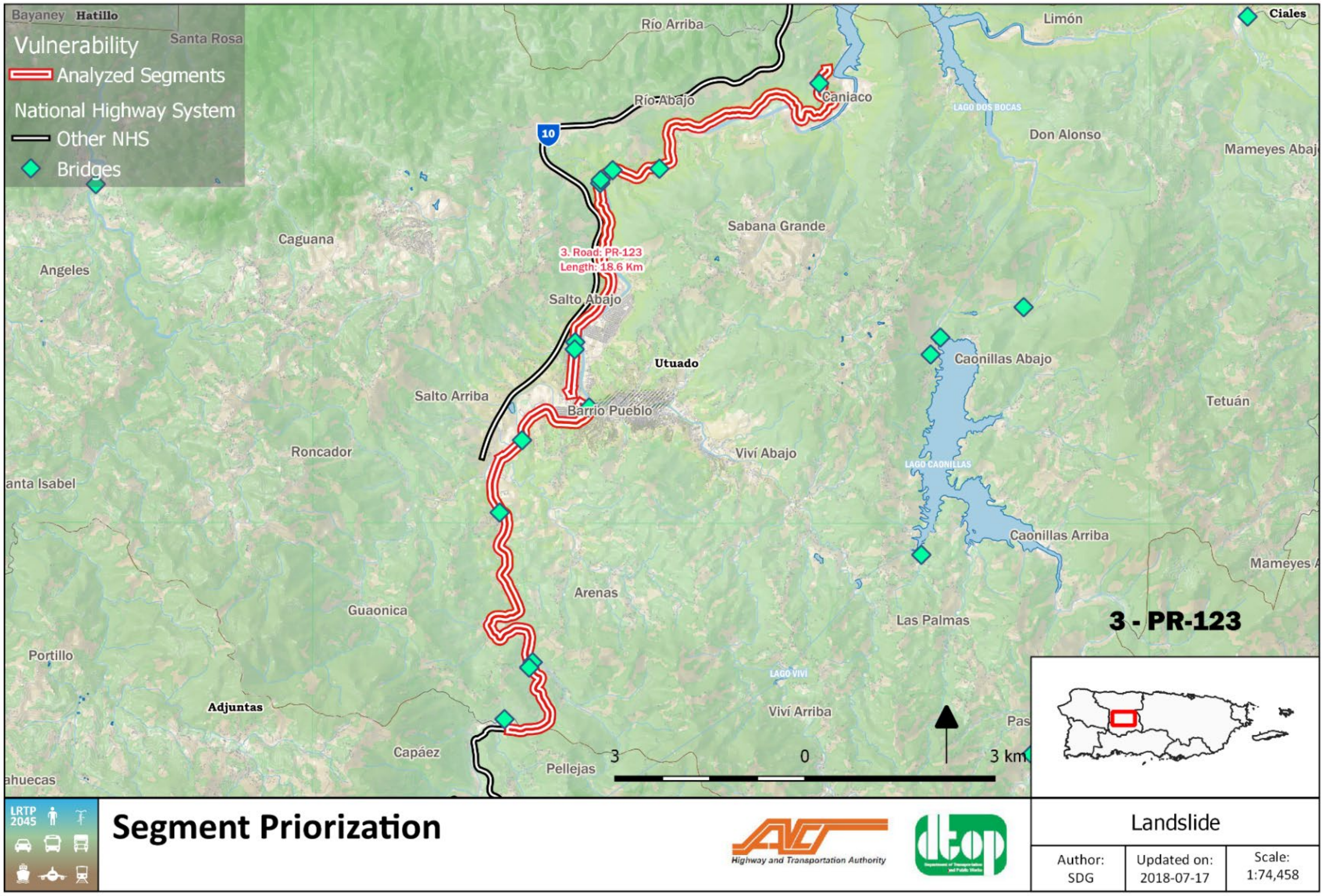
Source: SDG

Figure 6.18: PR-31: Las Piedras



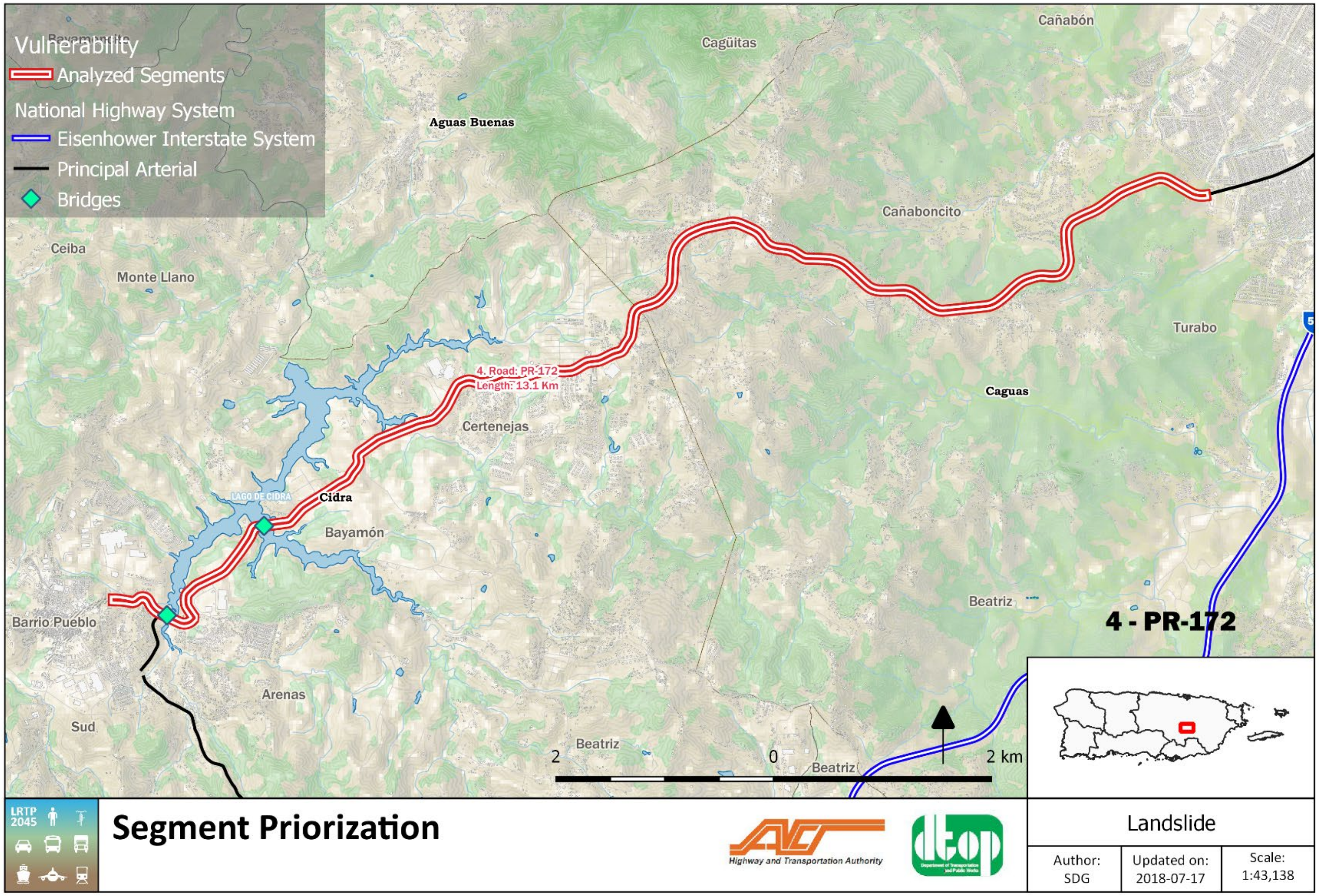
Source: SDG

Figure 6.19: PR-123: Utuado



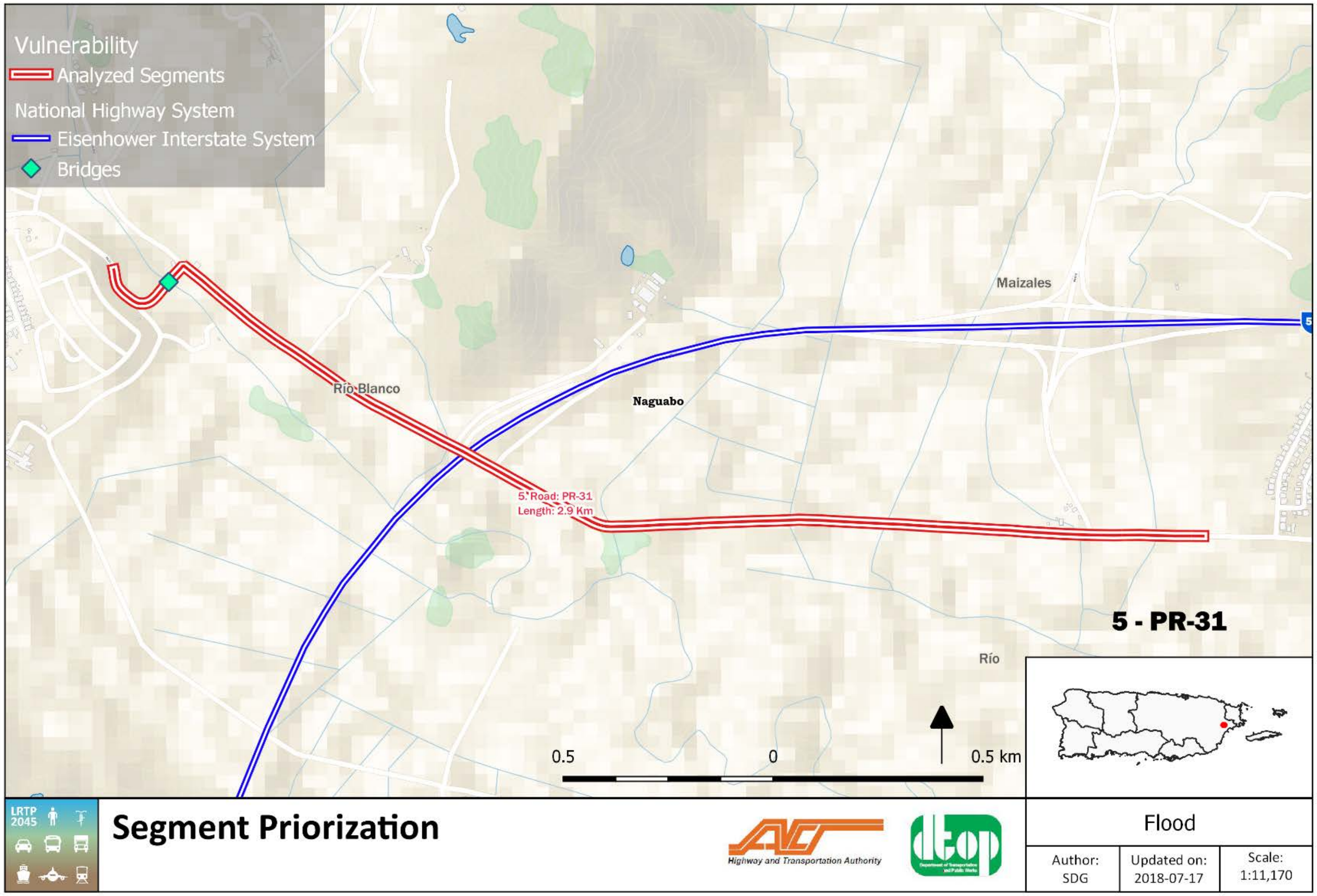
Source: SDG

Figure 6.20: PR-172: Cidra/Caguas



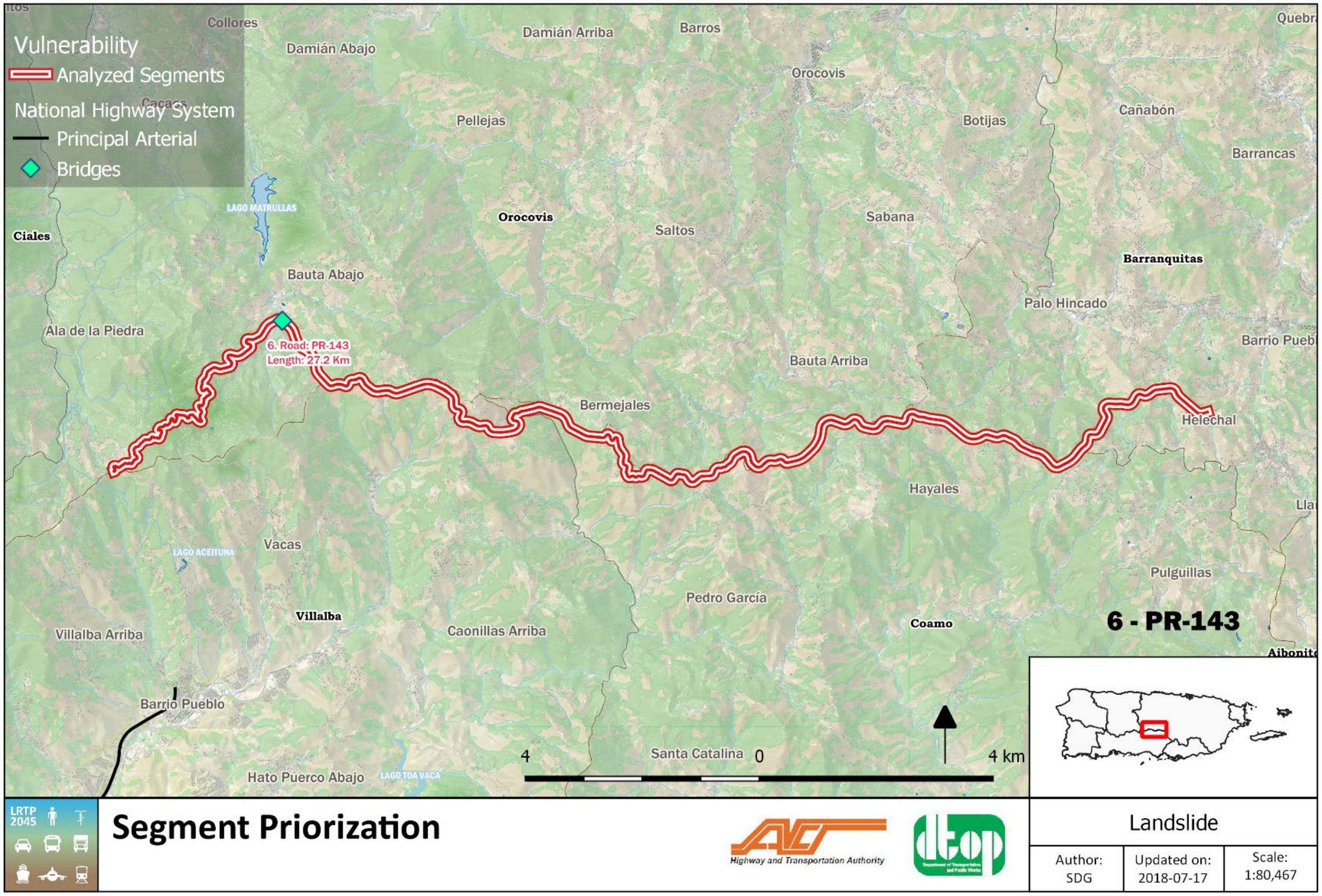
Source: SDG

Figure 6.21: PR-31 Naguabo



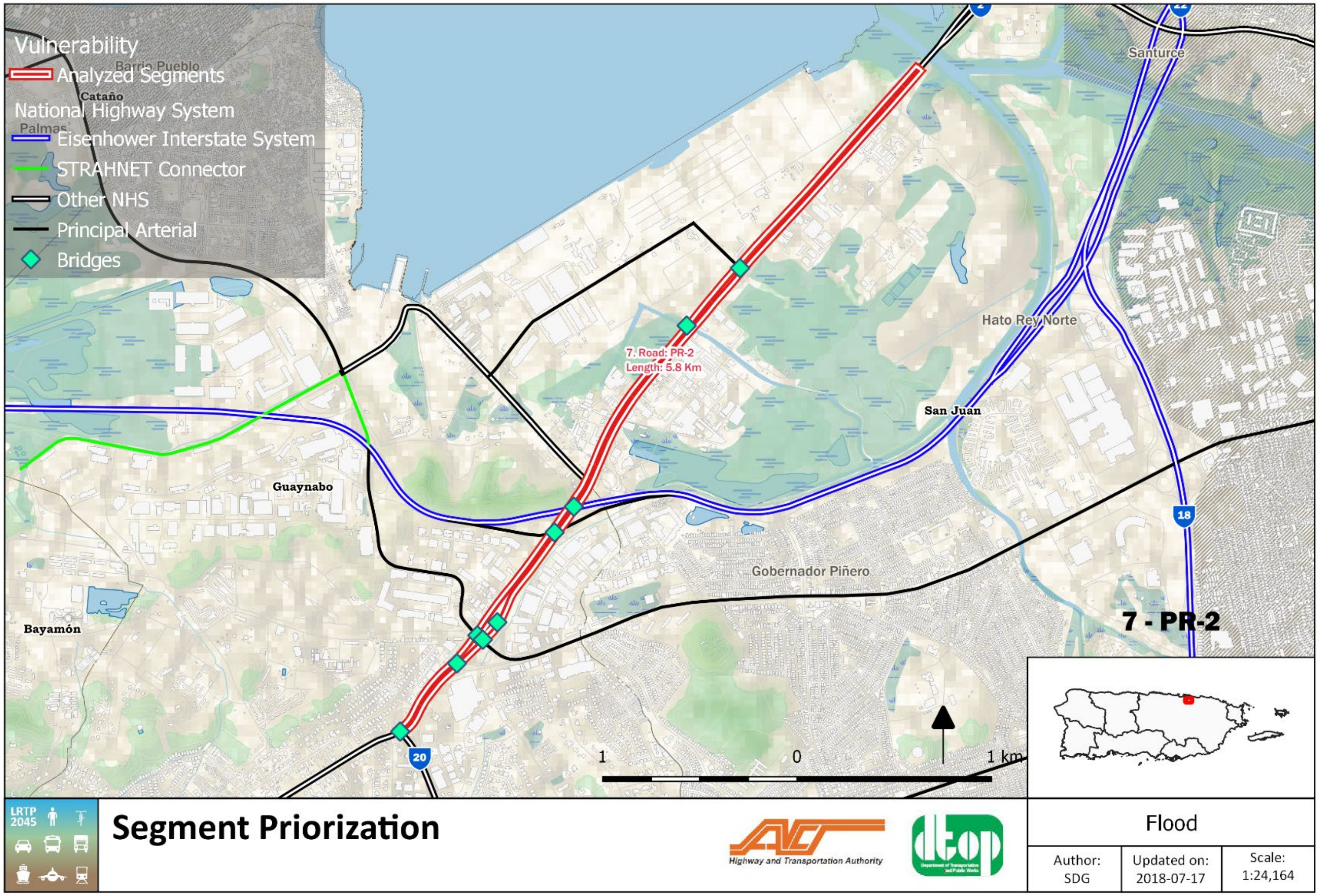
Source: SDG

Figure 6.22: PR-143: Orocovis / Barranquitas



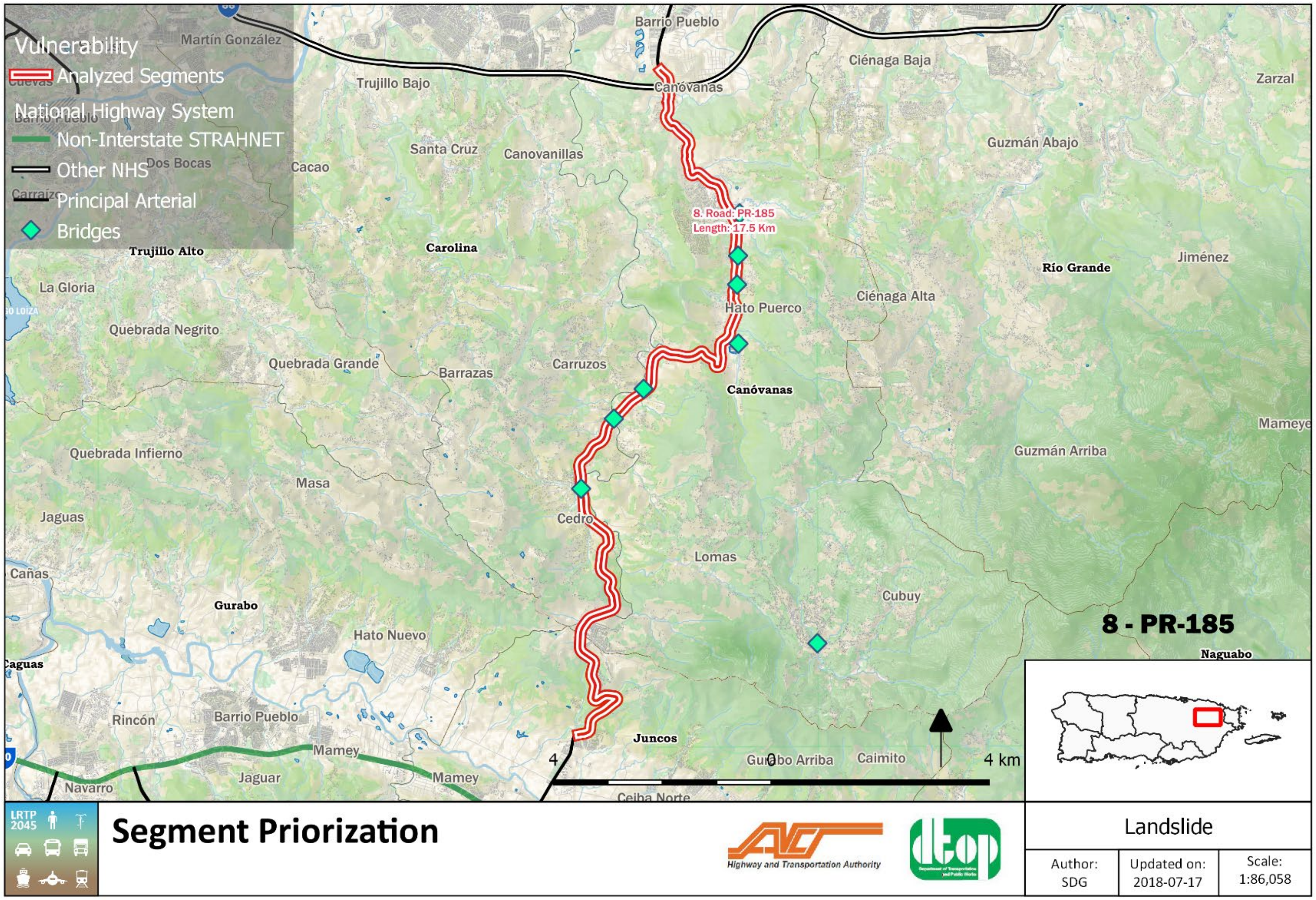
Source: SDG

Figure 6.23: PR-2 Guaynabo



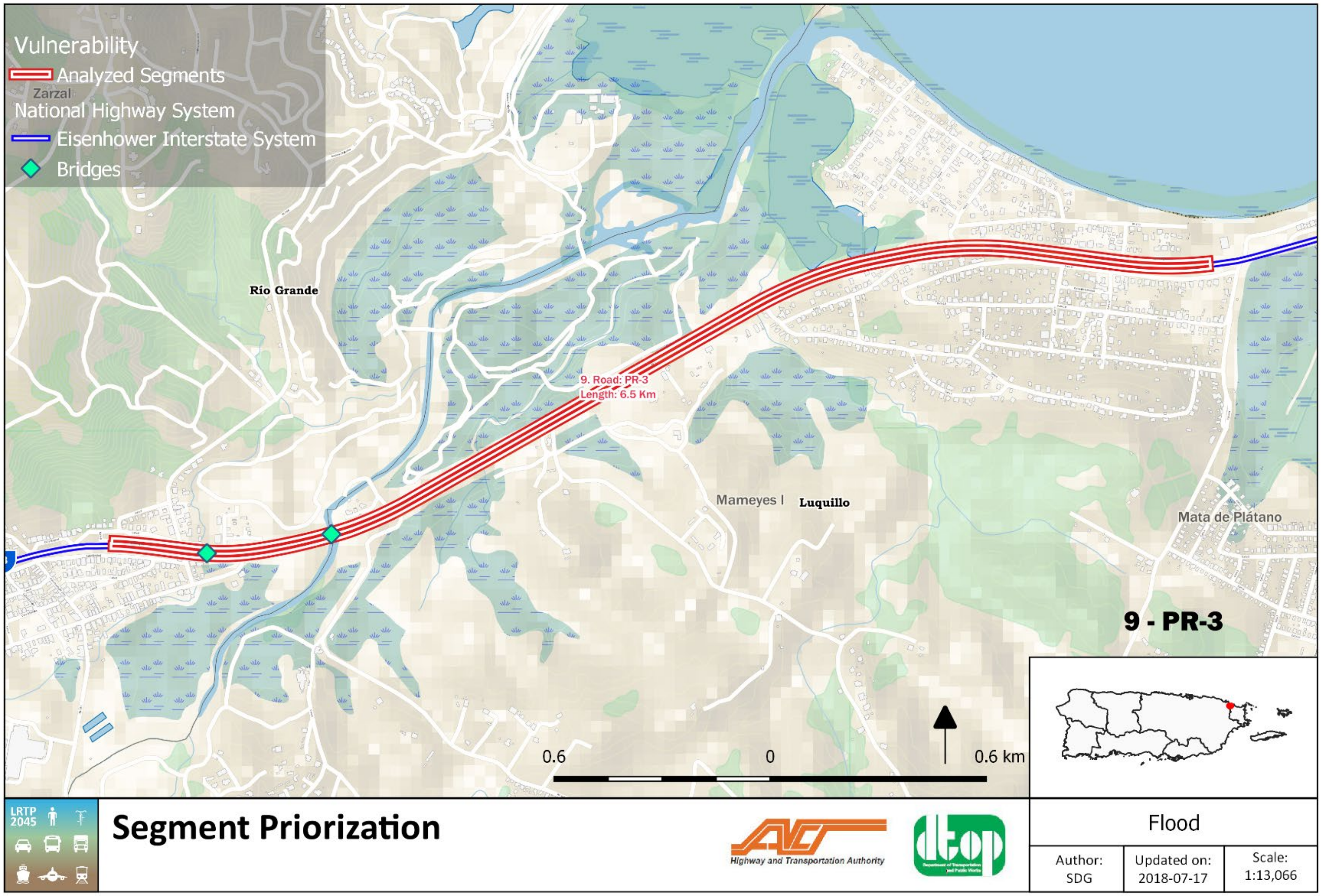
Source: SDG

Figure 6.24: PR-185: Canóvanas / Juncos



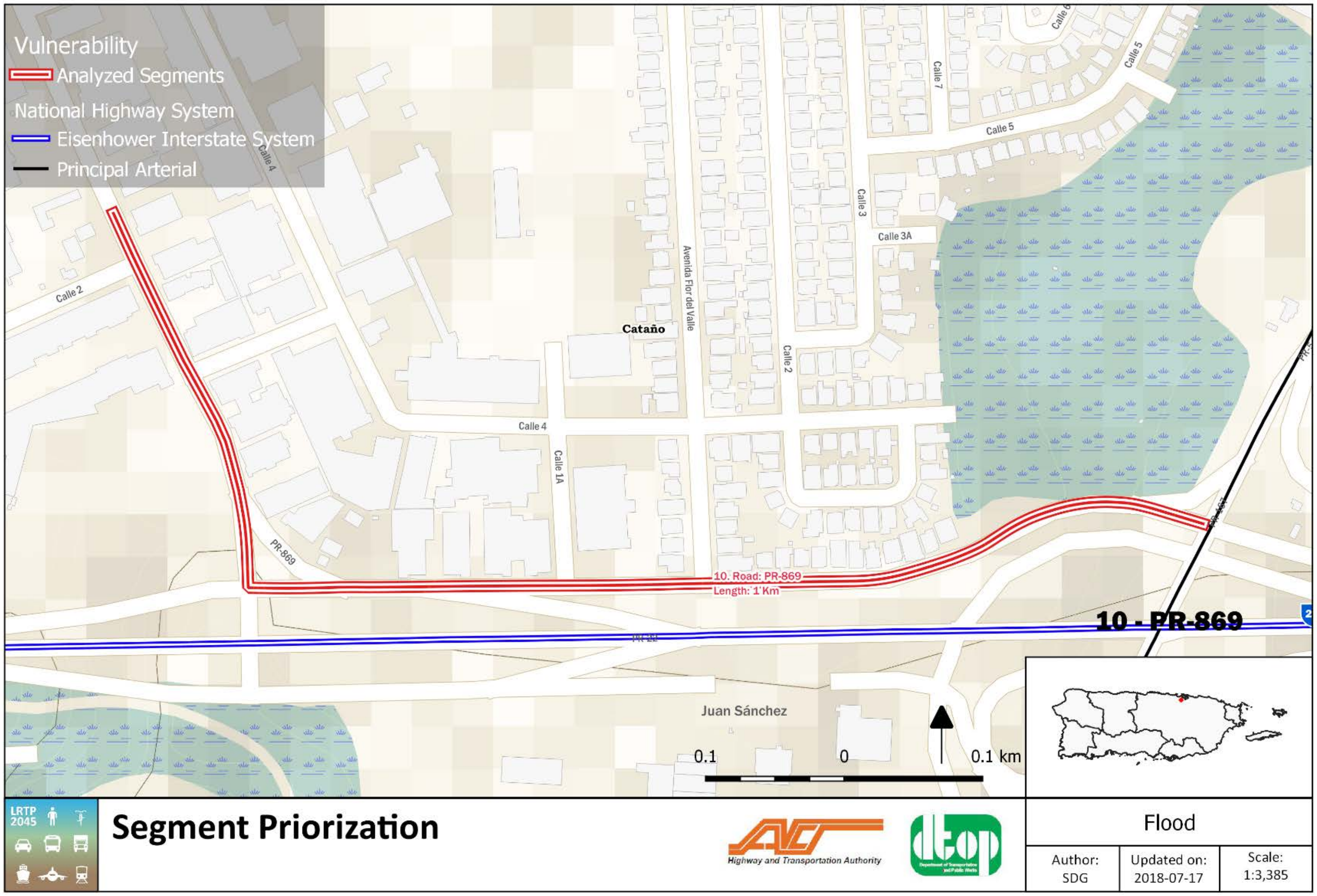
Source: SDG

Figure 6.25: PR-3: Luquillo



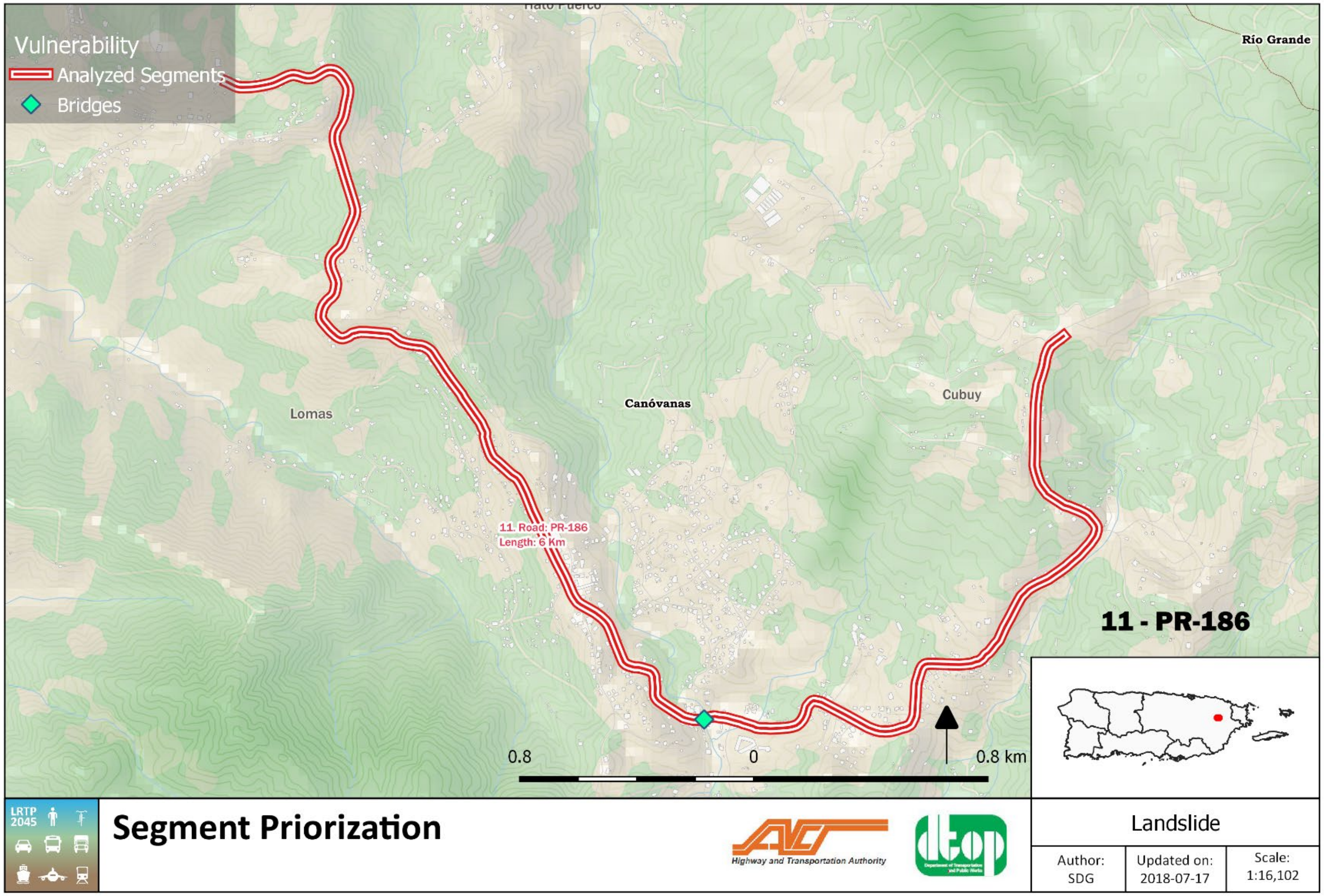
Source: SDG

Figure 6.26: PR-869: Cataño



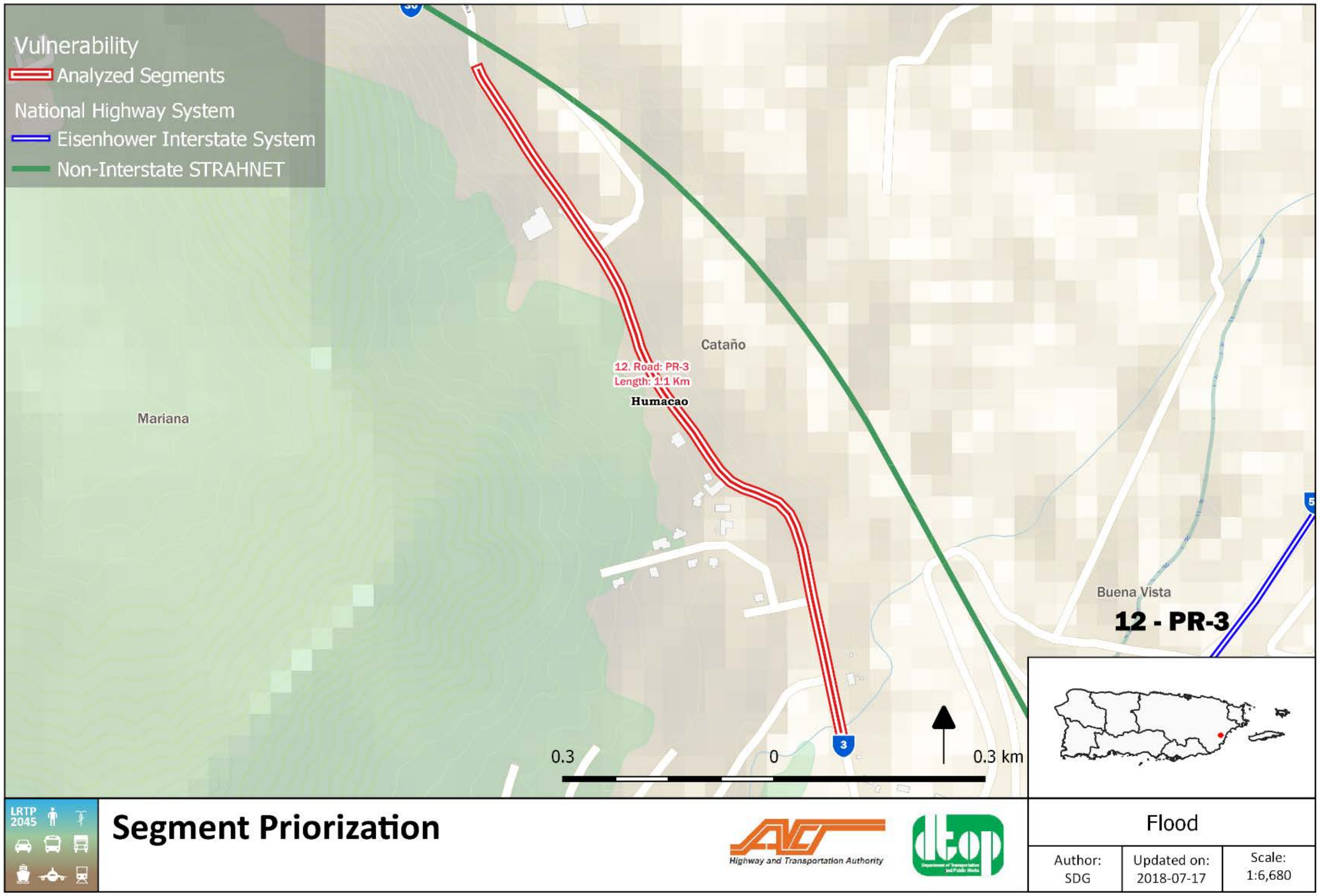
Source: SDG

Figure 6.27: PR-186: Canóvanas



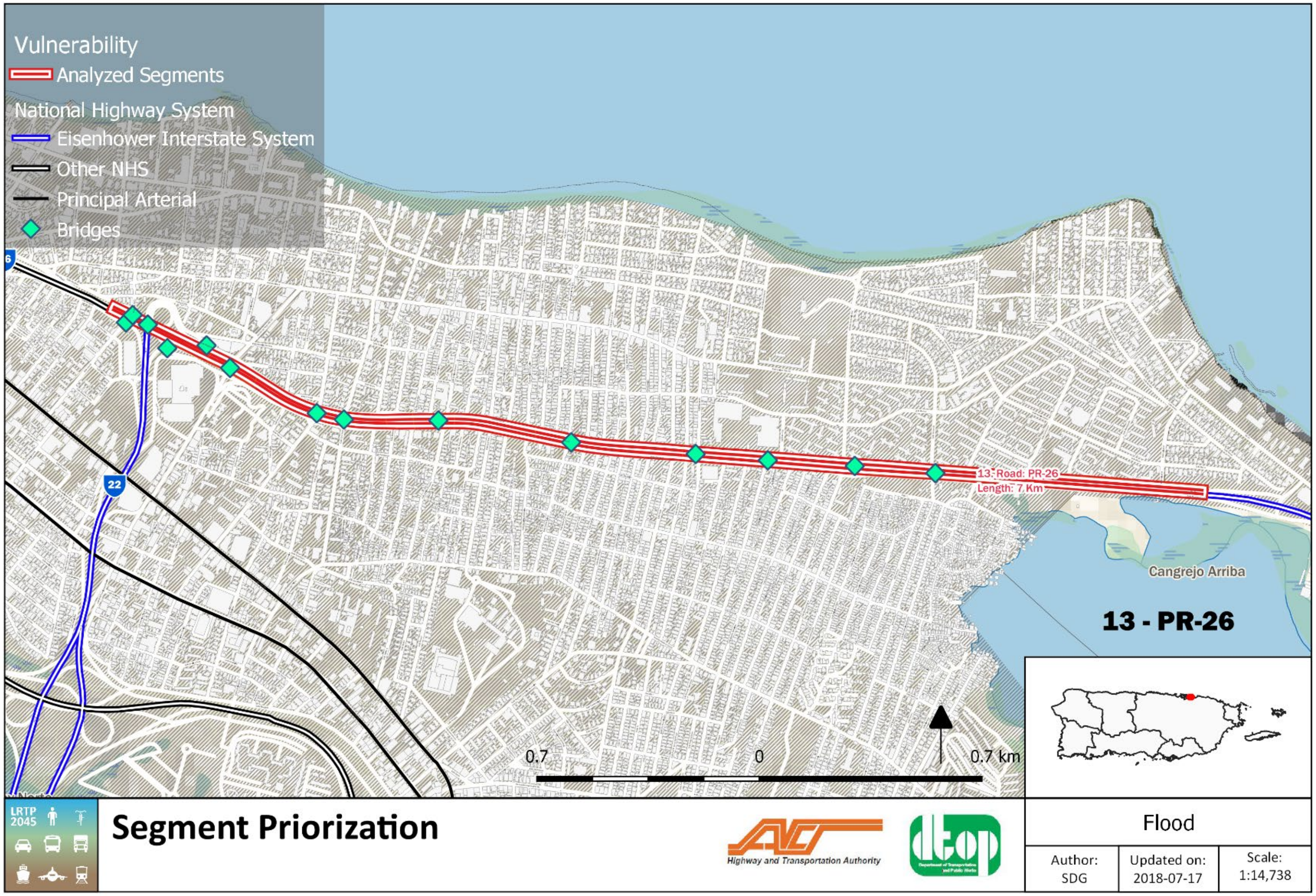
Source: SDG

Figure 6.28: PR-3: Humacao



Source: SDG

Figure 6.29: PR-26: San Juan

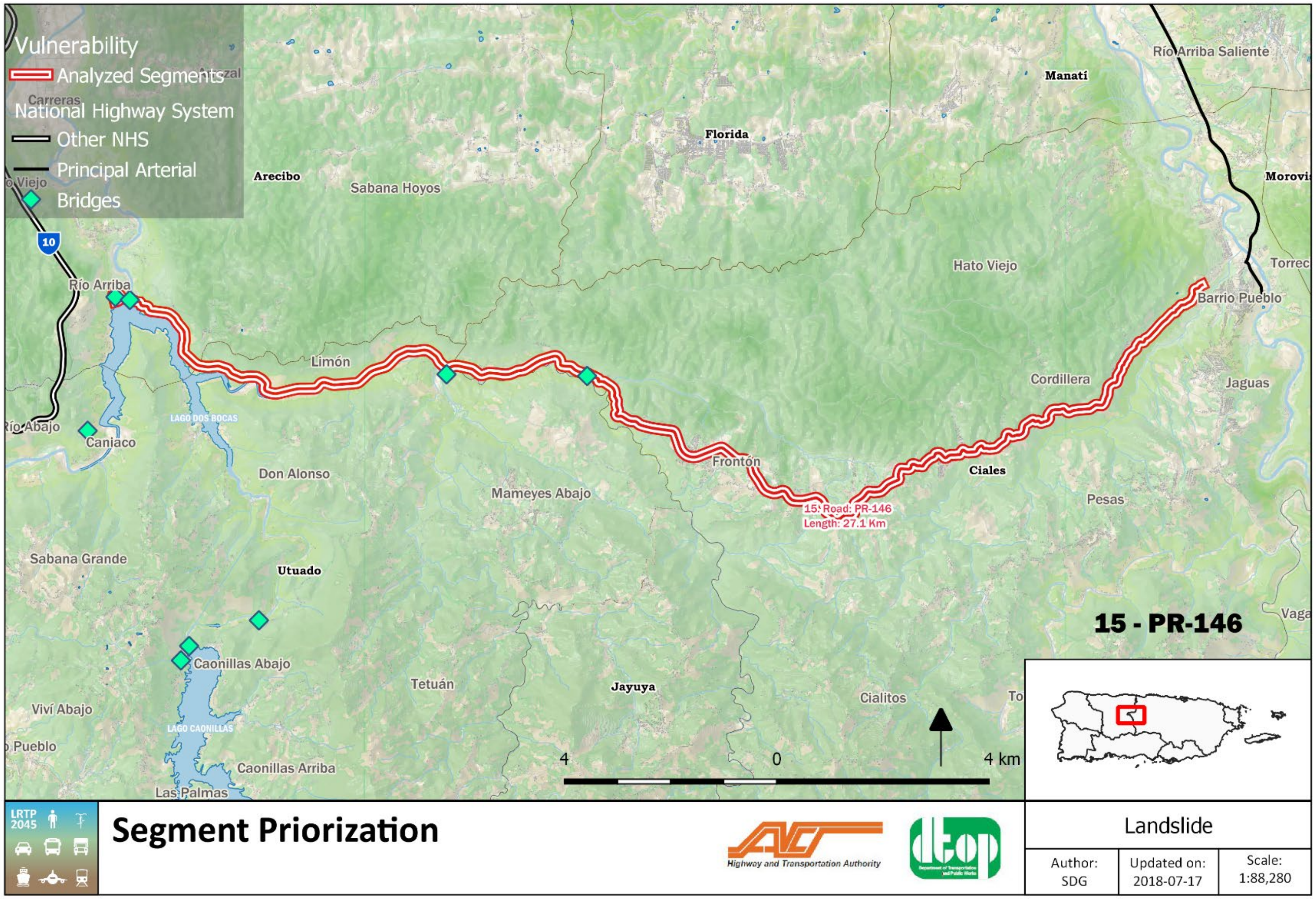


Source: SDG

Figure 6.30: PR-1: Ponce, Juana Díaz, Santa Isabel, Salinas

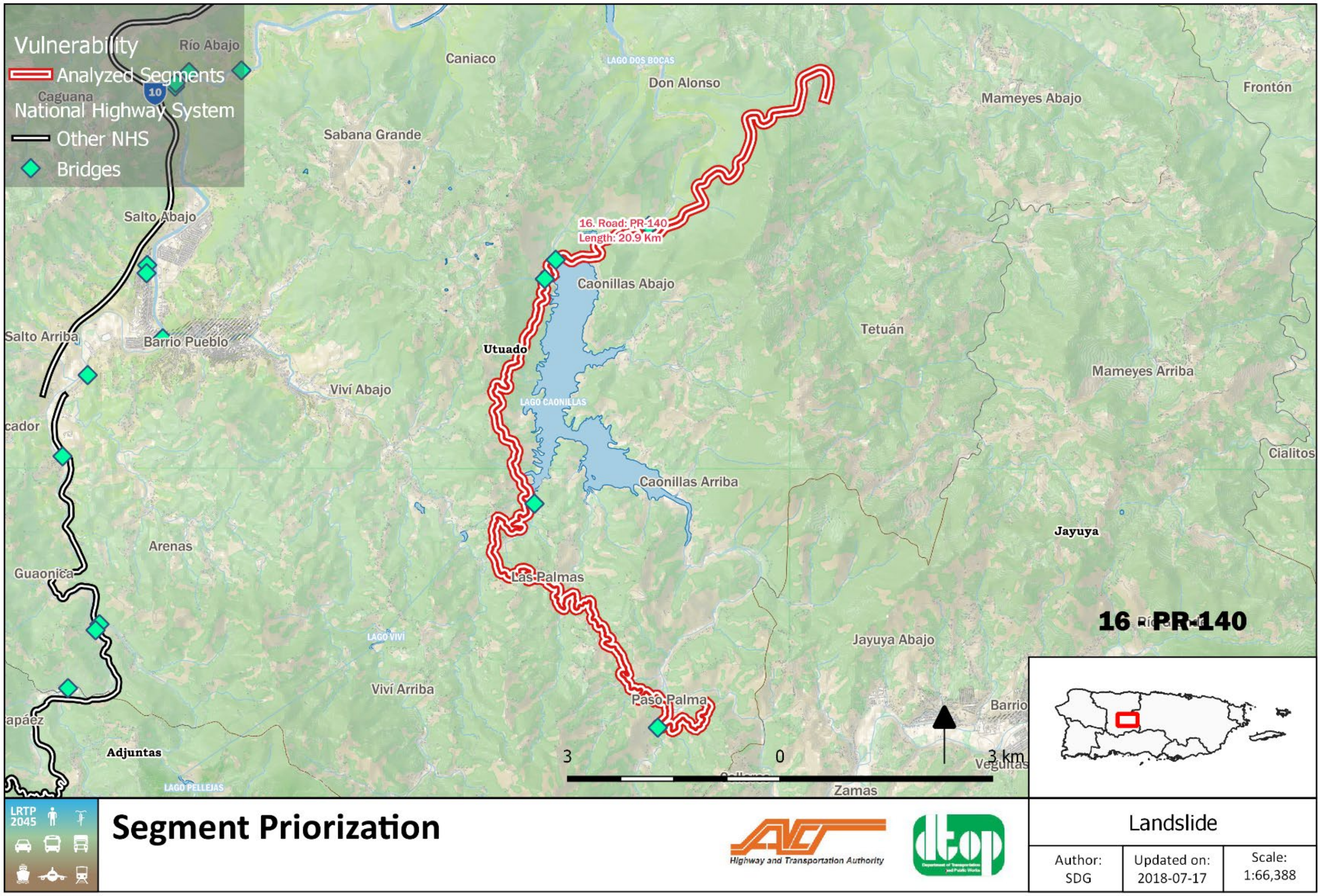
Source: SDG

Figure 6.31: PR-146: Ciales



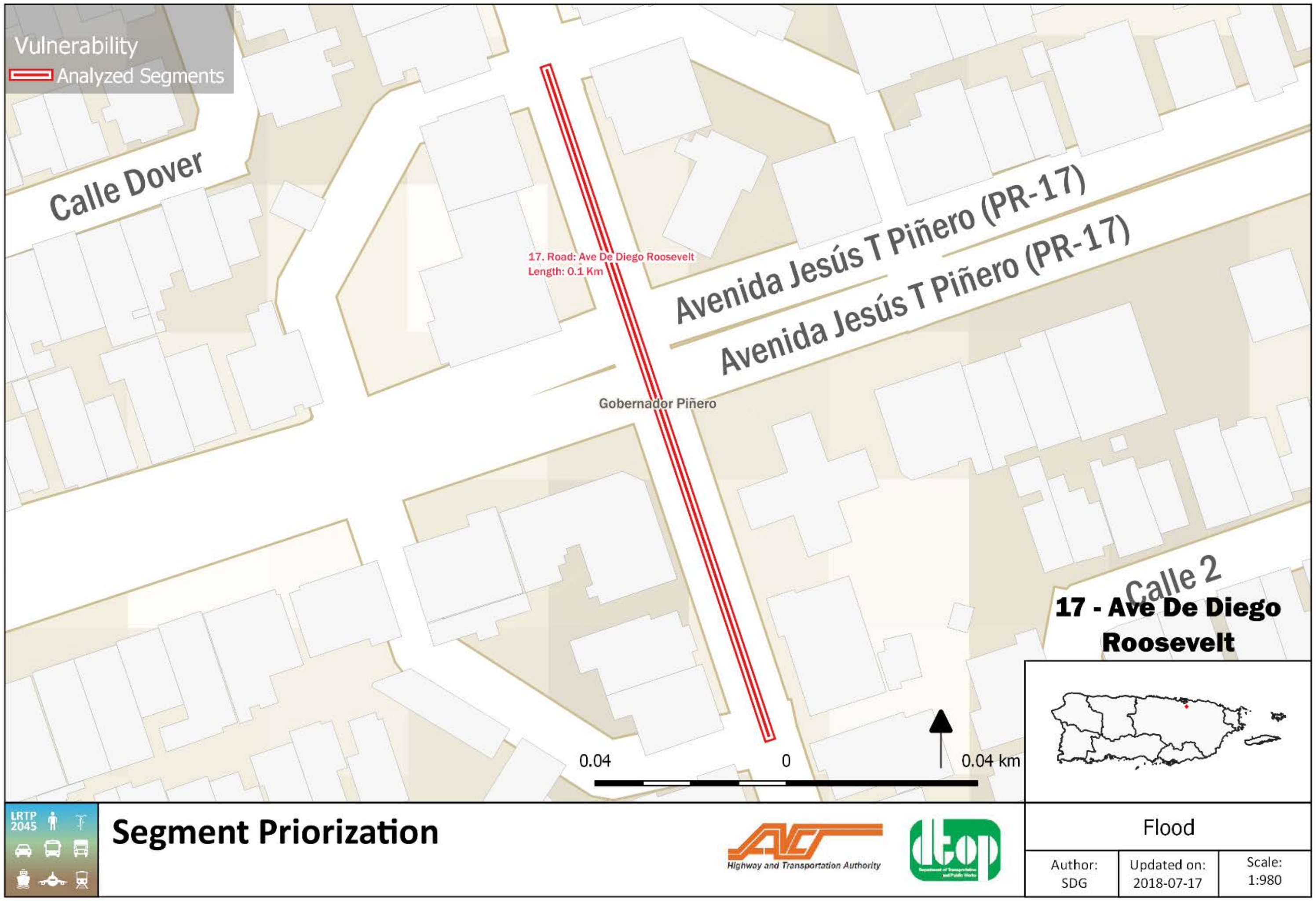
Source: SDG

Figure 6.32: PR-140: Utuado



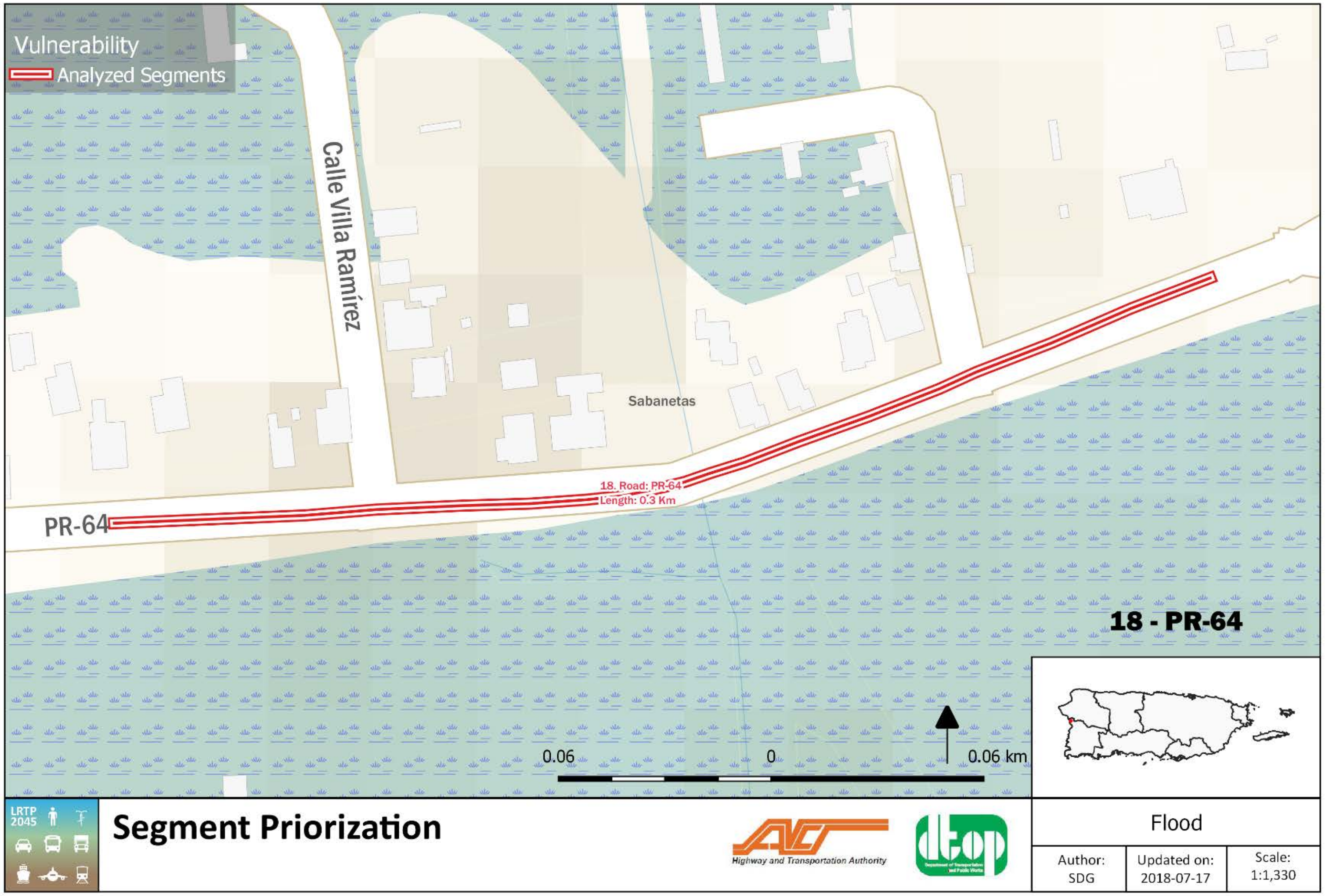
Source: SDG

Figure 6.33: Av. De Diego: San Juan



Source: SDG

Figure 6.34: PR-64: Mayagüez



Source: SDG

Figure 6.35: PR-2: Vega Baja

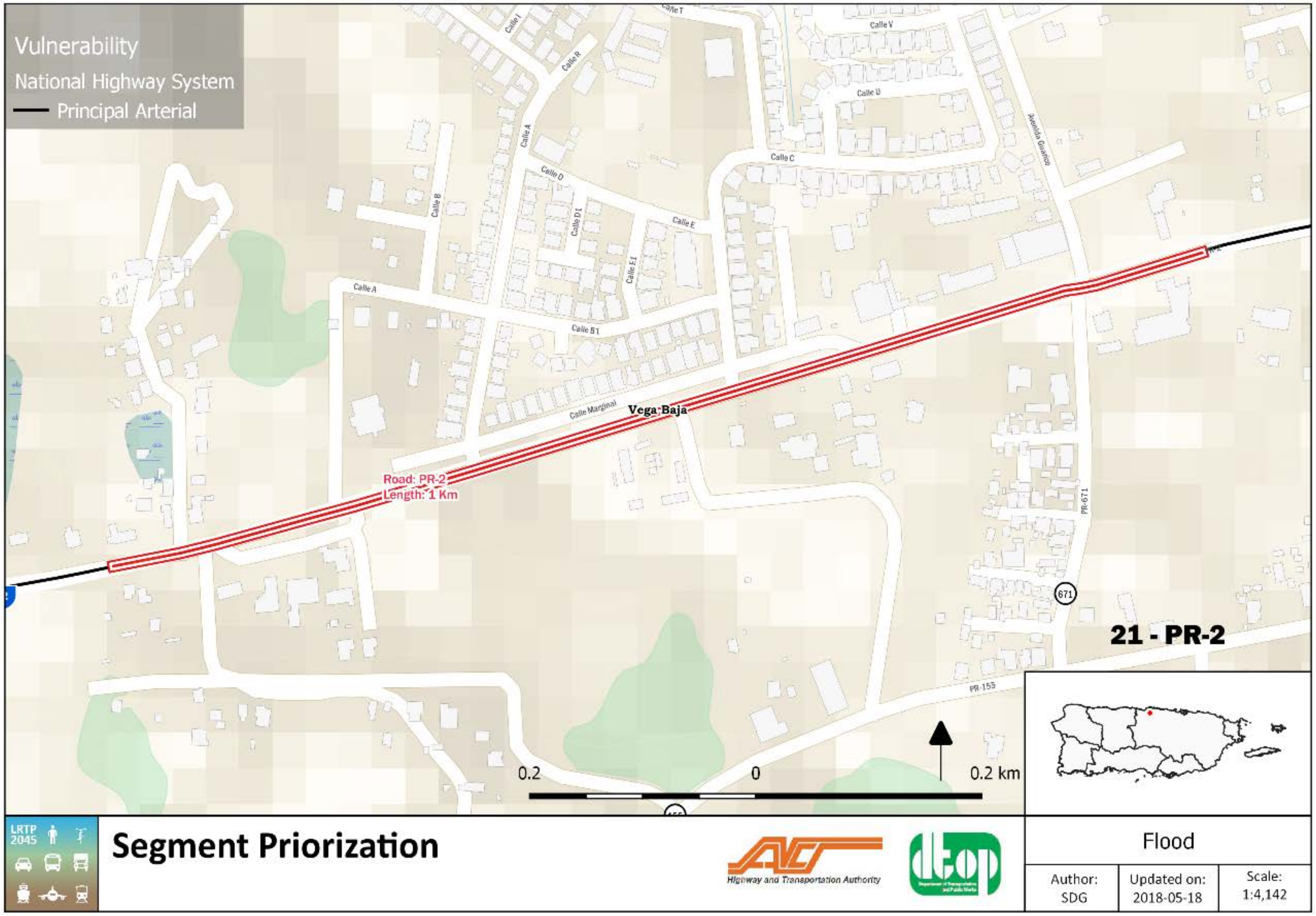
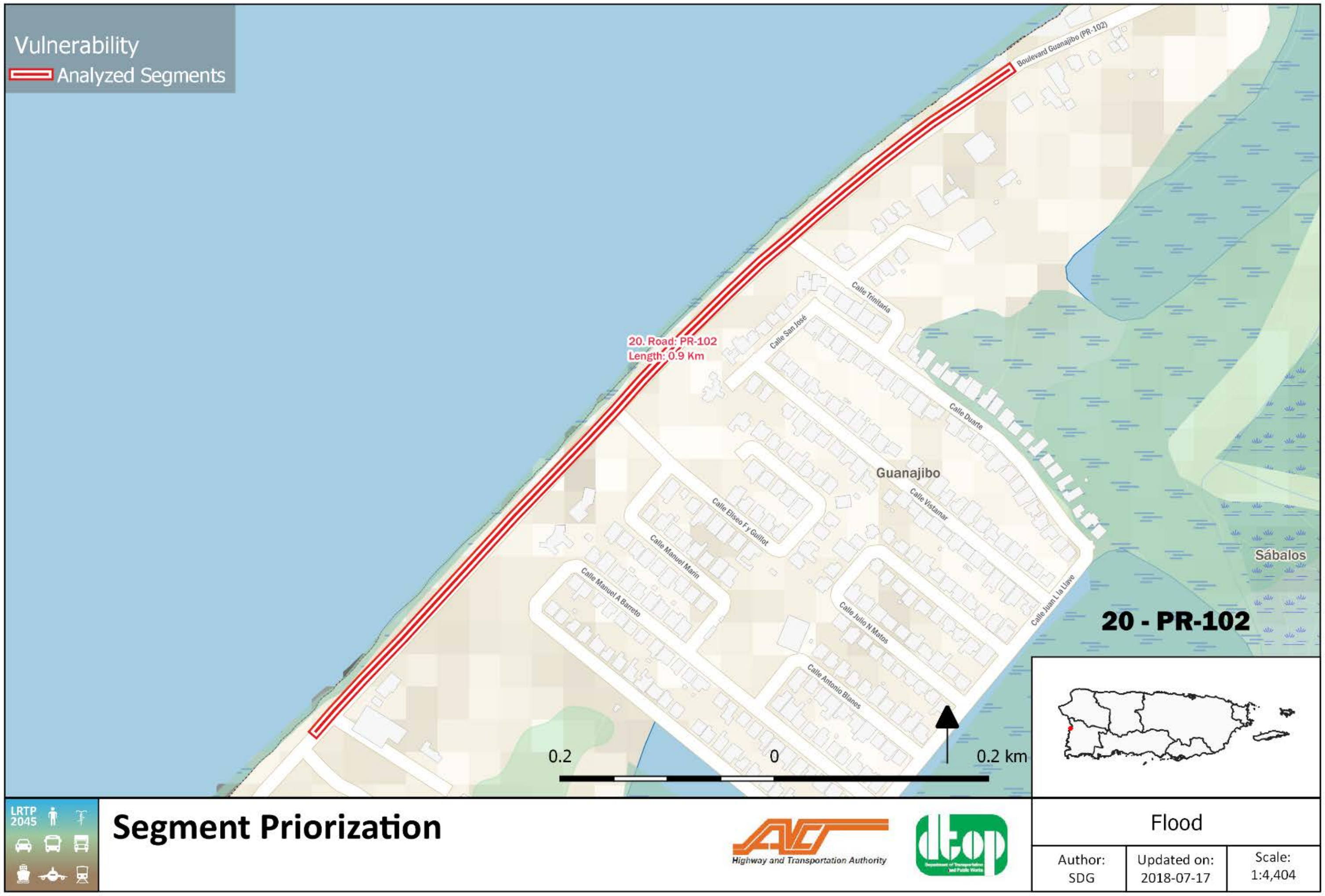
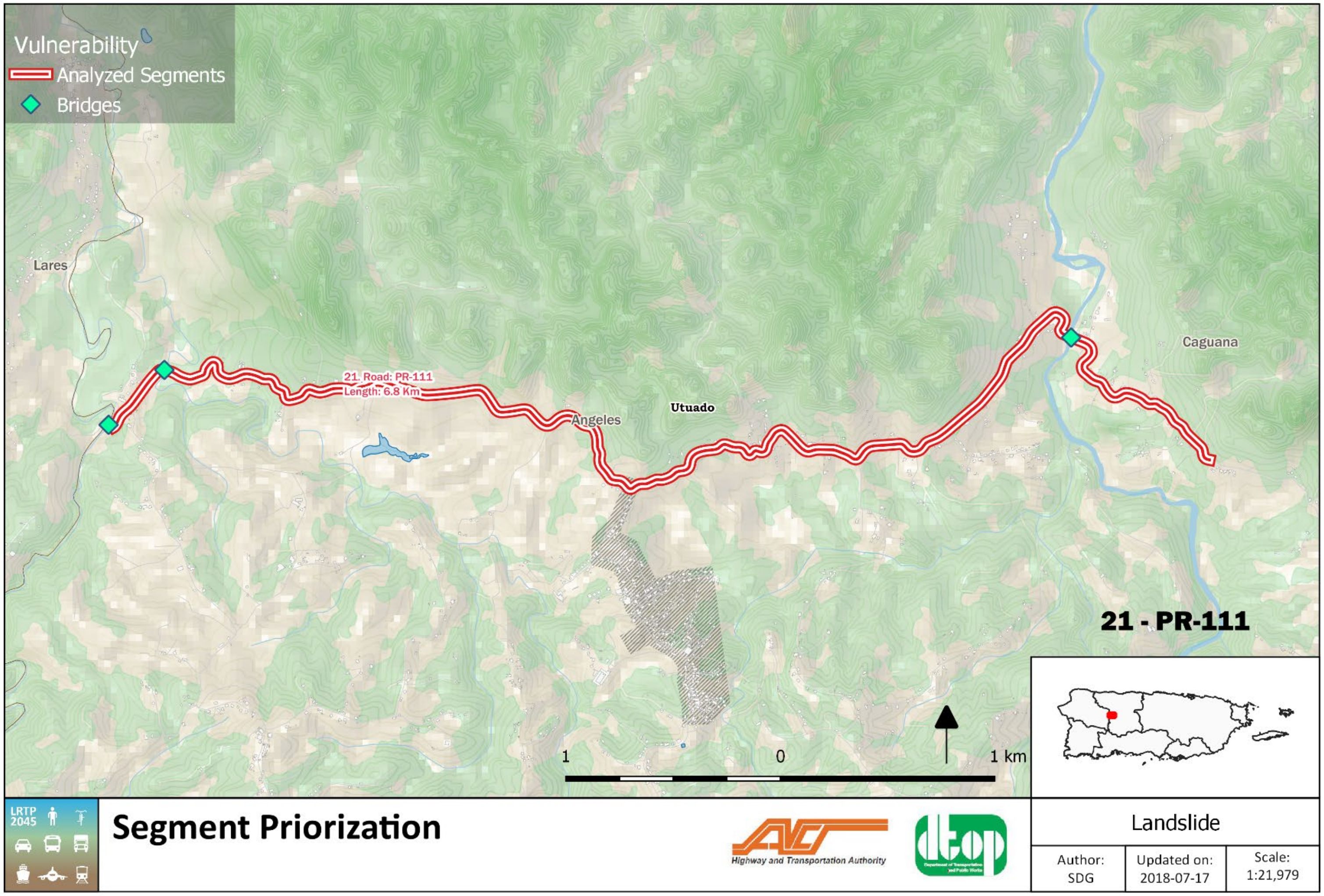


Figure 6.36: PR-102: Mayagüez



Source: SDG

Figure 6.37: PR-111



Source: SDG

Bottleneck Analysis

Introduction

The planning factors include the priority of supporting the economic vitality, especially by enabling global competitiveness, productivity, and efficiency as well as promoting efficient system management and operation. Congestion management and reduction is an important factor to consider within this 2045LRTP.

Typically, road congestion is associated with traffic volume, level of service (LOS), and speed. These indicators can be measured considering the following key performance indicators (KPIs): delay, queue, LOS, volume to capacity ratio (V/C), speed, travel time or density.

As part of the 2045 LRTP, a bottleneck analysis based on delays identification was performed for the NHS. For this analysis, data from NPMRDS corresponding to years 2016-2018 was utilized for extracting speed and distance of TMC coded segments, in order to calculate travel time. The variable delay was obtained through comparing travel time at reference speed and travel time at traffic speed, to assess the time of delay for all segments, per period of day.

<u>Travel Time Reliability</u>

Generally, urban areas face congestion during peak hours. As a result, citizens are required to adjust the travel time to account for the estimated delay and ensure arriving at their destination on time. The reliability of this travel time adjustment influences user's decision on whether to leave early to account for that delay or risk being late to their destination. Travel time dependability affects citizen's everyday life factors such as value of time, quality of life and well-being.

<u>Bottleneck Analysis</u>

According to FHWA, bottlenecks are recurring congestion events, and considered "active if traffic is detected to be queued upstream of the location and unqueued downstream (page 106)".[90] As opposed to nonrecurring events of congestion attributed to traffic anomalies such as car accidents, bottlenecks are predictable in cause, location, time of day and approximate duration. This specific bottleneck analysis focuses on identifying segments with major delays along the NHS in Puerto Rico. By identifying these segments, there can be a determination of: specific locations where congestion is highest along a road and the daily period of occurrence.

Methodology

<u>Segment Identification</u>

To identify possible bottlenecks, it is necessary to consider segments with travel times higher than the expected at reference speed for a road segment or TMC. Subsequently, vehicle delays per segment were obtained in minutes by subtracting the average travel and reference travel time. By

[90] Daganzo, C.F. (1999). "Remarks on Traffic Flow Modeling and its Applications," Traffic and Mobility, 105–115, Springer Berlin Heidelberg, Berlin, Germany.

measuring delay, possible bottleneck segments and roads can be identified as those with higher delays on traveling time.

To conduct the Bottleneck Analysis this analysis was conducted in each Region, per period of the day (AM, MD, PM, NT). Once all the Regions were analyzed by period, a recurrence assessment was made for the same months to identify the top ten (10) worst segments in terms of delays. The ten (10) segments (TMC) with the highest recurrence were the TMC selected for the analysis of the average delays per Region per period, presented in the following section.

Analysis of Results

For all Regions in Puerto Rico, periods with the highest delays were past mid-day and mid-day periods. For these periods of the day, Regions with the highest delays were San Juan and Aguadilla TMA with values above 5.0 minutes and up to 9.5 minutes on average delay for top ten segments.

For other urbanized areas, the North top ten segments had high average delays going from 5.0-7.0 minutes; Southwest had average delays between 3.5 to 5.5 minutes; and East, Southeast and South Regions had the lowest average delays ranging from 2.0-2.7 minutes. Road segments with maximum delays per road and per period of the day are identified in Figure 6.38, where locations of these segments are highlighted according to the maximum delay recorded per period of the day.

In the Region of San Juan TMA, segments with higher delays are mostly concentrated in urbanized areas such as San Juan, Bayamon, Guaynabo, Toa Baja, Carolina, Río Grande, Caguas, Juncos, Humacao, y Naguabo. The top 10 segments with worst delays were identified along PR-2, PR-901, Avenida Jesús T. Piñero, PR-52E, and PR-3. The road with most bottleneck segments and worst delays in this region was PR-2, ranking the highest for all periods of the day and throughout all months of the period studied.

In the case of San Juan and Bayamón, some of the locations include: a loop of Ave. Muñoz Rivera in Old San Juan, along Calle Marginal in Puerto Nuevo, Teodoro Moscoso bridge connecting the Luis Muñoz Marín International Airport, and Ave. Jesús T. Piñero. In Bayamón, some areas include Ave. 65 de Infantería around Goya, Ave. Comercio, and south of Bayamón.

Outside of San Juan and Bayamón, segments are located along roads to the west of Bayamón around densely urbanized areas like Manatí, Vega Baja, and Vega Alta. Similarly, to the southeast of San Juan TMA Region, there are segments connecting certain communities like PR-30 between Gurabo and Juncos, and along the coast I PR-901 between Maunabo and Puerto Yabucoa.

In the Region of Aguadilla, all TMC segments studied were located along PR-2. The top 10 TMC segments with the worst delays recorded values between 1.0-9.0 minutes on average per month. The past-midday period had the highest delay on average throughout the period of study with 4.6 minutes, in comparison to mid-day period with 3.8 minutes, night period with 3.2 minutes, and morning period with 2.0 minutes on average. Segments with the highest recurrence of delays throughout periods of day were located in areas between Aguada and Añasco (PR-417 to PR-109) in both directions, Aguadilla from PR-107 to intersection with PR-110, Isabela from PR-113 (Cara del Indio) to PR-4494, as described in Figure 6.38.

In the North Region, segments with the highest recurrence of delays throughout the day were located along PR-2, PR-22 and PR-10. The top 10 TMC segments with the worst delays were along PR-2 and PR-10, with delay values ranging between 2.0-8.0 minutes on average per month. The periods of the day with the highest delays were past-midday period with 5.6 minutes, night period with 5.4 minutes, and mid-day period with 4.8 minutes. The morning period reported a lower average of 2.7 minutes delay. Segments with highest recurrence of delays throughout periods of the day were located in three sections along PR-2: between Quebradillas and Camuy, between Hatillo and Arecibo, and between Arecibo and Barceloneta.

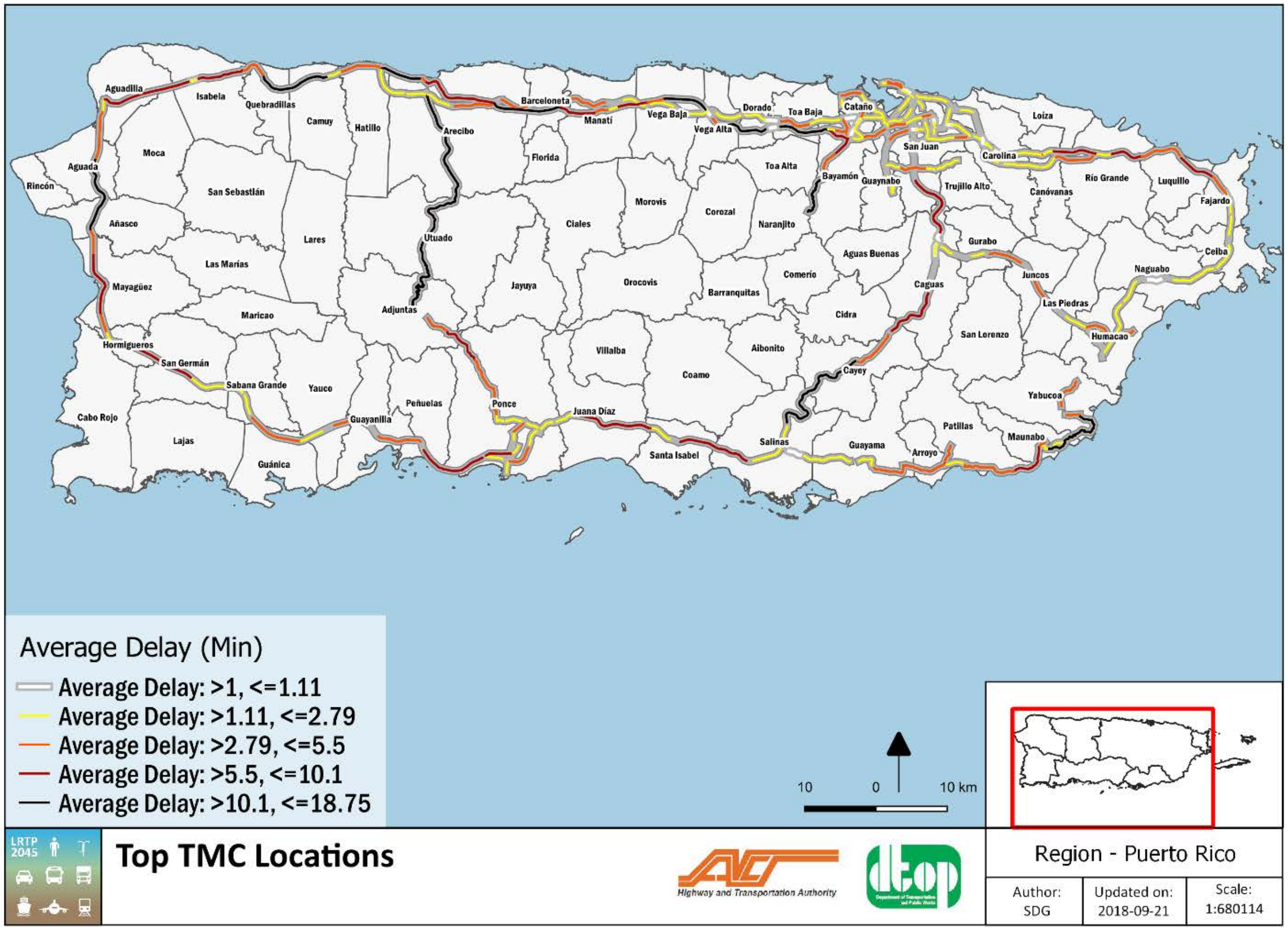
For the South Region, all TMC segments studied were located along PR-2, PR-52, PR-10 and Avenida Tito Castro. The top 10 TMC segments with the worst delays were along PR-2, PR-52, and Avenida Tito Castro with delay values ranging between 1.7-5.8 minutes on average per month. The periods of the day with the highest average delay were night-period with 2.5 minutes, past-midday period with 2.4 minutes, mid-day period with 2.0 minutes, and morning period with 1.5 minutes. Segments with highest recurrence of delays throughout periods of the day were located in PR-2 between Ponce and Peñuelas, Avenida Tito Castro in Ponce, Central Juana Diaz county and between Santa Isabel and Salinas.

For the East Region, all TMC segments studied were located along PR-3 and PR-53. The top 10 TMC segments with the worst delays were along PR-3 with delay values ranging between 1.0-3.0 minutes on average per segment per month. The periods of the day had the following average delays: past mid-day period with 1.9 minutes, mid-day period with 1.7 minutes, night-period with 1.4 minutes, and morning period with 1.3 minutes. Segments with highest recurrence of delays throughout periods of the day were all located in Luquillo county along PR-3, in sections between PR-194 and PR-976; between Playa Fortuna and PR-968 in Luquillo; and between Luquillo and Fajardo.

For the Southeast Region, all TMC segments studied were located along PR-52, PR-53 and PR.3. The top 10 TMC segments with the worst delays were along PR-3 with delay values ranging between 1.0-3.0 minutes on average per segment per month. The periods of the day had the following average delays: past mid-day period with 2.0 minutes, mid-day period with 1.9 minutes, night-period with 1.8 minutes, and morning period with 1.3 minutes. Segments with the highest recurrence of delays throughout periods of the day were located in PR-52 section between Santa Isabel and Salinas, in PR-3 between Patillas and Maunabo. Other areas with high delays include PR-3 and PR-54 between Guayama and Arroyo.

For the Southwest Region, all TMC segments studied were located along PR-2. The top 10 TMC segments with the worst delays were located along PR-2 and had values ranging between 1.0-5.5 minutes on average per segment per month. The periods of the day had the following average delays: past mid-day period with 3.7 minutes, mid-day period with 3.2 minutes, night-period with 2.3 minutes, and morning period with 1.9 minutes. Segments with highest recurrence of delays throughout periods of the day were located in PR-2 sections in Mayagüez, between Mayagüez Pueblo and Mayagüez Mall.

Figure 6.38: Puerto Rico,Top Bottleneck Locations[91]



Source: SDG, based on NPMRDS Analytics

[91] The Cayey segment of the PR-52 that is categorized with a delay between 10.1 – 18.75 min; construction in the area has been constant since early 2016 which increase travel times in this segment beyond regular levels ta.

COST FEASIBILITY PLAN SCENARIOS

Transportation Funding Summary

This section describes the Cost-Feasible Plan recommendations from 2019 to 2045, a 27-year period. The initial period of 2019-2023 is covered by the PRHTA Revised Fiscal Plan 2018-2023 as certified by the Financial Oversight and Management Board for Puerto Rico on June 29, 2018, including completion of current projects. The requirements of the TAMP then dominate the spending projections through to 2028. From 2029 to 2045 the projections will remain cost-constrained, depending on the combination of future FHWA funding allocation and potential transfers from the Government of Puerto Rico.

As outlined in Chapter 5, the forecasts of the sources and allocation of transportation revenues were developed though to 2045, the horizon year of this plan. It is necessary for the LRTP to be developed as fiscally constrained, and to only recommend projects and improvements where there is identified funding to support their implementation. In practice there is no certainty around any of the funding streams except in the very short term, and prudent assumptions are therefore required.

It has been assumed that the level of Federal funding available will remain constant in real terms, and that the PR Government transfers will be maintained at around $200m per year in real terms, in order to maintain the SGR targets for interstates and NHS, and to progressively address the SGR backlog on non-NHS highways. The limited remaining highways funds are then applied to address the prioritized list of projects, including studies; operational improvements; and limited new construction for capacity improvement. A specific allocation is made towards safety including bicycle and pedestrian projects, for design and right of way for enhanced bicycle/pedestrian facilities. All available FTA 5339 funds are assumed to be dedicated to transit fleet renewal and SGR of transit facilities.

During the period through to 2028, the pattern of transportation system expenditure follows the TAMP balanced scenarios, and reflects an obligation to apply all available FHWA funds to achieve minimum required condition of interstate pavements and NHS bridges condition, and to work towards the PRHTA specified target for the condition of non-interstate NHS pavements. A specific mandatory allocation of FHWA funds is also made towards safety projects. There will also need to be state contributions to interstate and NHS SGR projects during this period, and towards SGR on the non-NHS network. During this period the scope to undertake additional highways projects will be extremely limited, although initial work could start from 2025 and gradually ramp up.

Both the available funding and costs are expressed in 2018 prices rather than Year of Expenditure estimates, given the significant uncertainties around both funding and construction price inflation over the medium and longer term. It is implicitly assumed that inflationary pressures will be compensated by increases in the level of funding made available. To the extent that this presumption is not met, it will be necessary to either postpone or delay projects. The over-riding priority to achieve SGR targets could mean that there is minimal funding available for other long-term projects unless there is either scope for an increase in PR Government transfers, or a restoration of the taxes and levies previously made available to PRHTA which are currently the subject of a clawback.

The projected allocation of funding is summarized in Table 6.8 below.

Table 6.8: Forecast of Regional Transportation Funds and Allocation ($000s, 2018 prices)

		2019-23	2024-28	2029-33	2034-39	2040-45
		Fiscal Plan	TAMP			
FHWA	FHWA Construction Spend	974,302				
	FHWA Construction Soft Costs	164,391				
	FHWA contribution to SGR Pavements & Bridges		510,905	510,905	613,086	613,086
	FHWA Safety projects		183,245	183,245	219,894	219,894
State	Non-Federal Construction Projects	483,039				
	Non-Federal Construction Soft Costs	85,512				
	Construction Local	45,950				
	State contribution to Interstate and NHS SGR		253,180	129,030	154,836	154,836
	State contribution to non-NHS SGR		585,606	627,556	753,068	753,068
	Prioritized highways projects		61,488	118,220	149,201	156,416
	Traffic signals SGR		66,145	66,145	79,374	79,374
	Design	42,131	39,410	39,410	47,292	47,292
	Right of Way	58,631	16,500	16,500	19,800	19,800
	Total Capital Expenditure - Highways	**1,833,529**	**1,716,479**	**1,691,012**	**2,036,550**	**2,043,765**
FTA	Transit CIP	115,000				
	Transit fleet renewal and SGR		25,000	25,000	30,000	30,000
	Total Capital Expenditure - Transit	**115,000**	**25,000**	**25,000**	**30,000**	**30,000**

Source: SDG analysis of fiscal plan, TAMP and priority project list

Projects Considered

Projects considered for the 2045 LRTP are detailed in Appendix H. This list was compiled during the meetings with different committees (primarily the Freight Advisory Committee and the technical committee), list sent in by municipalities and revision of projects in the STIP that will not be completed within the STIP (current STIP project lists relevant to Puerto Rico, separated by regions, are included in Table 6.9 to Table 6.11; including the bridge projects - Table 6.13 to Table 6.15; and safety projects - Table 6.16 to Table 6.19) timeframe (more detail on the list of projects in Appendix H). The list of projects underwent a detailed revision with the Technical Team of the PRHTA to eliminate those projects already considered as part of other streams of funds such as:

- Under construction or will be within the next 5 years as defined in the STIP or the pipeline of the PRHTA; and
- Considered within emergency funding such as the FHWA Emergency funding, Detailed Damage Inspection Reports (DDIR lists) – the lists used are included in Appendix H.

Projects falling within the following classifications were compiled a list of projects that will be candidates for funding under their respective funding allocations:

- Pavement and Bridge Preservation;
- Safety (according to Strategic Highway Safety Plan);
- Pavement and Bridge Reconstruction
- Bridges;
- Transit; and
- Intelligent Traffic System.

There is a series of projects identified to be considered for CDBG-DR funding that will potentially have access to additional funds in the short to mid-term; these are:

1. PR-10 (AC-100069, AC-100071, AC-100055, AC-100076) Adjuntas-Utuado;
2. San Lorenzo South Bypass, from PR-183/ PR-181 to PR-745 (AC-918101) San Lorenzo;
3. Aguas Buenas North Bypass, from PR-156 East to PR-156 West (AC-020802, AC-020803) Aguas Buenas;
4. PR-158 Connector, Phase I and Phase II from PR-52 to PR-1, (AC-015802) Cayey;
5. PR-122, Lajas-San German Connector from PR-321 to PR-166, (AC-012201) Lajas-San German;
6. PR-18N to PR-21E ramp and Medical Center Connector San Juan;
7. Extension PR-5, from PR-199 to PR-167, Bayamón-Toa Alta;
8. Isabela Connector, from PR-472 to PR-112 (AC-047205) Isabela;
9. Expressway Conversion of PR-2 Ponce-Mayagüez;
10. Higuilar Avenue from PR-696 to PR-22/PR-694 Dorado;
11. PR-22 extension, Hatillo- Aguadilla from PR-22/PR-2 to PR-2/PR-111 Hatillo-Aguadilla;
12. Cidra Connector, from Avenida Industrial to PR-184 (AC-017242, AC-017246, AC-017247) Cidra;
13. Relocation of PR-111 from PR-111/PR-448 to PR-111/PR-111R San Sebastián-Lares;
14. Barranquitas Bypass from PR-156 to PR-759 (AC-010194) Barranquitas;
15. Villalba Bypass, from PR-151 to PR-150, (AC-556103) Villalba;
16. Improvements to Aguadilla's Airport Access, from PR-110 to PR-107, includes Burns Street Connector (AC-000218) Aguadilla;
17. Loíza Bypass, from PR-188 to PR-187, (AC-018760) Loíza;
18. Widening PR-845, from PR-844 to PR-199, (AC-084511) San Juan-Trujillo Alto;
19. Widening PR-545, from PR-52 to PR-14, Coamo; and
20. Peñuelas South Bypass (PR-3132) from its intersection with PR-3132 (Northwest limit) to existing PR-3121 (Northeast Limit) Peñuelas.

Additionally, list of vulnerable roads and cycling safety projects are referred to in Appendix H, as these can be apportioned as part of safety, emergency or reconstruction projects. Illustrative major projects requiring funding identification thru P3 alternative and federal loans are included in Appendix J. It is considered a systematic preservation program is continued beyond reaching SGR.

There are initiatives underway for repair work in the entire Island road network such as State Road Modernization Program (PEMOC – in spanish Programa Estatal de Modernización de Carreteras) and “Abriendo Caminos”; the full list of projects under these two initiatives are included in Appendix H.

Other agencies such as the Eastern Federal Lands Highway Division (EFLHD) develop improvement programs including transportation infrastructure. Appendix H includes the FY 2019-2022 EFLHD Transportation Improvement Program for Puerto Rico.

The rest of the projects were considered within the main list of projects which were ranked based on the how these responded to the 2045LRTP Goals and Objectives. Costs were assigned to these projects determining when in time these projects will have funding available. For all of the island’s regions, the projects and their expected year of construction start are included in Table 6.20 Table 6.29, for the Medium to Long Term periods.

These projects have been assigned based on the ranking (Appendix H) and funding available; nonetheless, if additional funding becomes available these could be developed at an earlier stage.

Table 6.9: List of San Juan TMA projects in STIP Short Term (2017-2020)

AC #	Description	Municipality	STIP Total Costs
000259	**Construction of Noise Barrier, Los Almendros Development, PR-22 km 12.2 to km 12.7**	**Bayamon**	**$787,750**
000533	Environmental Study Extension PR-5 From PR-199 to PR-167	Bayamón	$2,076,369
010166	Additional Funds for the Construction of a new Recreational Trail for Bicycles and Pedestrians from Rio Bayamon to PR-165	Toa Baja	$1,000,000
010194	Barranquitas South Bypass LP-9999(189)	Barranquitas	$300,000
015801	Construction of PR-158, from PR- 743 to Parque Tecnológico Entrance - Phase 1	Cayey	$13,000,000
015802	Construction of PR-158, from Parque Tecnológico to PR-1, Cayey - Phase 2	Cayey	$1,306,583
017242	Cidra East Connector form #2 Street (Industrial Avenue) to PR-734 (Phase 1) Length 1.38	Cidra	$3,000,000
018760	Feasibility Study and Design PR-187 Bypass Feasibility and Update Environmental Study South Bypass from PR-188 to Medianía Baja (PR-187) (CFHWA)	Loíza	$1,494,103
019143	Replacement of Bridge #194 PR-31 km 8.8	Naguabo	$7,289,814
020802	Aguas Buenas Bypass from PR-156, KM 53 to PR-173, Lenght 3.1	Aguas Buenas	$2,275,000
084511	Widening PR-845 from Pasternak Street to Int. PR-199	San Juan / Trujillo Alto	$375,000
300124	Congestion Managed Lanes - Phase 5 - PR-30-San Juan (km 0.30 to km. 7.20) - reversible lane using reversible lane barrier system on PR-30 from Km. 0.30 to Km. 7.20	San Juan / Trujillo Alto / Caguas	$7,521,640
301133	Additional Funds for the Feasibility Study RFP - Improvements PR-3 Río Grande - Fajardo Corridor Including Access Management Plan from its intersection with PR-66 Municipality of Rio Grande to its intersection with PR-53 Municipality of Fajardo	Rio Grande / Fajardo	$764,169
520130	Congestion Managed Lanes -Phase 1 - PR-52 -San Juan (km.0.30 to km. 9.16) - Two additional lanes on the median of PR-18 and PR-52 from San Juan to Caguas. These lanes will be managed using dynamic tolling to provide a reliable travel time for users. These lanes will be reversible (AM northbound and PM	San Juan / Trujillo Alto / Caguas	$32,369,532
800480	Technical Studies NEPA San Lorenzo Bypass from PR-181 Int. PR-183 to PR- 181 Int. PR-9912 (AC-918101)	San Lorenzo	$478,149
800497	New Connector (Cancer Comprehensive Center) between PR-18 and PR-21 (includes new bridge over PR-18 and a new ramp from PR-18 to PR-21)	San Juan	$24,525,750

800508	Congestion Managed Lanes - Phase 4 - PR-52 /PR-30 - Caguas (km. 13.96 to km 16.63) - Improve the PR-52/PR-30 Interchange by providing a bridge interconnecting both roadways. The bridge will improve access from PR-1 to PR-52 northbound for all users, and provide access from PR-30 to PR-52 (AM) and from PR-52 to PR-30 (PM) for users of the dynamic toll facility. This phase will also provide open road tolling at the Caguas Norte Toll Plaza.	San Juan / Trujillo Alto / Caguas	$28,039,829
800509	Congestion Managed Lanes - ITS (All Phases) - will provide ITS instrumentation for all phases of the Congestion Managed Lanes projects for the operation of the dynamic toll and traffic incident management.	San Juan / Trujillo Alto / Caguas	$11,736,421
800510	Congested Managed Lanes - Noise Barriers - Vista Alegre Community, Borinquen Gardens, Parque Forestal, Berm- Residential Area, Quintas de San Luis, Berm-Villa Parana - will provide the noise abatement measures recommended as part of the environmental exclusion document prepared for the Congestion Managed Lanes project.	San Juan / Trujillo Alto / Caguas	$5,375,345
800523	Noise Barriers at PR-22 Paco Davila km 19.2 - km 19.5, El Patio km. 16.5 - km 17.1, Monte Claro km.14.1 - km 14.6, Rio Hondo 1 km. 12.8 - km 13.6 (Eastbound), Rio Hondo 2 km. 13.0 - km 13.25 (Westbound), Rio Hondo 3 km. 12.5 - km 12.9	Bayamon / Toa Alta	$3,345,496
TOTAL			$147,060,950

Source: STIP 2017-2020; Feb 2018

Table 6.10: List of Aguadilla TMA projects in STIP Short Term (2017-2020)

AC #	Description	Municipality	STIP Total Costs
411901	Las Marias Connector, from KM 119 To Ramón Rivera Street	Las Marias	$4,640,250
000213	Additional Funds for the Feasibility Study RFP - Improvements PR-2, Aguadilla - Mayagüez Corridor from its intersection with PR-107 Municipality of Aguadilla to its intersection with PR-114 Municipality of Mayagüez	Aguadilla / Mayagüez	$380,000
011191	Relocation of PR-111 km. 27.9 a km. 34.0	San Sebastian / Lares	$2,500,000
500023	Bicycle and Pedestrian Route	Rincon	$5,175,954
011213	Improvements to PR-112 and Connector to PR-4494 - access to the Industrial Zone to the Isabela Connector, it includes improvements to PR-112. This project will be known as the Cano Rosa Connector	Isabela	$125,000
000218	Improvements to access to Aguadilla Airport through PR-110, 107 and connector to Burn Street	Aguadilla	$1,000,000
TOTAL			**$13,821,204**

Source: STIP 2017-2020; Feb 2018

Table 6.11: List of Other UZAs projects in STIP Short Term (2017-2020)

AC #	Description	Municipality	STIP Total Cost	TPR
065403	Bridge Critical Findings - Rehabilitation of Bridge # 1638 - over Rio Grande River on Victor Rojas Avenue in Arecibo	Arecibo	$689,500	NTPR
100076	Construction PR-10 from Sta. 95+00 to 109+80	Adjuntas	$8,500,000	NTPR
100081	Reconstruction of PR-10, kms 59.4, 60.4, 60.9, 61.1	Utuado / Adjuntas	$7,763,711	NTPR
800356	Reconstruction of PR-135 km. 78.5	Adjuntas	$360,000	NTPR
301133	Additional Funds for the Feasibility Study RFP - Improvements PR-3 Rio Grande - Fajardo Corridor Including Access Management Plan from its intersection with PR-66 Municipality of ZP-20 Rio Grande to its intersection with PR-53 Municipality of Fajardo	Rio Grande / Fajardo	$764,169	ETPR
054509	PR-545 Widening from PR-52 (Km. 1.03) to PR-14 (km. 6.03)	Coamo	$1,620,475	STPR
520129	Conversion of Old Juana Diaz Toll Facility to a Truck Weigh and Inspection Station at PR-52	Juana Diaz	$1,000,000	STPR
556103	Villalba Bypass - From PR-560 to PR-151 (STA. 24+82 to STA. 31+64) Length 0.68	Villalba	$500,000	STPR
800475	Systematic Bridges Preservation Program (2017) Bridge #2032, at PR-2 over PR-128, km 197.8, Yauco	Island-wide	$1,301,258	STPR
010029	Widening of PR-100 from PR-308 to PR-101	Cabo Rojo	$300,000	SWTPR
012201	Construction Lajas San Germán Connector Phase II, PR-321 to-PR-122	Lajas / San German	$625,000	SWTPR
200200	Design and NEPA Int. PR-2 and PR-114	Mayagüez	$2,000,000	SWTPR
200241	Access Request Analysis and Preliminary Design of Geometric Improvements to PR-2 (Entrance RUM, La Vita)	Mayagüez	$2,000,000	SWTPR
200248	Conversion to Expressway PR-2 Lavadero Ward	Hormigueros	$13,750,413	SWTPR
TOTAL			**$41,174,526**	

Source: STIP 2017-2020; Feb 2018

Table 6.12: List of Island-wide projects in STIP Short Term (2017-2020)

AC #	Description	STIP Total Cost
800474	Rehabilitation of Complex Bridge #300, Naranjito	$13,341,876
800477	PR-52 from km 66 to km 71.6 to km 77	$32,172,982
900123	SPR-54 - State Planning and Research Program (2017)	$6,000,000
900124	Bridge Critical Findings (2017) ROW - Bridge #547 over Cruz Creek at PR-824, km 2. 8, Toa Alta; Construction - Bridge #547 over Cruz Creek at PR-824, km 2. 8, Toa Alta ROW - Bridge #780 over Matrullas River at PR-143, km 36, Orocovis ROW - Bridge #2314 over Cayaguas River, off PR-902, km 0.1, San Lorenzo	$579,434
990133	Intelligent Transportation System (ITS) (2017) Reversible Lane Barrier Operation PR-18 and PR-52	$900,000
800475	Systematic Bridges Preservation Program (2017) Bridge #2032, at PR-2 over PR-128, km 197.8, Yauco	$1,301,258
992477	Bridge Inventory System NBIS (33) (2018)	$1,874,961
990134	Upgrade of Safety Devices in the Highway System (2017) PR-66 km 0 to km 20	$7,173,465
990135	Island-wide Roadwide Traffic Signals, Pavement Marking, Signing and Geometric Safety Improvements Projects (2017) PR-52, from km 49 to km 52.3, Salinas -PR-52, from km 55.3 to km 61, Salinas -PR-20 from km 0 to km 10, Guaynabo - PR-152 from km 0 to km 11.5, Barranquitas - Naranjito PR-152 km 13.65 to km 20.5, Barranquitas - Naranjito	$27,431,780
800485	Pavement Rehabilitation and Reconstruction of Roads (2018)	$50,211,087
800486	Rehabilitation and Replacement of Bridges (2018)	$9,316,000
900128	SPR-55 - State Planning and Research Program (2018)	$6,000,000
900129	Bridge Critical Findings (2018) Island-wide	$6,268,000
990146	Intelligent Transportation System (ITS) (2018)	$2,375,000
800487	Systematic Bridges Preservation Program (2018)	$3,094,000
992478	Bridge Inventory System NBIS (33) (2019)	$1,791,141
800493	Implementation of Strategic Highway Safety Plan (2018)	$2,500,000
990144	Upgrade of Safety Devices in the Highway System (2018)	$14,356,261
990145	Island-wide Roadwide Traffic Signals, Pavement Marking, Signing and Geometric Safety Improvements Projects (2018)	$6,459,210
990152	Highway Safety Improvements - Puerto Rico Section 154 and 164 Penalty (HSIP- Elegible Activities) (2018)	$3,800,000

AC #	Description	STIP Total Cost
800511	Pavement Rehabilitation and Reconstruction of Roads (2019)	$14,820,069
800512	Rehabilitation and Replacement of Bridges (2019)	$13,307,000
900132	SPR-56 - State Planning and Research Program (2019)	$6,000,000
990153	Intelligent Transportation System (ITS) (2019)	$3,400,000
900133	Bridge Critical Findings	$2,800,000
992479	Bridge Inventory System NBIS (33) (2020)	$1,750,000
800514	Island-wide Roadwide Traffic Signals, Pavement Marking, Signing and Geometric Safety Improvements Projects (2019)	$12,519,684
800515	Implementation of Strategic Highway Safety Plan (2019)	$6,000,000
990155	Upgrade of Safety Devices in the Highway System (2019)	$13,454,000
990154	Highway Safety Improvements - Puerto Rico Section 154 and 164 Penalty (HSIP- Elegible Activities) (2019)	$3,800,000
800516	Rehabilitation and Replacement of Bridges (2020)	$12,490,000
800518	Pavement Rehabilitation and Reconstruction of Roads (2020)	$40,107,356
900134	Upgrade of Safety Devices in the Highway System (2017); PR-66 km 0 to km 20	$6,000,000
900135	Island-wide Roadwide Traffic Signals, Pavement Marking, Signing and Geometric Safety Improvements Projects (2017) PR-52, from km 49 to km 52.3, Salinas - PR-52, from km 55.3 to km 61, Salinas - PR-20 from km 0 to km 10, Guaynabo - PR-152 from km 0 to km 11.5, Barranquitas - Naranjito PR152 km 13.65 to km 20.5, Barranquitas - Naranjito	$3,594,000
C	Intelligent Transportation System (ITS) (2020)	$5,736,842
	Upgrade of Safety Devices in the Highway System (2019) NBIS	$2,000,000
800519	Upgrade of Safety Devices in the Highway System (2020)	$5,000,000
800520	Implementation of Strategic Highway Safety Plan (2020)	$3,801,628
800521	Island-wide Roadwide Traffic Signals, Pavement Marking, Signing and Geometric Safety Improvements Projects (2020)	$24,948,372
990157	Highway Safety Improvements - Puerto Rico Section 154 and 164 Penalty (HSIP- Elegible Activities) (2020)	$3,800,000
TOTAL		**$382,275,406**

Source: STIP 2017-2020; Feb 2018

Table 6.13: List of San Juan TMA Bridge Projects STIP (2017-2020)

Bridge ID	Road	Km	Municipality	Costs
547	PR 824	2.80	Toa Alta	$ 523,820
1058	PR 9912	0.10	San Lorenzo	$ 1,698,000
3000	PR 5	18.75	Naranjito	$ 13,225,001
780	PR 143	36.00	Orocovis	$ 98,000
2314	Off PR 902	0.10	San Lorenzo	$ 195,000
1131	PR 29 Eastbound	1.40	Bayamón	$ 2,885,000
1343	Local Road	0.20	San Lorenzo	$ 196,000
2511	PR 9916	0.02	San Lorenzo	$ 290,000
1132	PR 29 Westbound	1.40	San Lorenzo	$ 2,677,000
1657	PR 861	11.00	Toa Alta	$ 2,500,000
122	PR 3	68.10	Naguabo	$ 3,500,000
1130	PR 145	1.00	Ciales	$ 5,845,000
2508	PR 913	1.10	San Lorenzo	$ 126,000
443	PR 951	4.90	Loíza	$ 335,000
176	PR 14	57.25	Aibonito	$ 238,000
574	PR 971	17.30	Naguabo	$ 250,000
2479	PR 174	14.00	Bayamón	$ 2,622,000

Source: STIP 2017-2020; Feb 2018

Table 6.14: List of Aguadilla TMA Bridge Projects STIP (2017-2020)

Bridge ID2	Road	Km	Municipality	Costs
1492	Off PR 110	0.30	Moca	$ 126,000
881	PR 497	2.70	San Sebastian	$ 282,000

Source: STIP 2017-2020; Feb 20

Table 6.15: List of Other UZAs Bridge Projects STIP (2017-2020)

Bridge ID2	Road	Km	Municipality	TPR	Costs
1638		Victor Rojas	Arecibo	NTPR	$ 1,500,000
505	PR 603	0.07	Utuado	NTPR	$ 2,391,000
158	PR 123	59.3	Utuado	NTPR	$ 150,000
1683	OFF PR 603 @1.0	0.01	Utuado	NTPR	$ 150,000
1531	PR 141	10	Jayuya	NTPR	$ 50,000
631	PR 200R	0.1	Vieques	ETPR	$ 1,484,000
1133	Off PR 200	0.01	Vieques	ETPR	$ 1,323,000
116	PR 3	53	Ceiba	ETPR	$ 260,000
2032	PR 2	197.8	Yauco	STPR	$ 1,301,258
944	PR 2 Eastbound	208.7	Guayanilla	STPR	$ 248,000
2039	PR 52 Southbound	49.5	Salinas	STPR	$ 2,529,000
2038	PR 52 Northbound	49.5	Salinas	STPR	$ 3,844,000
950	PR 149	59.3	Villalba	STPR	$ 379,000
2681	PR 555	9.3	Coamo	STPR	$ 530,000
1471	PR 100	0.8	Hormigueros	SWTPR	$ 2,899,000
1096	PR 102	35.4	San German	SWTPR	$ 2,800,000
261	PR 128	32.6	Maricao	SWTPR	$ 514,000
217	PR 106	2.5	Mayagüez	SWTPR	$ 1,705,000
1381	PR 103	3.6	Cabo Rojo	SWTPR	$ 131,000

Source: STIP 2017-2020; Feb 2018

Table 6.16: List of San Juan TMA Safety Projects STIP (2017-2020)

Program/Project	Municipality	Costs
AC- 990134 Upgrade of Safety Devices in the Highway System		
Upgrade of Safety Devices in the Highway System PR-66 km 0 to km 20	Carolina - Canóvanas	$7,173,465
AC-990135 Safety Improvements Island-wide		
Safety Corridor PR-20 Km 0 to km 10	Guaynabo	$16,976,051
Safety Improvements PR-152 from km 0 to km 11.5	Barranquitas / Naranjito	$1,980,001
Safety Improvements PR-152 from km 13 to km 20.5	Barranquitas / Naranjito	$1,375,001
AC-990145 Safety Improvements Island-wide		
Safety Corridor PR-173 km 0 @ km 9	Aibonito - Cidra	$2,025,940
AC-800493 SHSP Funds		
Safety Corridor PR-152 Km 11 @ Km 13.5	Barranquitas - Naranjito	$3,800,000
AC-990155 Upgrade of Safety Devices in the Highway System		
Safety Corridor PR-167 km 0 @ km 9	Comerío	$4,170,000
Safety Corridor PR-52 Km 38 @ Km 49	Cayey - Salinas	$9,284,000
AC-800514 Safety Improvements Island-wide		
Safety Corridor PR-149 Km 0 @ Km 12.8	Manatí - Ciales	$4,269,684
Geometric Improvements on De Diego Avenue (PR-37)	San Juan	$2,250,000
AC-800519 Upgrade of Safety Devices in the Highway System		
Safety Corridor PR-137 KM 0 @ 9	Vega Baja - Morovis	$5,000,000
AC-800521 Safety Improvements Island-wide		
Safety Corridor PR-203 Km 0 @ Km 7.1	Gurabo - San Lorenzo	$6,196,000
Safety Corridor PR-189 KM 0 @ 11	Gurabo	$4,000,000
Safety Corridor PR-176 Km 0 @ Km 4	San Juan	$1,100,000
Safety Corridor PR-183 Km 0 @ Km 10	Caguas - San Lorenzo	$5,406,372
AC-800520 SHSP Funds		
Geometric and Safety Improvements Intersection PR-29	Bayamon	$1,000,000

Source: STIP 2017-2020; Feb 2018

Table 6.17: List of Aguadilla TMA Safety Projects STIP (2017-2020)

Program/Project	Municipality	Costs
AC-800515 SHSP Funds		
Safety Corridor PR-115 km 0 @ km 10	Añasco- Rincon	$3,000,000
Safety Corridor PR-115 km 10 @ km 20	Rincon-Aguada	$3,000,000
AC-990145 Safety Improvements Island-wide		
Safety Corridor PR-420 km. 0 @ km 9	Moca	$2,801,628

Source: STIP 2017-2020; Feb 2018

Table 6.18: List of Other UZAs Safety Projects STIP (2017-2020)

Program/Project	Municipality	TPR	Costs
AC-990135 Safety Improvements Island-wide			
Safety Corridor PR-52 Km 49 to km 52.3	Salinas	STPR	$3,424,227
Safety Corridor PR-52 km 55.3 to km 61	Salinas	STPR	$3,676,500
AC-990144 Upgrade of Safety Devices in the Highway System			
Safety Improvements PR-10 KM 0 @ KM 29	Ponce - Adjuntas	STPR	$14,356,261
AC-990145 Safety Improvements Island-wide			
Safety Improvements PR-12 km 0 @ km 7	Ponce	STPR	$4,433,270
AC-800514 Safety Improvements Island-wide			
Safety Corridor PR-102 Km 7.8 @ Km 17.8	Cabo Rojo	SWTPR	$3,000,000
Safety Corridor PR -52 Km 52.3 @ km 55.3	Salinas	STPR	$3,000,000
AC-800515 SHSP Funds			
Safety Corridor PR-385 Km 0 @ Km 5	Peñuelas	STPR	$3,800,000
AC-800521 Safety Improvements Island-wide			
Safety Corridor PR-101 Km 0 @ Km 10	San German - Lajas	SWTPR	$4,046,000
Safety Corridor PR-116 Km 3 @ Km 14	Lajas	SWTPR	$4,200,000
AC-800520 SHSP Funds			
Safety Corridor PR-101 Km 10 @ Km 20	Lajas - Cabo Rojo	SWTPR	$3,800,000

Source: STIP 2017-2020; Feb 2018

Table 6.19: List of Island-wide Safety Projects STIP (2017-2020)

Program/Project	Municipality	Region	Costs
RFP SHSP Update and Implementation	All	Island-wide	$ 2,500,000

Source: STIP 2017-2020; Feb 2018

Table 6.20: List of San Juan TMA Committed Projects; Mid Term (2021-2030)

Project Name	Reference Cost	Municipality	Start Date
Feasibility Study, Capacity Increase of PR-181	$400,000	Trujillo Alto	2025
Construction of Ramp PR-22 and Avenue Trio Vegabajeño (Ramps side west for the PR-22 with the Avenue Trio Vegabajeño)	$1,500,000	Vega Baja	2029
Feasibility Study, PR-28 km 0-6 Improvements to heavy traffic mobility	$900,000	Bayamón, Guaynabo, San Juan	2029
Feasibility Study, PR-37 to manage cargo	$900,000	San Juan	2029
Reconstruction, PR-15 KM 24.9-25.7	$531,589	Cayey	2029
Feasibility study and reconstruction to elevate pedestrian bridge over PR-18	$2,000,000	San Juan	2029
Environmental Study/ROW/Design/Construction start-up, Extension PR-5 From PR-199 to PR-167 (AC-000533)	$82,400,000	Bayamon	2029

Source: PRHTA technical team with SDG support

Table 6.21: List of Aguadilla TMA Committed Projects; Mid Term (2021-2030)

Project Name	Reference Cost	Municipality	Start Date
Improvements to PR-112 and Connector to PR-4494- access to the Industrial Zone to the Isabela Connector, it also includes improvements to the PR-112. This project will be known as the Cano Rosa Connector (AC-011213)	$4,350,000	Isabela	2028
Construction Las Marías Connector, from PR-119 to Ramón Rivera street (AC-411901)	$3,600,000	Las Marías	2030
Operational Traffic Study, PR-2 KM 111.5 (Intersection KFC) Operational traffic study to determine if the traffic signals to control traffic method in the intersection is the right one to avoid accident	$204,130	Isabela	2030
Reconstruction, considering safety and security, PR-466 km 7.2 & PR-466 km 6.5.	$664,486	Isabela	2030

Source: PRHTA technical team with SDG support

Table 6.22: List of Other Uza's Committed Projects; Mid Term (2021-2030)

Project Name	Reference Cost	Municipality	Start Date	TPR
Feasibility and Environmental Study, PR-2 km 145to km 152 road improvements and congestion management	$ 60,000,000	Mayagüez	2025	SWTPR

Route Study, Connector of Industrial park and Merceditas	$ 1,000,000	Ponce	2029	STPR
Feasibility Study, PR-681 & PR-2 (conenctor from PR-681 (Islote) to Carretera PR-2)	$ 900,000	Arecibo	2029	NTPR
Feasibility Study, road widening for PR-681 & PR-6681	$ 900,000	Arecibo	2029	NTPR
Construction, Widening of PR-100 From PR-308 to PR-101 (AC-010029)	$ 12,000,000	Cabo Rojo	2030	SWTPR

Source: PRHTA technical team with SDG support

Table 6.23: List of Island-wide Committed Projects; Mid Term (2021-2030)

Project Name	Reference Cost	Municipality	Start Date
Vulnerability Study, Island-wide	$1,000,000	Island-wide	2029

Source: PRHTA technical team with SDG support

Table 6.24: List of San Juan TMA Committed Projects; Mid to Long Term (2031-2040)

Project Name	Reference Cost	Municipality	Start Date
Feasibility and Update Environmental Study, South Bypass from PR-188 to Medianía Baja (PR-187) (CFHWA) (AC-018760)	$10,650,000	Loíza	2034
Construction Cidra East Connector form #2 Street (Industrial Avenue) to PR-734 (Phase 1) Length 1.38 (AC-017242)	$18,000,000	Cidra	2034
Feasibility Study, Improvements at intersection of PR-5 with PR-24	$900,000	Cataño	2036
Route Location and NEPA Process Compliance, Higuillar Avenue extension to PR-22	$2,000,000	Dorado	2036
Feasibility Study, PR-865 and PR-2 Elevated intersection	$1,000,000	Toa Baja	2036
Completion of Cidra connector from PR-734 to PR-1 and PR-7787 Phase II	$666,127	Cidra	2036
Completion of Cidra connector from PR-734 to PR-1 and PR-7788 Phase III;	$395,513	Cidra, Cayey	2036
Tunel Minillas conditions assessment	$1,000,000	San Juan	2036
Construction, Cayey Connector, Connector PR-15, phase II (from Parque Tecnológico PR-1, Cayey Connector PR-158) (AC-015802)	$12,000,000	Cayey	2036
Study to evaluate evacuation route to the Húcares Community (detour from the Húcares Parcelas to PR-3)	$208,165	Naguabo	2037

Project Name	Reference Cost	Municipality	Start Date
ROW and Construction, Barranquitas South Bypass (From PR-156 to PR-719) (AC-010194)	$12,600,000	Barranquitas	2037
ROW and Construction, Isabela Connector from PR-472 to PR-113 (AC-100055)	$42,195,000	San Juan	2037
Feasibility Study, Collector PR-30 - widening	$900,000	Gurabo	2038

Source: PRHTA technical team with SDG support

Table 6.25: List of Aguadilla TMA Committed Projects; Mid to Long Term (2031-2040)

Project Name	Reference Cost	Municipality	Start Date
Design, ROW, and Construction of Isabela connector PR-112 to PR-472 (AC-047205)	$ 7,174,042	Isabela	2034
Feasibility Study, PR-404 by-pass	$ 900,000	Moca	2036
Additional Funds for Feasibility Study, Improvements to Aguadilla Airport access through PR-100, PR-107and connector to Burn street (AC-000228)	$7,200,000	Aguadilla	2036
Study, Design, permit process and reconstruction, PR-4466 km 3 Bo. Bajuras (study, Design, permit process and construction of pluvial, safety guard and Signalization)	$900,000	Isabela	2036
Reconstruction, including general improvements PR-4455 from km 0 to 2.5 (scarification, pavement, marking and road sign)	$4,596,989	Isabela	2036
Reconstruction, PR-459 from km 9 to 15 (Bo. Jobos/Bo. Bejucos); potentially including, scarification, pavement, marking and road sign	$ 3,000,000	Isabela	2038
Construction, Relocation of PR-111 km. 27.9 a km. 34.0 (AC-011191)	$ 43,200,000	San Sebastian/Lares	2040

Source: PRHTA technical team with SDG support

Table 6.26: List of Other Uza's Committed Projects; Mid to Long Term (2031-2040)

Project Name	Reference Cost	Municipality	Start Date	TPR
Construction, PR-10 relocation from STA. 37+80.00 to STA. 57+00.00, SEC. II, length 0.41 km (AC-100069)	$ 29,430,900	Utuado/Adjuntas	2033	NTPR
Feasibility Study, Ponce By-Pass from PR-14 to Rio Matilde	$ 900,000	Ponce	2034	STPR

Feasibility Study, PR-7751 connector de Arroyo from PR-753 to PR-3, KM 132.4	$ 900,000	Arroyo	2037	SETPR
Access Request Analysis and Preliminary Design of Geometric Improvements to PR-2 (Entrance RUM, La Vita) (AC-200241)	$ 25,200,000	Mayagüez	2038	SWTPR

Source: PRHTA technical team with SDG support

Table 6.27: List of San Juan TMA Committed Projects; Long Term (2041-2045)

Project Name	Reference Cost	Municipality	Start Date
Route Location and NEPA Compliance Study, PR-9187, Rio Grande; Int PR-3 with PR-187 and PR-956 to PR-3	$1,000,000	Río Grande	2041
Construction, Aguas Buenas Bypass from PR-156, km 53 to PR-173, Length 3.1 km (AC-020802)	$36,000,000	Aguas Buenas	2041
Feasibility Study, PR-203 Extension	$900,000	San Lorenzo	2041
ROW and Construction, Widening PR-845 from Pasternak Street to Int. PR-199 (AC-084511)	$4,650,000	Trujillo Alto	2045
Feasibility Study, new construction of PR-183 to PR181 Int. PR-9912	$2,000,000	San Lorenzo	2045
Feasibility Study, Access Ramp to Country Estate, PR-167	$900,000	Bayamon	2045
Feasibility Study, Access/Exit Ramps to/from AEMEAD to/from PR-6	$900,000	Bayamon	2045
Yabucoa Connector (completing the connector between Calle Cataina Morales and Avenida Los Veteranos)	$208,1645	Yabucoa	2045

Source: PRHTA technical team with SDG support

Table 6.28: List of Aguadilla TMA Committed Projects; Long Term (2041-2045)

Project Name	Reference Cost	Municipality	Start Date
Feasibility PR-113 Connector of the beach area	$ 900,000	Isabela	2045

Source: PRHTA technical team with SDG support

Table 6.29: List of Other Uza's Committed Projects; Long Term (2041-2045)

Project Name	Reference Cost	Municipality	Start Date	TPR
Feasibility Study, PR-3132 South solution to road closure issues	$ 416,329	Peñuelas	2041	STPR
Construction, PR-545 Widening from PR-52 (Km. 1.03) to PR-14 (km. 6.03) (AC-054509)	$ 6,000,000	Coamo	2041	STPR
ROW and Construction, Villalba Bypass - From PR-560 to PR-151 (STA. 24+82 to STA. 31+64) Length 0.68 (AC-556103)	$ 27,300,000	Villalba	2043	STPR
ROW and Construction, overpass at the intersection of PR-2 with PR-114, includes the channelization of Merle and Pulida Creek and the construction of a North - South Frontage Road at PR-114 (AC-200200)	$ 28,620,000	Mayagüez	2044	SWTPR
Feasibility Study, Connector from Highway PR-140 to PR-681	$ 900,000	Barceloneta	2045	NTPR
ROW, Lajas San German Connector Phase II, PR-321 to PR-122 (AC-012201)	$ 2,250,000	Lajas/San German	2045	SWTPR

Source: PRHTA technical team with SDG support

2045 Models

Using the calibrated 2016 model and updating the socioeconomic inputs for 2045; 2045 scenarios models were prepared. These included the base scenario considering:

- No changes in the roadway network (No-Build Scenario);
- The scenario considering the committed roadway projects (2045 Existing and Committed (E+C)); and
- The scenario with committed projects plus the new construction projects included in the Fiscal Plan as strategic/P3 projects (2045 E+C plus PR-22 and PR-5).

2045 No-Build (Do-Nothing Scenario)

Land use patterns, growths in population and employment, and trends in travel patterns will affect the demand on the Region's transportation system in different ways. In order to understand the future demands on the transportation system for the 2045 LRTP, a No-Build scenario in 2045 travel demand situation was firstly analyzed. The No-Build condition in 2045 assumes that there are no improvements to the existing transportation system in the next 27-year horizon. Only the land use patterns, population, and employment are changed based upon our socioeconomic forecasts presented in Chapter 2. Table 6.30: presents the statistics of performance measures of the 2045 No-Build and the results comparisons to the Base Case.

All transportation planning regions on the island except for Aguadilla TMA have the long-term decrease of population and employment in 2045. Shown in the results of the No-Build scenario, both Island-wide person trips and vehicle trips have reduced by approximately 16%. Trucks trips also decreased by 8.2%.

Because of the trip loss, the Island-wide vehicle miles traveled and vehicle hours traveled reduced correspondingly. Vehicles travel under congested situation (vehicle miles traveled on the roadway segment with volumes exceeding its capacity) dropped significantly by over 35%. The average travel speed on the overall roadway system and on the limited access roads increased. These results indicate a better highway level of service (LOS) in 2045 without any improvements to transportation system.

Due to the improved highway LOS, the overall transit shares in decrease from 2.4% in the Base Case to 2.1% in this No-Build scenario.

Table 6.30: Island-wide Summary of 2045 No-Build Scenario

Measures of Effectiveness	Base Case (2016)	2045 No-Build	% Change (No-Build vs. Base Case)
System Performance			
Average network speed (mph)	25.0	26.3	5.5%
Total transit passengers per route mile	6.4	4.7	(26.6%)
% non-motorized trips	3.6%	4.0%	11.6%
% transit trips	2.4%	2.1%	(12.0%)
Average highway trip cost	$2.02	$2.15	6.5%
Average transit trip cost	$1.88	$1.97	5.1%
% Population within 0.5-mile walk to transit	17.0%	16.7%	(1.6%)
% Employment with 0.5-mile walk to transit	35.1%	34.5%	(1.9%)
Vehicles hours of delay	341,997	235,946	(31.0%)
Vehicle hours of travel/1000 vehicle miles of travel	40.1	38.0	(5.2%)
VMT above capacity	1,177,739	764,278	(35.1%)
Speed on limited access roads and expressways	30.8	32.7	6.3%
Gallons of fuel consumed	2,723,659	2,448,576	(10.1%)
System Usage			
Vehicle miles of travel	62,916,521	56,562,107	(10.1%)
Vehicle hours of travel	2,520,563	2,147,472	(14.8%)
Average network speed	25.0	26.3	5.5%
Person trips	7,640,633	6,405,844	(16.2%)
Vehicular trips	5,730,818	4,814,316	(16.0%)
Truck trips	280,917	257,906	(8.2%)

Source: SDG analysis of 2045 No-Build scenario on PRHTA Island-wide Model

2045 Existing and Committed (E+C) Scenario

This model considers the list of projects presented in Table 6.31. This model considers the effect of the road improvement project in the roadway network.

Table 6.31: Committed Projects reflected in the 2045 modeling

SAN JUAN TMA
Construction of Ramp PR-22 and Avenue Trio Vegabajeño (Ramps side west for the PR-22 with the Avenue Trio Vegabajeño)
Construction Cidra East Connector form #2 Street (Industrial Avenue) to PR-734 (Phase 1) Length 1.38 (AC-017242)
Completion of Cidra connector from PR-734 to PR-1 and PR-7787 Phase II
Completion of Cidra connector from PR-734 to PR-1 and PR-7788 Phase III;
Construction, Cayey Connector, Connector PR-15, phase II (from Parque Tecnológico PR-1, Cayey Connector PR-158) (AC-015802)
ROW and Construction, Barranquitas South Bypass (From PR-156 to PR-719) (AC-010194)
ROW and Construction, Isabela Connector from PR-472 to PR-113 (AC-100055)
Construction, Aguas Buenas Bypass from PR-156, km 53 to PR-173, Length 3.1 km (AC-020802)
ROW and Construction, Widening PR-845 from Pasternak Street to Int. PR-199 (AC-084511)
Yabucoa Connector (completing the connector between Calle Cataina Morales and Avenida Los Veteranos)
AGUADILLA TMA
Construction Las Marías Connector, from PR-119 to Ramón Rivera street (AC-411901)
Design, ROW, and Construction of Isabela connector PR-112 to PR-472 (AC-047205)
Feasibility Study, PR-404 by-pass
Additional Funds for Feasibility Study, Improvements to Aguadilla Airport access through PR-100, PR-107and connector to Burn street (AC-000228)
OTHER UZAs
ROW and Construction, overpass at the intersection of PR-2 with PR-114, includes the channelization of Merle and Pulida Creek and the construction of a North - South Frontage Road at PR-114 (AC-200200)
ROW, Lajas San German Connector Phase II, PR-321 to PR-122 (AC-012201)
Access Request Analysis and Preliminary Design of Geometric Improvements to PR-2 (Entrance RUM, La Vita) (AC-200241)
ROW and Construction, Villalba Bypass - From PR-560 to PR-151 (STA. 24+82 to STA. 31+64) Length 0.68 (AC-556103)

Source: PRHTA technical team with SDG support

The 2045 E+C scenario results (Table 6.9) in a mode shift of approximately 9,500 trips away from roadway to transit compared to the No-Build scenario. Majority of these trips are within the San Juan TMA. This represents an increase in passengers per route mile by approximately 17%.

The overall mode share of Island-wide transit trips on an average weekday was increased from 2.1% in the No-Build scenario to 2.5%. This mode shift occurs in tandem with increases in roadway travel speeds. This result indicates that local bus services in San Juan are also benefitting from the increase roadway travel speed by being faster and more reliable, mitigating some of the potential mode shift away from transit.

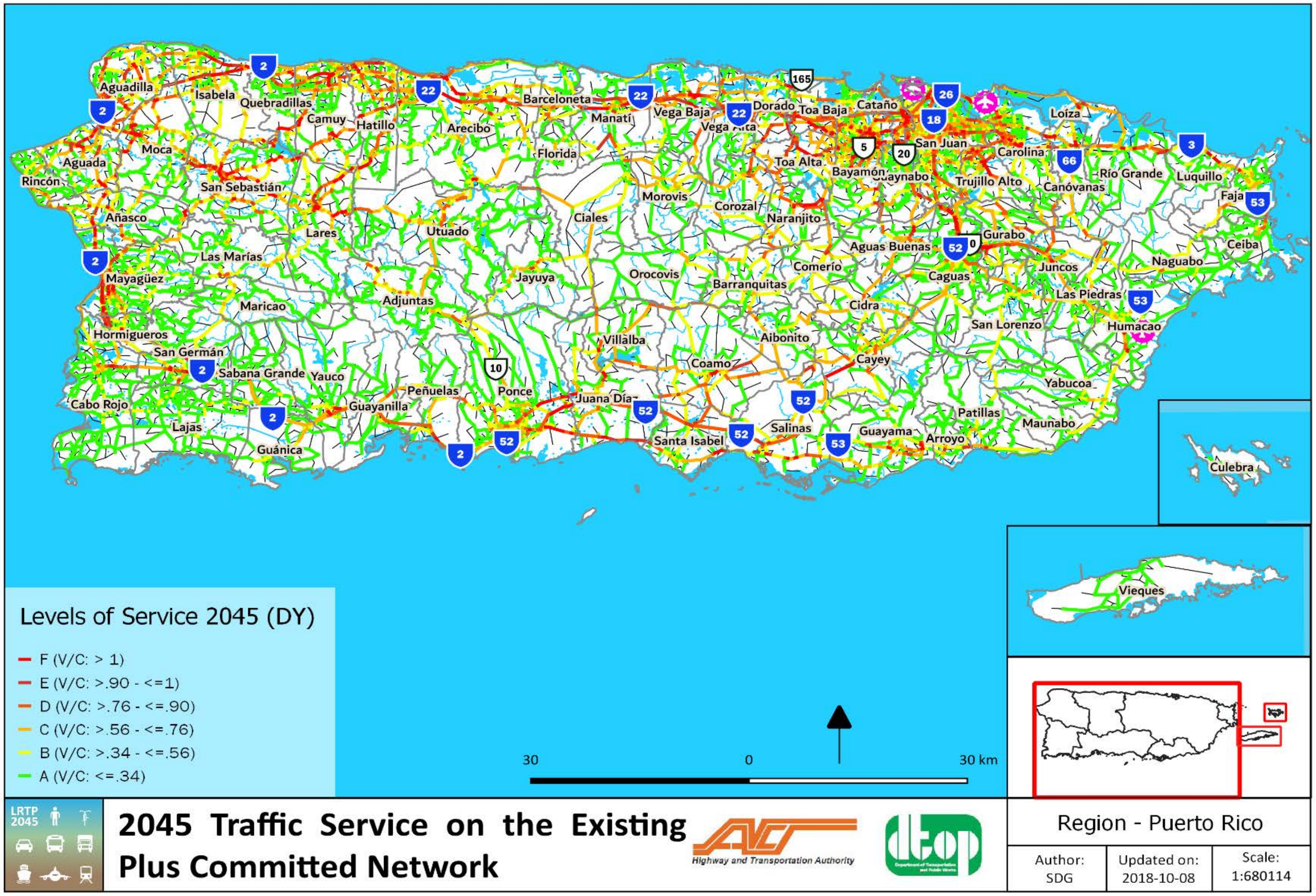
Besides the transit improvement, the incremental impacts of highway improvements cause a significant decrease of Island-wide congested VMT by approximately 13%. The average travel speeds on both limited access roads and local arterials increase. All these suggest that highway LOS is improving (Figure 6.41 to Figure 6.42).

Figure 6.39 through Figure 2.40 show the average weekday traffic and the volume-to capacity ratios of the 2045 Existing Plus Committed scenario on the island.

Figure 6.39: 2045 Traffic on The Existing Plus Committed Network

Source: P.R. Network Model Forecasts by Steer Davies Gleave for the year 2045 using Cube Voyager

Figure 6.40: 2045 Traffic Service on the Existing Plus Committed Network



Source: P.R. Network Model Forecasts by Steer Davies Gleave for the year 2045 using Cube Voyager

2045 PR-22 Extension + PR-5 Extension

This scenario considers the E+C plus the strategic/P3 projects for extensions of PR-22 from Hatillo to Camuy and PR-5 Toa Alta to Bayamón. The results of this scenario are shown in Table 6.14.

The extension of PR-22 and PR-5 have larger impacts on the highway LOS in Aguadilla TMA and in San Juan TMA. Overall on the island, the performance measures of this scenario are very similar to the E+C scenario. Compare to the No-Build, traffic shifts to transit largely due to the transit improvements in San Juan TMA. As a result, the transit passengers per route miles grew by approximately 16%. There is a slight decrease in trip lengths due to the transit scenario, suggesting that, on average, the shorter drive trips are shifting to transit. Figure 6.41 show the average weekday traffic of this scenario while Figure 6.42 present the Island-wide roadway level of service.

Table 6.32: Island-wide Summary of 2045 Scenarios

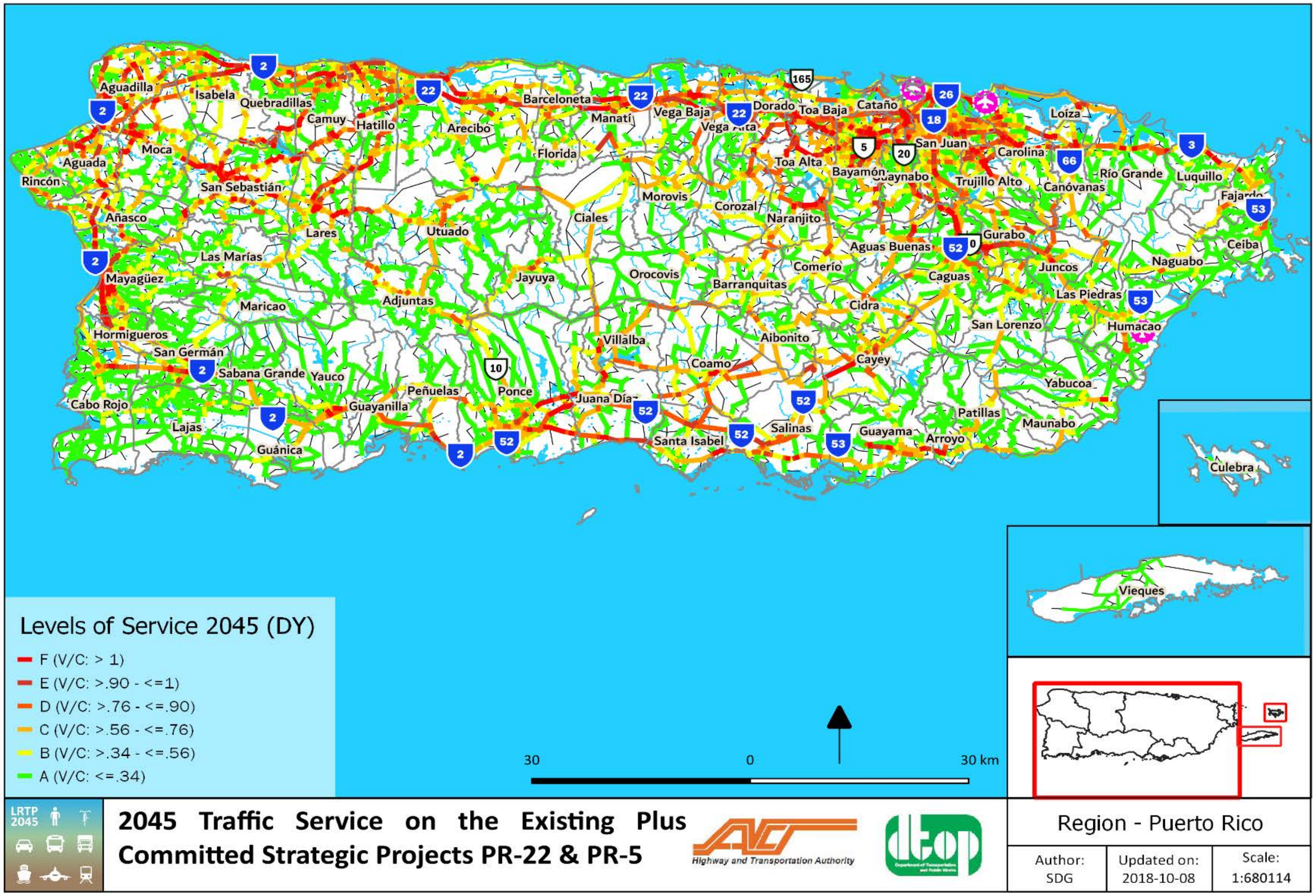
Measures of Effectiveness	2045 No Build	2045 E+C	% Change (E+C vs. No-Build)	2045 PR-22 Ext. & PR-5 Ext	% Change (PR-22 Ext & PR-5 Ext vs. No-Build)
System Performance					
Average network speed (mph)	26.3	27.0	2.3%	26.8	1.7%
Total transit passengers per route mile	4.7	5.5	16.7%	5.5	16.3%
% non-motorized trips	4.0%	3.5%	(13.2%)	3.5%	(13.1%)
% transit trips	2.1%	2.5%	16.7%	2.4%	16.1%
Average highway trip cost	$2.15	$2.22	3.0%	$2.20	2.1%
Average transit trip cost	$1.97	$2.01	1.8%	$2	1.2%
% Population within 0.5-mile walk to transit	16.7%	16.8%	0.8%	16.8%	0.8%
% Employment with 0.5-mile walk to transit	34.5%	35.5%	3.0%	35.5%	3.0%
Vehicles hours of delay	235,946	226,665	(3.9%)	222,711	(5.6%)
Vehicle hours of travel/1000 vehicle miles of travel	38.0	37.1	(2.3%)	37.3	(1.6%)
VMT above capacity	764,278	665,812	(12.9%)	632,959	(17.2%)
Speed on limited access roads and expressways	32.7	34.5	5.5%	34.0	4.0%
Gallons of fuel consumed	2,448,576	2,484,535	1.5%	2,459,955	0.5%
System Usage					
Vehicle miles of travel	56,562,107	57,392,751	1.5%	56,824,950	0.5%
Vehicle hours of travel	2,147,472	2,129,032	(0.9%)	2,122,312	(1.2%)
Average network speed	26.3	27.0	2.3%	26.8	1.7%
Person trips	6,405,844	6,405,414	0.0%	6,405,606	0.0%
Vehicular trips	4,814,316	4,804,825	(0.2%)	4,805,185	(0.2%)
Truck trips	257,906	257,697	(0.1%)	257,757	(0.1%)

Sources: SDG analysis of 2045 scenarios on PRHTA Island-wide Model

Figure 6.41: 2045 Traffic on the Existing Plus Committed Strategic Projects PR-22 & PR-5

Source: P.R. Network Model Forecasts by Steer Davies Gleave for the year 2045 using Cube Voyager

Figure 6.42: 2045 Traffic Service on the Existing Plus Committed Strategic Projects PR-22 & PR-5



Source: P.R. Network Model Forecasts by Steer Davies Gleave for the year 2045 using Cube Voyager

7 CHAPTER 7 POLICY GUIDELINES TOWARD THE TRANSPORTATION INFRASTRUCTURE

The DTPW along with its affiliated agencies, the PRHTA and the Puerto Rico MPO face an unprecedented future that requires policy direction. This 2045 LRTP update, by following the national transportation goals, emphasizing in safety (reduce fatalities), improving asset conditions to state of good repair, reducing congestion, improving freight mobility, and maintaining the environment and air quality. This section mentions policies defined to address these challenges in the incoming future.

This chapter is divided into 6 sections:

1. New TSM&O Technologies for Next 5 Years;
2. Congestion Management Process;
3. Freight;
4. Safety and Security;
5. Environment and Sustainability; and
6. Looking Forward.

NEW TSM&O TECHNOLOGIES FOR NEXT 5 YEARS

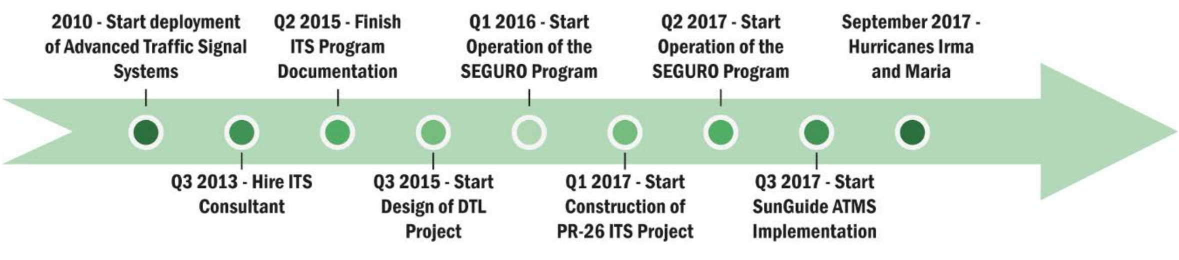
Transportation Systems Management and Operations: Recent ITS Developments and Future Needs

This section provides an overview of recent ITS developments in Puerto Rico, as well as upcoming projects – both in place and recommended for the next 5 years. It also touches on mobility of the future, and how any new technologies should be firmly focused on the end-user and their needs. Topics include:

- Advanced Traffic Signals Systems;
- Traffic Incident Management and Traveler Information Dissemination;
- Travel Time Reliability Improvement;
- Highway Safety Patrol Program (SEGURO); and
- Intelligent Mobility and Disruption.

The Puerto Rico DTPW and the PRHTA during recent years have performed several activities to move forward with the implementation of the Transportation Systems Management and Operations (TSM&O) Program in the San Juan TMA, and other urbanized areas in Puerto Rico. The most important activities related to the TSM&O Program performed in recent years are presented in Figure 7.1.

Figure 7.1: TSM&O Program Development Timeline



Source: PRHTA

During summer 2015, the PRHTA completed the revision to the San Juan Metropolitan Area ITS Regional Architecture which is the cornerstone of the implementation of ITS in the San Juan TMA. The resulting document contains a detailed evaluation of the Region’s needs, capabilities, as well as a roadmap on how to fulfill those needs. This road map is comprised of several infrastructure projects and implementation of services and protocols, in order to reach the Region’s established transportation goals.

The needs identified for the San Juan TMA Region provided an initial framework of the areas for project implementation. These are included below:

- **Traffic Management:**
  - Effectively manage arterials system-wide;
  - Improve traffic flow monitoring;
  - More widespread centralized computer control;
  - Improve ability to remotely modify signal timing;
  - Reduce emergency vehicle delays at signals;
  - Improve detection of incidents on roadways;
  - Improve management of incident response;
  - Improve inter-jurisdictional continuity for traffic management;
  - Upgrade signal hardware;
  - Improve signal coordination;
  - Better management of periods of high traffic demand;
  - Improve the quality real-time congestion information;
  - Communicate with adjacent cities;
  - Monitor emissions and air conditions along roadways;
  - Improve control of lighting along roadways;
  - Automate local parking management;
  - Enable regional coordination for parking;
  - Monitor vehicular speed along highways and arterials;
  - Improve management of roadway closures; and

  - Alert drivers to approaching roadway hazards.

- **Electronic Payment:**
  - Capability for drivers to pay tolls without stopping their vehicles (open road tolling); and
  - Integration of electronic payment for transit, toll roads, and parking.

- **Regional Traveler Information:**
  - Provide real time congestion information;
  - Provide real time transit vehicle arrival/departure information;
  - Expand traveler information delivery methods;
  - Disseminate static and real-time traffic information through a variety of methods;
  - Improve/simplify procedure to obtain travel information;
  - Provide information to private information service providers;
  - Better road construction information;
  - Provide in-route traveler information; and
  - Improve inter-agency operational data sharing and coordination.

- **Transit Management:**
  - Improve regional trip planning;
  - Improve patron safety (in-vehicle and at stations);
  - Implement transit vehicle location and tracking;
  - Implement transit dispatching and management;
  - Implement automatic passenger counting;
  - Coordinate with roadway agencies regarding incident and construction information;
  - Implement Transit Signal Priority at signalized intersections; and
  - Enable real-time transit information, including dissemination/display of bus arrival/departure times.

- **Maintenance and Construction Operations:**
  - Provide location and tracking of maintenance vehicles and field equipment;
  - Improve provision of real-time information on maintenance and construction activities to the public and other agencies;
  - Increase application of smart work zone technology to provide real-time work zone information and increase safety for field staff;
  - Improve coordination of construction and maintenance activities;
  - Improve fleet management and vehicle diagnostic capabilities;
  - Increase application of portable traffic control devices;
  - Coordinate traffic control plans among different agencies and jurisdictions; and
  - Improve weather data collection and processing capabilities.

- **Emergency Management:**
  - Increase broad understanding of existing incident management procedures;
  - Improve incident detection and verification;

  - Improve coordination of incident response;
  - Improve real-time traveler information regarding incidents, special events, and emergencies; and
  - Sharing of real-time and data to support inter-agency incident and emergency response.

- **Commercial Vehicle Operations:**
  - Review opportunities for CVISN implementation; and
  - Explore opportunities for Weigh-In-Motion sensors.

- **Advanced Traffic Signal Systems:**

In 2010, the PRHTA started with the modernization of many of the traffic signal systems around the Island to improve the safety and operation of signalized intersections. This effort started with the update of traffic signal systems on highway PR-2 from Moca to Hormigueros on the west-northwest area of Puerto Rico. These projects consisted in setting up modern traffic signals components, including controllers, to allow for remote systems configuration and monitoring. The projects also included the installation of other devices, such as CCTV surveillance cameras and microwave radar vehicle detection systems for queue detection and intersection surveillance. All these devices were interconnected via wireless communication which in turn connect via other means to the Traffic Management Center (TMC), located in San Juan.

Other projects developed as part of the traffic signal update effort included:

- PR-2 from Hatillo to Isabela;
- PR-3 from Rio Grande to Fajardo;
- Rio Mar – including PR-1, PR-25, and PR-35 in San Juan;
- PR-1 from San Juan to Caguas;
- PR-23 from San Juan to Guaynabo;
- PR-181 from San Juan to Trujillo Alto; and
- PR-199 from Trujillo Alto to Guaynabo.

These projects were completed or at advance construction stages as of late 2017. In Q1 2016, as part of the TSM&O Program activities, the PRHTA started the evaluation of the traffic signals systems operation on the PR-2 Moca to Hormigueros section with the purpose of performing a signal timing optimization project. This effort however was not able to be completed due to several problems that were affecting the remote communication with ITS devices, which disturbed configuration and monitoring capabilities. During this period, the PRHTA also started the procurement of a Preventive Maintenance and Emergency Repair Services contract to improve the uptime and upkeep of the ITS devices installed as part of the traffic signals systems update projects.

On September 2017, Puerto Rico was affected by hurricanes Irma and María, which rendered most of the traffic signals systems inoperable due to the lack of electrical power in the Island. Other impacts associated with the hurricanes include the displacement of wireless communication antennas affecting the communication line of sight, rendering the ITS network inoperable. Taking into consideration these situations, the PRHTA will perform an evaluation on how to restore the advanced traffic signal systems network. This evaluation will take into consideration the lessons learned from recent atmospheric events to improve its resiliency.

Once this evaluation is performed, the PRHTA plans to modify the traffic signals systems project delivery procedures to implement a systems engineering approach. Based on this new method, the PRHTA will continue to implement advanced traffic signal systems on the most important corridors but the focus of the project delivery will shift towards improving the testing, verification, and validation of the systems being implemented. Another important aspect is that the PRHTA will provide special emphasis on measuring the performance of the signalized corridors to reduce delays and improve mobility.

Deployment of ITS Devices for Traffic Incident Management and Traveler Information Dissemination

As mentioned, recently the focus of the TSM&O Program has been to improve the management of events that affect travel time reliability. The effort to improve the management of these events can be divided in two categories: (i) implementation of ITS technologies to aid in the management of traffic incidents, and (ii) the deployment of services and protocols to expedite traffic incident clearance.

The implementation of ITS technologies to aid in the management of traffic incidents began with the deployment of advanced traffic signal systems. These projects included the installation of CCTV cameras, and microwave radar vehicle detection systems which the PRHTA leveraged the TMC personnel to identify incidents on signalized roads and expressways/freeways. This approach, however, was altered due to the impacts of Hurricane María on September 2017. Due to the loss of communication with ITS field devices most of the installations were rendered inoperable.

Recently, the PRHTA initiated the deployment of ITS Devices on expressways/freeways with the purpose of traffic incident management and dissemination of traveler information. The first project of this kind started construction in Q1 2017 on Baldorioty de Castro Expressway (PR-26). The intervention will deploy ITS devices on PR-26, as shown in Table 7.1:

Table 7.1: PR-26 Sample ITS Devices Deployment

ITS Device Type	Expected Functionality
CCTV Surveillance Cameras	Traffic incident detection, verification and monitoring, and video streaming for traveller information.
Microwave Radar Vehicle Detectors	Traffic incident detection, traffic data collection, and speed map display.
Bluetooth readers	Travel time calculation.
Dynamic Message Signs	Traveller information dissemination (traffic incident information, alternate and emergency routes and travel time display).

Source: PRHTA

Other projects that will deploy these devices are in various procurement and design stages within the PRHTA. These devices are likely to be deployed as part of the Congestion Managed Lanes / Dynamic Toll Operation for the San Juan – Caguas corridor, which include highways PR-18, PR-30, and PR-52. Other facilities, such as expressways Luis Muñoz Rivera (PR-1), John F. Kennedy (PR-2), and Rafael Martínez Nadal (PR-20), and freeway Roberto Sánchez Vilella (PR-66) are at the planning stage.

The traveler information component of these projects will also aid the PRHTA in complying with federal regulations, especially 23 CFR 511.

The PRHTA has staffed (outsourced) the TMC to cover the functions of traffic incident management and traveler information dissemination. The current operational period covers Monday to Friday from 6:00 am to 9:00 pm and is expected to expand with time to a 24/7 schedule, as the PRHTA TSM&O program evolves.

The O&M lifecycle stages are crucial to the continued success of the TSM&O Program and shall be budgeted into the recurring costs of the transportation systems expenditures. Therefore, the PRHTA will evaluate different funding sources to cover the cost of the O&M expenditures.

Multidisciplinary Transportation Operations – Regional Traffic Management Center

The PRHTA is currently building a Regional Traffic Management Center (RTMC) at the PR-52 Caguas Norte Toll Plaza. The RTMC will be the hub for Puerto Rico's traffic management activities, including but not limited to traffic incident management, and traveler information dissemination. The RTMC will be co-located with the Puerto Rico Police and Medical Emergencies Bureaus, and will be the central location for coordination for major incidents and emergencies affecting the surface transportation network.

The PRHTA expects that the expansion of the ITS network in Puerto Rico will be integrated into this RTMC to continue with the centralized management and operation of the surface transportation network. The PRHTA will also evaluate the possibility of center-to-center interaction between different facilities, such as the Metropistas PR-22 TMC and other emergency management complexes to continue promoting a multidisciplinary approach to the transportation network management.

Travel Time Reliability Improvement

The PRHTA is in the final stages of design of the Congestion Managed Lanes / Dynamic Toll Operation for the San Juan – Caguas Corridor. This project will provide two dynamic toll lanes to be built on the median of PR-18 and PR-52 highways between Caguas and San Juan. See Table 7.2.

Table 7.2: Benefits of Managed Lanes over General Purpose Lanes

	Building General Purpose Lane	Building Managed Lanes
Short Term	Average vehicle speeds about the same.	
Medium Term	• Congestion builds in all lanes; and • Benefits of the new capacity diminish.	• Travel time benefits on the express lanes maintained; and • Overall shorter average travel times across the whole corridor.

	Building General Purpose Lane	Building Managed Lanes
Long Term	• Congestion returns to all lanes; and • No measurable benefit in travel time from new capacity.	• Congestion returns only to general purpose lanes; • Managed lanes continue to serve more vehicles at higher speeds; and • Greater overall corridor travel benefits.

Source: PRHTA

This project will deploy several ITS technologies for monitoring the traffic conditions within the dynamic toll lanes, as well as the general-purpose lanes. Table 7.3 provides a description of the types of functions to be performed by the ITS devices for dynamic toll operation only. Other functions could be performed as well, such as those presented in the table for traffic incident management and traveler information dissemination.

Table 7.3: DTL Project Sample ITS Devices

ITS Device Type	Expected Functionality (for DTL functions only)
Microwave Radar Vehicle Detectors	Determination of vehicle volumes and speed for price algorithm calculations.
Bluetooth readers	Travel time calculation to confirm reliability.
Dynamic Message Signs	Provide travellers with toll price.

Source: PRHTA

The PRHTA has already started implementing other activities related to improving the travel time reliability such as the traffic incident management strategies to expedite the clearance of events. The PRHTA plans to continue to implement other travel time reliability improvements, including Active Traffic Management (ATM) projects, such as Managed Lanes, Freeway Management, and Bus Rapid Transit, and Integrated Corridor Management (ICM) projects.

Highway Safety Patrol Program (SEGURO)

On April 2017, the PRHTA started the operation of the highway safety patrols program (SEGURO, for its Spanish acronym). The main purpose of this service is to provide safety to road users while they are involved in traffic incidents (vehicle breakdowns and crashes) and collection of data related to performance measures in these events. A second phase of the program started on June 2018, which expanded coverage to expressways segments of PR-1 and PR-2 in San Juan, as well as on PR-20.

The SEGURO program is an extension of the TMC operations dealing directly with response activities to traffic incidents. SEGURO operators are responsible for providing firsthand help to travelers, such as changing flat tires, and setting traffic control devices at incident scenes. SEGURO operators in coordination with TMC staff collect traffic incident data using a mobile application. Data obtained through the app is later analyzed and presented for the TMC monthly performance measurement reports.

The PRHTA expects to continue and expand the area covered by SEGURO. It is expected that the program will expand to highway PR-66, and other expressways/freeways not currently under coverage. The PRHTA also expects to expand the operational schedule to 24/7 while the TMC operation is modified.

Intelligent Mobility and Disruption

Mobility is expanding globally. With the rise of the smartphone, access to mobility is becoming simpler and more ‘on demand’. New modes, such as Transportation Network Companies (TNCs), electric bike share, electric scooters etc. are mixing with more traditional modes such as transit, providing a much broader ‘transportation ecosystem’ to the user. In many cases, these new services are providing ‘first/last mile’ solutions for riders who live a distance from transit stops and stations. Much progress has been made with transportation ‘user experience’ through the release of app-based services such as Uber, and the user now expects a much more fluid and seamless interaction with transportation services. In the future, these systems are expected to deliver ‘autonomy’ – driverless vehicles that provide a door to door service without the need for human interaction.

It is important that the 20415 LRTP builds on the progress made with ITS, that has primarily focused on congestion management in key corridors and focuses on non-car mode trips to influence behavior change – for residents and visitors to San Juan. This should include transit as well as new modes and consider how the two will integrate. The smartphone, and the opportunities that it could bring, should be carefully considered.

Consideration has already been given to a new Advanced Traveler Information System (ATIS) website to promote multi-modal trip planning, and provide the public with real time information. The implementation of version 2.0 was delayed due to the impact that the hurricanes had over the ITS network. The PRHTA expects that the implementation of the most recent version will be carried out once the ITS projects already in deployment start coming on-line. Future version of the ATIS website could include features towards improving the transit user experience, such as providing trip planners, parking management information, real-time routing information, among other value-added features.

However – serious consideration should also be given to third party applications for traveler information, that source data from ITS systems. With the availability of free to use navigation apps and websites such as Waze, Google Maps, Apple Maps, Transit App and CityMapper, it is now very easy to plan a trip from A to B using only addresses and a set of best available options. The standardization of transit data, via the GTFS feed approach, has meant that it is relatively simple for a large city to provide its citizens with point to point trip planning, without investing in expensive web technologies. Google Maps (and similar apps) will do this for free if the data is made available; apps tend to be global in approach, so the ‘user experience’ is the same for someone visiting San Juan from London than it is for a local resident.

Like the traffic information provided on Google Maps overlay, these tools can also provide ‘real time’ updates on transit services (alerts and departures) and shared mobility (i.e. number of bikes at a station). Apps will consume data provided by the city and third parties in an appropriate format such as GTFS-RT, via Automatic Vehicle Location (AVL) and Automatic Passenger Counter (APC) systems. There are huge opportunities for San Juan in this arena.

Overall, navigation apps make it easy for riders (or potential riders) to see where local bus stops and stations are, the routes they serve and importantly, services on route. This type of information provides confidence to the rider and encourages users to leave their car at home. Currently, Google Maps or any other GTFS-powered app are extremely unreliable in San Juan. This is frustrating for many types of user, including those who are tempted for mode alternatives different from cars.

Mode Integration

The integration of all transportation modes to ITS is paramount to achieve a successful implementation in Puerto Rico. Looking ahead, accurate trip planning will form the backbone of a 'mobility as a service' delivery model - to encourage multi-modal travel considered on trip by trip basis, rather than growth in car ownership and TNC trips.

Key improvements should at least include:

Currently, most transit services operate somewhat independently from each other, resulting in reduced ridership on public transportation modes and a higher number of trips on private vehicles. These effects in turn contribute to congestion problems in many parts of the Island, specifically in the San Juan TMA. The PRHTA plans to implement ITS strategies included in the Public Transportation Management User Services Bundle to integrate information collected from different transportation modes and present it to travelers so they can make an informed decision as to which transportation mode is better at a certain moment in time. It is desirable that an integrated system is open to:

- Provide real time information about multi-modal transportation services on kiosks, websites and apps – and present in GTFS-RT format;
- Dynamic signage at bus stops and trains stations to provide travelers with information about expected arrival times;
- Ability for users to reliably plan a complete trip using online electronic tools (Tren Urbano, Metro Urbano and AMA Metrobus websites), including accessible trips (wheelchair users etc.). This will require the integration of different data sets, via GTFS;
- Ability for the rider to purchase tickets online or via smartphone;
- Ability for the rider to understand in real time train or bus location. In the future, this could also include availability of bikes, scooters and car shares;
- Provide real time parking information in terms of availability, costs and payment methods – particularly at parking serving public transportation services; and
- Ability for the city to understand transit ridership through better data collection and analysis.

For improvements to happen, the Long-Range Transportation Plan should take the following into consideration:

<u>Carry Out User Research</u>

How do people use the system? What are the flaw points? What can be learned from user behaviors? Interview riders and create user personas to better understand user profile, and what changes are needed to increase ridership.

<u>The Creation of a Strategic Roadmap for Passenger Information</u>

The PRHTA should focus on becoming a 'platform' for the delivery of transportation modes, through the provision of data to third parties. To do this a product roadmap should be developed in the short term – this will set expectations and user requirements for future mobility.

The Development of an AVL/APC System for All Buses

Key to the delivery of a more open and accessible transit network is the provision of real time information for all vehicles. This data should then be made available publicly via the platform. Ideally, the data collected by these systems should be feedback to the agency for further analysis – using performance data to better improve the transit network.

Creation of a GIS Database of Geo-Located Bus Stops/Stations and Routes

Another key item is the creation of a GIS layer for transit assets – including bus stop locations. Innovative approaches have been taken globally to capture bus stop locations via smart phone apps.

The Creation of GTFS Data for All Buses Operating in San Juan, Including Connector Services

A project should focus on the creation of GTFS data for bus services in San Juan. There are many innovative approaches to capturing and processing this data. Once collected and published, this information can then be used for a broad range of navigation services, often for free.

Creation of a Central Transportation Website/App, with Integrated Trip Planner

There is currently no single user resource for accessing online transportation information, formatted for smart phones. As a priority, a new website should be developed that provides key information to transit riders, including trip planning, fare purchase and service alerts.

Incorporation of Accurate GTFS Data, and Transit Mapping, into Google Maps

Once complete, and a robust updating procedure is in place, regular checks should be made to Google Maps, Apple Maps and others. Feedback should be sought from end-users. Importantly, this information needs to be accurate and well maintained.

A Centralized Platform for the Dissemination of Transit 'Rider Alerts' to All Media Sources and User Groups

Another key element of a passenger information system is regularly updated Rider Alerts (GTFS-RT Alerts). This system will provide timely updates for users, via dedicated transit websites, apps and other sources such as Google and Apple Maps. Often, this system will form part of a software service connected with the creation and management of GTFS.

Interactions with Key Stakeholders Such as Google, Waze, Uber etc. to Better Understand What Services Could Be Provided.

Establish effective collaborative relationships with data collection agencies and private companies.

Consider strategies to ensure that new mobility services, such as dockless bike share and scooters can be managed to promote a more sustainable transport, in line with the benefit of users and a larger mode shift from car trips.

<u>Development of a Digital Mobile Ticketing System, Potentially Integrated with Existing Tolling Accounts.</u>

Make it easier for riders to purchase and use tickets. Allow for multiple points of purchase – including app and web-based systems. Where possible, tie to existing payment accounts.

<u>Integrations with the Broader ITS Community/Stakeholders, as Stated in the ITS Regional Architecture.</u>

Work closely with other key departments, data providers and consumers to share silos of information and knowledge.

CONGESTION MANAGEMENT PROCESS

Congestion Management System

The Congestion Management Process (CMP), previously known as Congestion Management System, is an essential part of the planning process. The CMP is a methodical approach for managing congestion to obtain up to date information of a Region's transportation system tendencies and performance. It uses analytic tools to address congestion within a territory, activity center, or corridor and to establish the method for reducing or eliminating traffic congestion issues. The FAST-Act's CMP suggests new management techniques, direct links to the planning process and to environmental considerations, as well as to travel demand reduction.

The general purpose of the Congestion Management Process appoints to: (i) apply an organized and systematic approach to traffic congestion in a metropolitan Region; (ii) reduce travel demand; (iii) address congestion management through effective administration and planning considerations; and (iv) help enhance the mobility of people and goods.

The previously discussed FAST-Act, as the binding law for the Island's 2045 LRTP, requires the Puerto Rico jurisdiction (San Juan TMA and Aguadilla TMA) to develop a Congestion Management Process as part of its planning operations. New and existing facilities in the Island will benefit from its results, for example by maximizing their use and by helping in the decision-making. See Table 7.4.

In summary, the CMP is being added to the roadmap established in the PRTHA's 2010 Congestion Management Plan Report, with benchmark measures of congestion established through the 2012 Congestion Management Process Report. This latter report identified and quantified measures for all road segments on the congestion management network; these links were characterized in terms of average speed, travel times and delays, traffic volumes and traffic service, safety conditions, transit ridership and other transit measures. With this frame of reference in place, the effect of congestion management improvements can be gauged in terms of the extent and degree of their positive impact on transportation system conditions. To advance the CMP, a technical committee is being formed to identify and prioritize new projects to address the highest need congestion management components.

Development of projects that contribute to congestion management is currently in progress. Significantly, one of the more important groups of projects in the FY2013-2017 period involves development of the ITS network, with an emphasis on the incident management component. The PRHTA has also established an interim traffic center in its headquarters building for management of the traffic signal system. There are also many capacity and non-capacity projects in the 2013-2017 CIP program that address elements of congestion management as highlighted in Chapter 5.

Table 7.4: Relation between Planning Factors and 2045 LRTP Goals

CONGESTION MANAGEMENT GOALS	2045 LRTP GOALS
Improve intermodal connectivity	A, B, C and D
Minimize delays caused by accidents	A, C and D
Optimize average travel time	A and C
Reduce traffic demand	A and C
Maximize existing capacity	A, B, C and D
Provide reliable travel times	A, B, C and D
Improve travel safety and security	A, C and D

Source: SDG and PRHTA

FREIGHT

2045 LRTP

The movement of goods (freight) is an important contributor to the economy of Puerto Rico. Freight's mobility affects the competitiveness of individual businesses and residents throughout the Island. The importance of freight in the Island wide transportation system is recognized in the Congestion Management Process (CMP) and in the 2045 LRTP's vision, goals, and objectives framework (specifically with the focus of Economy, the goal of Reinforce Economic Vitality and the objective of Facilitate the efficient movement of freight, business and tourism activities to achieve economic competitiveness). As part of the public outreach program, targeted efforts were made to engage a wider group of stakeholders (LRTP committees), freight interests were considered during the Plan development process with the establishment of the Freight Advisory Committee.

This Advisory Committee responds to the needs of the freight industry to be a proactive participant in the transportation planning process. The comments that the members of the Freight Advisory Committee mentioned are included in the appendices; some of these comments include the need to improve access to major airports/distribution centers and the need to complete the road network in the Island including:

- PR-5 extension;
- PR-22 extension;
- Mayagüez to Aguadilla corridor;
- Completing PR-10;
- PR-53 completion; and
- Also, the need to improve cargo services to Vieques and Culebra.

Also, the Advisory Committee had some specific suggestions on an extension of the freight network, some of these sections are presented in Figure 6.1.

Regional and national economic factors affect how freight moves. A shift between freight modes is not relevant in Puerto Rico once are transported by air of maritime shipments as trucking is the only mean of distribution in the island. For this reason, freight mobility becomes an economic factor tied to the performance of highways, particularly the strategic network. Improvements made to the network will benefit the freight industry as well as the other highway users.

Separate from the internal movement of freight in Puerto Rico there are also the Island's freight links to the Caribbean, continental United States, Latin America, and trans-Atlantic markets. These occur through Puerto Rico's primary airports and seaports, which carry air cargo, and serve as portals for the import and export of goods. Various government initiatives have focused on expanding these air and sea cargo hubs and the essential land access connections to them.

The new federal transportation legislation, the FAST-Act includes several provisions to improve the condition and performance of the national freight network and to support investment in freight-related surface transportation projects. The FAST-Act establishes a national policy of maintaining and improving the condition and performance of the National Multimodal Freight Network, one that provides a foundation for the U.S. to compete in the global economy. The FAST-Act specifies goals associated with this national policy related to the condition, safety, security, efficiency, productivity, resiliency, and reliability of the network, and in the reduction of adverse environmental impacts related to freight. FAST-Act requires DOT to establish (and publish on its website) a national freight strategic plan. The DOT will develop (and update) the plan in consultation with State DOTs, MPOs, and other appropriate public and private transportation stakeholders.

The national freight strategic plan will include:

- An assessment of:
    - The condition and performance of the network; and
    - Barriers to improved freight transportation performance and opportunities to overpass them;
- Forecasts of freight volumes for the succeeding 5-, 10-, and 20-year periods;
- An identification of:
    - Major trade gateways and national freight corridors that connect major population centers, trade centers, and other major freight generators;
    - Bottlenecks on the network that create significant freight congestion;
    - Corridors that access energy exploration, development, installation, or production areas;
    - Corridors that access major areas for manufacturing, agriculture, or natural resources;
    - Best practices for improving the performance of the network, including critical commerce corridors and rural and urban access to critical freight corridors; and
    - Best practices to mitigate the impacts of freight movement on communities;
- A process for addressing multistate projects and encouraging jurisdictions to collaborate; and
- Strategies to improve freight intermodal connectivity.

Within 5 years of completing the national freight strategic plan, and every 5 years thereafter, DOT must update the plan and publish it on its website.

National Multimodal Freight Network

Goals of the Network

The FAST-Act directs DOT to establish a National Multimodal Freight Network to:

- "Assist States in strategically directing resources toward improved system performance for the efficient movement of freight on the Network;
- Inform freight transportation planning;
- Assist in the prioritization of federal investment; and
- Assess and support federal investments to achieve the goals of the National Multimodal Freight Policy established in 49 U.S.C. 70101 and of the National Highway Freight Program described in 23 U.S.C. 167"[92].

Establishment of Interim Network

The DOT must establish an interim Network, that includes:

- "The National Highway Freight Network that DOT establishes under the National Highway Freight Program (23 U.S.C. 167);
- The freight rail systems of Class I railroads;
- U.S. public ports that have total annual foreign and domestic trade of at least 2 million short tons;
- U.S. inland and intracoastal waterways;
- The Great Lakes, the St. Lawrence Seaway, and coastal and ocean domestic freight routes;
- The 50 U.S. airports with the highest annual landed weight; and
- Other strategic freight assets, including strategic intermodal facilities and other freight rail lines"[93].

Other Freight Provisions

State Freight Advisory Committees

The FAST-Act requires DOT to encourage each State to establish a local freight advisory committee, to consist of a representative cross-section of public and private freight stakeholders. The role of a State freight advisory committee is to:

- "Advise the State on freight-related priorities, issues, projects, and funding needs;
- Serve as a forum for discussion for State transportation decisions affecting freight mobility;
- Communicate and coordinate regional priorities with other organizations;
- Promote the sharing of information between the private and public sectors on freight issues; and
- Participate in the development of the freight plan of the State"[94].

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[92] 49 U.S. Code § 70103 - National Multimodal Freight Network.

[93] 49 U.S. Code § 70103 - National Multimodal Freight Network.

[94] 49 USC 70201: State freight advisory committees.

State Freight Plans

To receive funding under the National Highway Freight Program (23 U.S.C. 167), the FAST-Act requires each state to develop a local freight plan, which must comprehensively address the State's freight planning activities and investments (both immediate and long-range). A state may develop its freight plan either separately from, or incorporated within, its statewide strategic long-range transportation plan required by 23 U.S.C. 135. Among other requirements, a state freight plan must:

- "Cover a 5-year forecast period;
- Be fiscally constrained;
- Include a "freight investment plan" with a list of priority projects; and
- Describe how the State will invest and match its National Highway Freight Program funds"[95].

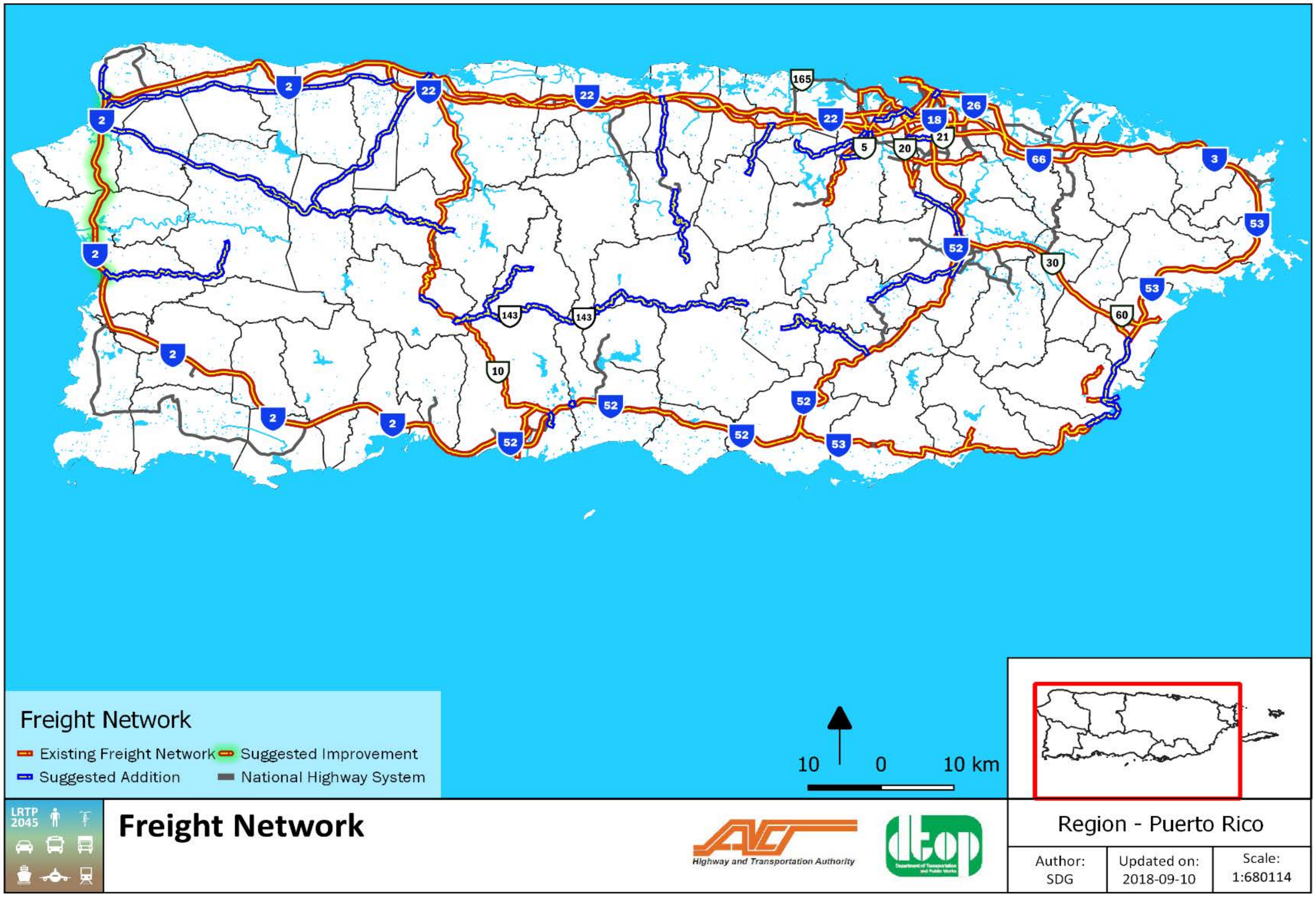
The state must update its freight plan at least every 5 years, and may update its freight investment plan more frequently than the overall freight plan.

The FAST-Act includes many provisions that modify federal requirements regarding the size and weight of vehicles that may travel on the Interstate System and the National Network.

The establishment of a Freight Advisory Committee as part of this plan and its continuation will facilitate a more targeted and prioritized approach to addressing freight mobility, and in cross-connecting transportation system planning, project definition and priorities, and coordination with congestion management initiatives. Figure 7.2 presents some of the logistics road additions to the freight network that the Advisory Committee suggested for Puerto Rico.

[95] 49 USC 70202: State freight plans.

Figure 7.2: Additions to Freight Network – Puerto Rico



Source: The existing Freight Network information layer was obtained form the Federal Highway Administration (FHWA)

SAFETY AND SECURITY

Safety

Security based initiatives are intended to cover all existent modes of transportation. This aspect is a priority for the PRHTA and therefore related enterprises have been constantly developing.

Transportation service's operators apply specific security measures based on the mode's demands. This security plan is broadened and designed based on the Federal Transit Administration's (FTA's) guides. Every service operator has a duty to execute the plan to achieve all defined security goals and objectives.

Puerto Rico has been the object of countless efforts to improve the security of its roads and highways. For the PRHTA, road security is an essential topic of discussion and priority. For this reason, security measures need to be included in the Highway Work Program, where, among others, geometric intersection improvement, traffic controls and highway reconstruction are analyzed.

Additionally, Puerto Rico's Transit Security Commission has the duty to implement and develop security measures and traffic accident prevention programs. Its main mission is to reduce the number of transportation related casualties and damage to property. The latter is achieved by establishing educational programs and proactive efforts to inform citizens about existent transit laws and regulations[96].

The commission's effort, through all of its related programs, has helped reduce the rates in transit related accidents and addressed numerous security concerns. This has been achieved as a collaborative work between the PRHTA, other agencies and organizations.

The National Road Security Plan (HSP) is the guide by which the commission, along with the PRHTA, identify security problems, define transportation objectives and goals and presents its project implementation. The Puerto Rico Strategic Highway Safety Plan[97] comprehend the following areas:

- Traffic Records & Information System;
- Emergency Medical Response;
- Occupant Protection;
- Alcohol Impaired Driving;
- Aggressive Driving;
- Vulnerable Road User;
- Young Drivers;

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[96] Norms and Procedures for the Administration of Federal Resources Manual, Transit Security Commission, reviewed June 2016.

http://comisionparalaseguridadeneltransito.com/wp-content/uploads/2017/02/MANUAL-DE-PROC-Y-NORMAS-DE-FONDOS-FEDERALES.pdf.

[97] Puerto Rico Strategic Highway Safety Plan 2014-2018.

- Roadway Departure; and
- Intersections.

Security

Security plans and concerns focus primarily on safer transportation facilities, crime prevention and addressing possible terrorist threats. All agencies responsible for managing transportation issues, including those in charge of ports and airports, have a duty to integrate and comply with the federal requirements established by TSA.

The Strategic Highway Network is relevant when considering security issues. This facility provides access and continuity for the movement of citizens, goods, services and freight, not only in a daily basis, but during war, threats or emergencies. Its importance resides in its capability to serve as a connection between the principal cities and is an asset in terms of defense.

Coordination between the DTPW/PRHTA, the state and municipal police departments is a must. This is essential to maintain security along the Island's principal roads and highways. Implementation of applications such as the ITS will expand or amplify the transportation facilities' capabilities to provide security services.

ENVIRONMENT AND SUSTAINABILITY

Overview

Puerto Rico, as a whole, is a composite of land forms ranging from dense urban developments to pristine natural settings such as El Yunque National Forest, The Guajataca Natural Reserve, The Window Shaped Caves in Arecibo, The Camuy Caverns, The Northeast Ecological Corridor, The Guánica Dry Forest and several of the most beautiful beaches in the world. From the surveys conducted with the public during the planning process, considerable interests and concerns were expressed about preserving environmental quality and fostering a more sustainable environment. The governor has established three initiatives, discussed below, that responded to the importance that Puerto Rico and its citizens placed on the environment. Consequently, the topics discussed in this section – environmental sustainability, social sustainability, and economic sustainability are vital and relevant to transportation planning across the entire island. Puerto Rico, due to all of its privileges, is well positioned to capture the opportunities of its urban structure to evolve a more livable urban environment.

Conservation and protection of the environment have been a long-standing principle of the Puerto Rico Commonwealth. Concern for the environment has been embraced within the broader concept of sustainability, which is defined by the U.S. Environmental Protection Agency (EPA) as a process that "creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations." Sustainability is focused on managing what we consume, how we consume it, and the byproducts of our consumption, in such a way that resources are preserved, regenerated, renewed, and available to those who follow.

From a review of several transportation agencies, their treatment of sustainability in relation to the transportation planning process encompasses environmental sustainability, social sustainability, and economic sustainability. Within this framework, sustainability can be viewed as including the following facets:

- Environmental sustainability:
    - Air quality;
    - Climate change;
    - Environmental management and mitigation;
    - Travel demand management; and
    - Congestion management.
- Social sustainability:
    - Livability: travel choices (transit, bicycles and pedestrians);
    - Transportation and land use linkage; and
    - Public health.
- Economic Sustainability.

As evidence of the continuing commitment to sustainability in Puerto Rico, the government issued in 2013 the Executive Order OE-2013-017, calling for the creation of a Sustainability Action Council with responsibility for:

- Formulating strategies to reduce reliance on carbon-based energy;
- Advising the Governor on climate change mitigation and response;
- Proposing laws for further protection of environmental resources;
- Identifying ways to create "green" jobs related to new forms of energy and environmental restoration; and
- Supporting the development and implementation of policies and laws, strategies and programs, and communications between academic centers for ongoing technical exchange of sustainability advances.

The Council was established to comprise a cross-section of membership drawn from academics, environmentalists, economists, businesses that have embraced the concept, technical professionals, and the public. This council on sustainability presents an opportunity for the MPO and PRHTA to provide input and information on an ongoing basis as it relates to the transportation system.

The following sections describe how the activities of the MPO and its transportation partners relate to the important environmental topics that are essential components of a well-rounded transportation planning and transportation system management framework.

Sustainability and the Environment

Air Quality

This section summarizes the status of the air quality for Puerto Rico. Air quality measurement stations are located through the entire island in municipalities such as Bayamón, Juncos, San Juan, Adjuntas, Barceloneta, Arecibo, Mayagüez, Salinas, Cataño, Guaynabo, Humacao, Ponce, Fajardo, Guayama and Guayanilla.[98]

Pursuant to the provisions of the Clean Air Act (CAA) and its subsequent amendments, the EPA has established the National Ambiental Air Quality Standards (NAAQS) for six criteria pollutants. These standards have been established to protect the public health. When an area meets a particular standard, it is stated that it is an "Attainment" area. Otherwise it is designated as a "Non-Attainment" area, which implies that a compliance plan shall be developed until the "Attainment" status is obtained. Nevertheless, transportation sources contribute to four of the six criteria pollutants for which EPA has established standards to protect public health and/or safety. The pollutants are: ozone (O3), carbon monoxide (CO), particulate matter (PM10 and PM2.5), and nitrogen dioxide (NO2). Until 1991, the entire Island was designated as one in which all the NAAQS were met. In September 2005, the 2030 San Juan LRTP was found in transportation conformity since requirements of the federal CAA PM10 emissions associated with the surface transportation network were less than the SIP emissions inventory established in 1993.

However, an exceedance of the Particulate Matter (PM10) was verified in the municipality of Guaynabo, after which the Urbanized area of this municipality was placed under a "Non-Attainment" status. After developing and implementing compliance measures that were incorporated in the State Implementation Plan (SIP), air quality monitoring data provide support for a delisting request that was submitted and approved by the EPA in January 12, 2010. The decision was published in the Federal Register[99] and is part of the required conformity analysis which established a maximum level of PM10 pollutants that may be emitted by the area's transportation system. LRTPs for areas where attainment for any of the pollutants does not exist must show that the implementation of the plan will not exceed the allowable level of emissions.

The responsible agencies and officials in the Commonwealth have committed to policies, specific projects, and a general course of action that promote good development, efficient transportation systems, and protection of the environment. This in turn contributes to improved air quality and creates more sustainable communities. A variety of concerted actions and policies such as pedestrian friendly land uses and improvement of pedestrian facilities, intersection improvements and other low-cost transportation measures, covering of loads on trucks, stabilizing the sides of roadways, paving parking areas, street cleaning and removal of road dust, and restoring roads to good repair can help in this endeavor. The increased emphasis on and implementation of transit improvements is a major commitment that will bring benefits for many years to come. These and other actions of the responsible agencies and officials will serve to improve the air quality.

The importance of air quality and the need of addressing the issue of greenhouse gases prompted the issuance of Executive Order EO-2013-018. This EO required to perform a study of greenhouse gases in Puerto Rico to be jointly led by the Energy Affairs Administration, the EQB,

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[98] Puerto Rico Environmental Quality Board, "Puerto Rico Air Monitoring Plan 2018-2019" p. 1-45. The stations functioning partially or completely after hurricane María are located in Cataño, Guaynabo, Bayamón, Ponce, Guayama and Arecibo.

[99] Volume 75, No. 7, pages 1543 and 1544.

and the Department of Natural Resources and Environment. The purpose of the study was to provide a profile of the level and sources of greenhouse gases in Puerto Rico, the impact on the environment of these carbon emissions, and strategies to reduce the emissions. The MPO and PRHTA participated in this effort as the emission of greenhouse gases from the transportation system contributes to the overall mix of gas sources. In September 2014, the agencies issued the Puerto Rico Greenhouse Gases Baseline Report. Perhaps the most relevant conclusion of the report is that the Green House Gases (GHG) emissions in Puerto Rico rose faster than the US average through 2005, falling and stabilizing afterwards. However, future emission levels are predicted to be significantly higher than 1990 levels in 2020 and beyond. These levels are higher than many subnational, national, and international targets for GHG emission reduction. The EO provides strategies targeting the two (2) primary emitting sectors: the electric power generation and the transportation and land use.

Regarding to the transportation and land use sector, which are the ones pertinent to this report, the forecasts for emission reductions are encouraging, even before the establishment of a concerted local policy adoption. The emissions from the on-road fleets (light duty cars and trucks as a well as heavy-duty trucks), reached peak levels during the 2000-2010 decades and are being predicted to fall over time. This trend is the result of the expectation that the total amount of driving (VMT) has been holding steady without growth in recent years. This observation is compatible with the one observed on a nationwide basis in the United States, due to higher fuel prices and greater levels of urbanization, and has broken decades-long linkages between economic and VMT growth. Also, the expected dramatic improvement of light duty vehicles is expected to play a starring role in the predicted emissions due to the relatively great number of them constituting a primary source of on-road fuel use. Mandated federal corporate average fuel economy (CAFE) standards require new vehicles to average the emissions equivalent of 54.5 miles driven per gallon of gasoline combusted by the year 2025. For heavy trucks, there is also a forecast to achieve higher efficiency gains.

Even though projected emission reductions are expected, they are not sufficient to reach the desired goal which is to have emission levels comparable to 1990 levels. Additionally, the most significant driver for the reductions in emissions, new fuel efficiency standards, are not predicted to continue up to 2050. Therefore, additional measures shall be implemented. The most promising of them is the adoption of a local strategy that provides incentives for the conversion of the auto fleet to electric vehicles. Potential candidates for this strategy are:

- Provide vehicles charging infrastructure;
- Easing of the permitting process for the construction of private charging facilities;
- Establishing or enhancing subsidies for charging equipment and/or vehicles; and
- Enhancing tax credits for electric vehicles purchases.

The MPO is already and continue to be involved with transportation planning and management activities that should be an integral part of the study recommendations.

Climate Change

Climate change issues and their effects on developed environments are a rapidly emerging consideration in LRTP documents across coastal areas and specially in Puerto Rico, in the aftermath of Hurricane María. The relation to transportation is through transportation greenhouse emissions from vehicles using the transportation system. Overall, transportation accounts for 29 percent of all greenhouse gas emissions. The EPA reports that the average car owner releases 4.8 million metric tons of carbon dioxide each year by driving. The total amount of carbon generated by the transportation system is a function of the vehicle mix in the fleet, the fuels used, and the operational efficiency of the system (network travel speed). The federal government has recently approved new Corporate Average Fuel Economy (CAFE) standards for new vehicles, which will further reduce emissions. Changing vehicles and their emission rates is reasonably manageable. Changing how well the system moves these vehicles and how people change their needs to consume transportation mobility is more challenging.

There are two dimensions to the transportation reach: mobility and accessibility. Mobility refers to how much ground or distance can be covered rapidly; thus, vehicle miles of travel is a positive indicator of this dimension. Automobiles on uncongested freeways greatly expanded urban mobility, encouraging suburbanization. Accessibility, the other dimension, means the ability to reach a desired range of various needs (shopping, services, schools, work, recreation) within a relatively short distance. If such resources, or at least many of them, are available within a short reach, then overall vehicle miles of travel can be reduced, so strategies and policies to adjust personal decisions about place of residence, place of work, and place of other destinations can influence trip lengths and travel mode choices, thus reducing the amount of travel and the environmental consequences of that travel. And if that travel involves more non-motorized travel by walking or bicycling, a collateral benefit that has been demonstrated in the literature is improved personal health and better quality of life.

The publication by the FHWA, *Integrating Climate Change Considerations into the Transportation Planning Process: Final Report* (2008) discusses how acknowledgement of climate change concerns can be coordinated with transportation planning processes. Regarding the LRTP process, climate change can be reflected in the plan vision, goals, and objectives; it can be connected to projects that provide benefit in terms of reduced vehicle miles of travel and reduction in greenhouse gas emissions; and it can be monitored in terms of performance measures of programs and projects.

Under Goal 4 of this 2045 LRTP—promote environmental sustainability—the four stated objectives address minimizing adverse impacts to the natural and built environments; reducing greenhouse gas emissions and energy consumption, and improve air quality; supporting integrated transportation and land use planning for more livable communities and reduced travel; and enhancing alternative modes and travel demand strategies. All of these objectives interface with climate change concerns. Other plan objectives also connect to climate change as discussed in the FHWA report. Various projects in the plan relate to reduced vehicle miles traveled and emissions, and the outputs from the travel demand model include a number of useful performance measures that relate to climate change impacts.

In terms of the planning process, the FHWA report notes there are avenues to integrate climate change into the MPO's ongoing activities; these are related to coordination with other agencies, land use planning and integration, and funding linkages. On these fronts, the MPO has opportunities to introduce climate change to its coordination with the Island planning and environmental agencies, in its coordination with the Planning Board regarding regional land use planning that is presently underway, and in linking funding decisions in part to climate change considerations.

This impact of transportation activity can be addressed through the following means:

- Reducing the direct emissions from vehicles:
    - Improving vehicle miles per gallon via the CAFE standards established by the EPA and USDOT); and
    - Improving traffic conditions by reduced congestion and improved signal timing.
- Reducing vehicle miles of travel:
    - By reducing trip length;
    - By increasing vehicle occupancy through higher automobile occupancy (carpooling);
    - By increasing vanpooling;
    - By increasing use of transit;
    - By decreasing required trip lengths by improved land use decisions;
    - By promoting more non-motorized travel by walking and bicycling;
    - By eliminating the need for travel (compressed days of work and telecommuting); and
    - By promoting the development of walkable, mixed land use activity centers with access to transit for longer distance trips.
- Reducing congestion on major travel corridors:
    - By improving travel speeds; and
    - By providing competitive transit service.

The PRHTA has been active on a number of these fronts with projects that contribute to reduced transportation impacts on the environment, through its development of the CMP and through the implementation of other projects that address traffic operations. In addition, PRHTA has been coordinating with various municipalities and regional economic development organizations on potential transit projects as well as trails and greenways projects.

One of the primary concerns of climate change besides air quality is the longer-term effect of rising sea levels due to increases in atmospheric temperatures and the melting of the arctic icepack. Since 1880, sea levels have risen by 8 inches. Some projections say sea level will rise by a foot by 2040 and by up to two feet by 2060. According to climatologists at Climate Central[100], as reported in their peer-reviewed surging seas report, 55 sites across the United States were analyzed to evaluate the level at which the "storm of the century" would normalize, determining that most major storm events would normalize at about four feet above the high tide line. Of the vulnerable populations in the United States, half of those living in Florida and eight of the top ten cities determined to be in Florida. It was found that two counties in South Florida, Broward and Miami-Dade, each have more people living below four feet of elevation than any state other than Louisiana. The recent storm event Sandy, impacting New Jersey and New York, is further demonstration of the devastating impact of such events.

[100] www.climatecentral.org.

As a result of this concern, the four counties in Southeast Florida entered into the Southeast Florida Regional Climate Change Compact to work cooperatively to address climate and the resulting sea level concerns. These issues are problematic in terms of their solution, but planning and policy development, as reflected in transportation system planning and management, is a proactive approach that was acknowledged by FHWA for its vision. As an example of the complexity in dealing with climate change effects, a recent combination of tropical storm surge and high tides caused considerable damage to the Florida State Route A1A roadway on the Fort Lauderdale beach, triggering an expensive refurbishing project to put the roadway corridor back into operational use. Various reaches of Southeast Florida beaches have experienced recurring issues with beach erosion and beach replenishment. These same issues can confront Puerto Rico's coastal realms.

Planning for sea rise and climate change contingencies is a proactive measure that enhances the development of evacuation planning for low-lying coastal areas. A number of low-elevation communities in Puerto Rico coastal areas are susceptible to marginal increases in sea rise over the long term or to combinations of high tide and storm-related water elevation increases and surges. In addition, the Puerto Rico State Agency for Emergency and Disaster Management (PRSAEDM) and partners have recognized the potential for tsunami events within the Region and have done advance planning to support the preparedness and response elements of such events. PRSAEDM coordinates programs addressing disaster preparedness, response, recovery, and mitigation across focus areas including earthquake safety and risk reduction, the National Flood Insurance Program, the National Hurricane Program, Mitigation Grant Program, Assistance Program for Flood Mitigation, and Pre-Disaster Mitigation Program.

The significance of pursuing climate change response strategies was authenticated by the Governor of Puerto Rico, who issued Executive Order EO-2013-016. This EO designated the Department of Natural and Environmental Resources (DNER) as the lead agency with the responsibility to perform an analysis of the climate of Puerto Rico and assess and identify vulnerabilities of the infrastructure with the goal to establish and develop an Adaptation Plan to cope with such findings. All local infrastructure government agencies as well as some private entities were addressed by this order. In June 2016, with the assistance of the DNER, the DTPW published a report entitled Climatic Change- Adaptation Plan. This plan established a road map that shall be followed in order to successfully adapt the agency infrastructure to the potential adverse impacts resulting from the climate change. This is an on-going multi-year process that will require the identification of economic resources and modifications to the current transportation infrastructure at some specific locations.

It is recommended that the MPO and PRHTA participate in this effort as transportation infrastructure that may be vulnerable along the coasts and elsewhere is ubiquitous. The MPO is already involved with transportation planning and management activities that should be an integral part of the study recommendations. The PRHTA and MPO, working together, could advance an analysis of the transportation network using Geographic Information System databases, including topographic information, to perform a susceptibility analysis for transportation infrastructure due to increases in seawater elevation. This analysis would provide a starting point for further discussion of land use and infrastructure concerns resulting from rising seas and related issues, and could inform certain decisions about how to invest in at-risk roadways, for example. The MPO looks to build on its current collective efforts that relate to climate change, both in terms of the processes that it is involved in, and in the planning documents that are produced.

Environmental Management and Mitigation

Another important facet of transportation is the impact of transportation projects on the environment. The prevalence of environmental assets across the Island heightens the need to plan projects to avoid or minimize environmental impacts, and to devise proactive mitigation strategies to compensate properly for needed improvements with unavoidable impacts. As individual projects are developed, they are subjected to the required environmental scrutiny, complying with both federal and Commonwealth laws and regulations. Puerto Rico has traditionally placed a high value on its environmental resources and has in place its own robust environmental impact review process that, in tandem with National Environmental Policy Act (NEPA) requirements for environmental assessment of qualifying projects, creates a framework for minimizing environmental harm.

These process tools include agreements between PRHTA and other local and federal agencies, including the Permits Management Office, the Department of Natural Resources and Environment, the Planning Board, the State Historic Preservation Office, the Puerto Rico Culture Institute, and the EQB. Puerto Rico also recently created a Permits Management Office, which is designated to issue construction and development permits, and provides a consolidated clearinghouse for the rules and requirements of other government agencies under a Joint Permit Regulation for Construction Works and Land Uses. For federally funded projects with required environmental documentation, the PRHTA coordinates with the EQB regarding compliance with Commonwealth environmental regulations.

Congestion Management Process

As described separately in this chapter, the PRHTA has embarked on the development of its Congestion Management Plan and Process as required under federal regulations. The plan development process thus far has defined the congestion management network for the San Juan and Aguadilla Regions; established goals, objectives, and measures; developed a set of toolbox strategies to address congestion management; and identified target locations for further analysis. The identified strategies are multimodal and span a spectrum of capacity, throughput efficiency, and alternative mode approaches. The next phase of work should identify specific priority congestion management projects that can be incorporated into the 5-Year TIP and the long-range transportation plan process. The CMP should prove to be an effective channel for prioritizing high-impact projects into the transportation system, and as a result, contributing to improved air quality, reduced fuel consumption, and more efficient use of transportation assets.

Social Sustainability

Livability

Livability is planning concept that seeks to interconnect decisions about the transportation system with land use planning, environmental protection, and economic development to promote communities where reliance on the auto is greatly diminished, where a variety of mixed uses of sufficient density are highly accessible by walking or bicycling, and where quality of life is enhanced by improving environmental quality. As noted in the publication *Livability in Transportation Guidebook: Planning Approaches that Promote Livability*[101], there are a number of allied urban planning initiatives that interface with livability, including smart growth, walkable communities, transit-oriented development, life-long communities, complete streets, and new urbanism. This planning concept has received renewed visibility with the initiation in 2009 of the Interagency Partnership for Sustainable Communities formed between three (3) important United States agencies (U.S. Department of Housing and Urban Development, U.S. Environmental Protection Agency, and U.S. DOT). This partnership has advanced six (6) livability principles that are being reflected in existing and new federal programs across these three agencies, reflecting initiatives through transportation, housing, and the natural and built environments[102].

The six livability principles are:

- **Provide more transportation choices** to decrease household transportation costs, reduce our dependence on oil, improve air quality, and promote public health;
- **Expand location- and energy-efficient housing choices** for people of all ages, incomes, races, and ethnicities to increase mobility and lower the combined cost of housing and transportation;
- **Improve economic competitiveness of neighborhoods** by giving people reliable access to employment centers, educational opportunities, services and other basic needs;
- **Target federal funding toward existing communities –** through transit-oriented and land recycling – to revitalize communities, reduce public works costs, and safeguard rural landscapes;
- **Align federal policies and funding** to remove barriers to collaboration, leverage funding and increase the effectiveness of programs to plan for future growth; and
- **Enhance the unique characteristics of all communities** by investing in healthy, safe and walkable neighborhoods, whether rural, urban or suburban.

The federal, Commonwealth, and local governments have differing roles and responsibilities in relation to the application of these principles. The Puerto Rico's Land Use Plan promotes the development of more livable communities. This plan acknowledges the role of the transportation system as supportive to workers and to the creation of an overall better quality of life. The Plan and Guide for the Design of Complete Streets from PRHTA also recognizes the important role of transportation development for the creation of better and livable societies. The Plan's goals and objectives pretend to achieve habitable communities by improving the transportation system

The framework of vision, goals, and objectives for the 2045 LRTP include Objective 4.3 which relates to "integrated transportation and land use planning for more livable communities and reduced (automobile) travel." Several other objectives are also supportive of livability in

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[101] FHWA/FTA, 2010.

[102] Livability in Transportation Guidebook: Planning Approaches that Promote Livability (FHWA/FTA, 2010).

terms of improved connectivity, enhanced integration between and within modes, increased travel choices, reduced congestion and travel time, leveraging the efficiency of prior infrastructure investments, minimizing adverse environmental impacts, reducing greenhouse gas emissions and energy consumption, and enhancing alternative modes and travel demand strategies.

Transportation Demand Management

Transportation demand management (TDM) refers to a set of strategies that are focused on influencing individual travel choices relating to the need for a trip, the Origen and Destination points for the trip and how-when the trip is made. The intention of TDM is to help alleviate travel congestion through lower cost means than major capital investments for physical system capacity. Additionally, it provides strategies to increase shared and non-motorized forms of transportation, while addressing the need to reduce congestion and air pollution.

The TDM is an integral component of a Congestion Management Process (CMP). Many TDM strategies can be employed to affect travel demand, Table 7.5 presents these strategies.

Table 7.5: TDM Strategies

TDM Strategies	Definitions
Ridership programs	Trip matching, carpooling, vanpooling, high-occupancy vehicle lanes.
Transit Usage	Improved or new transit services, favourable transit pricing through passes and fares.
Alternatives Modes	Encouraging more trips by bicycling and walking, to reduce vehicular trips and to support improved public health.
Telework/Telecommute Programs	Replacing commuting with remote work sites relying on telecommunications.
Compressed work weeks	Variable work hours to take commute trips out of the peak hour, or to reduce the number of trips.
Parking management	Managing parking supply and cost to influence travel choices.
Park & ride facilities	Built to support increased use of connecting transit services.
Congestion pricing	Dynamic pricing of toll facilities to discourage peak-period trips.
Transit oriented development	Mixed-use developments at transit nodes to reduce auto-based trips and increase transit and non-motorized travel.

Source: SDG/PRTHA

The TDM strategies mentioned, are included in the CMP developed for the San Juan TMA and Aguadilla TMA. As that process begins to find specific congestion management projects for implementation, TDM approaches will be considered. Table 7.6 presents several TDM-related projects that have been implemented in Puerto Rico.

Table 7.6: TDM – Related Projects in Puerto Rico

TDM strategy	Project & location
Transit Usage	There has been an increase on the usage of municipal transit services (contrasting a decreased on Público services), most of these services are free to the public. Also, there was a new restructuration of some routes from AMA (routes that were eliminated, were again established), with the purpose of capturing a higher ridership and expanding the coverage of the system.
Congestion Pricing, Transit Usage, and Park-and-Ride Facilities	The reversible dynamic-tolled lanes project on PR-and a new BRT-style Metro Urbano transit service, connecting from the Bayamón Tren Urbano station and a similar project proposed for PR-52.
Transit Oriented Development	PRHTA sponsored several planning studies of TOD development around Tren Urbano stations, and there is supporting legislation in place. It is the hope that, as real estate market conditions improve, results from this planning will begin to be realized.
Alternative modes	PRHTA has develop a Comprehensive Bicycle and Pedestrian Plans as well a Complete Street Plan and Design Guidelines. Both plans promote alternative modes trough a various initiative, publicity and educational campaign.

Source: SDG/PRTHA

Transportation - Land Use Linkage and Scenario Analysis

The prior discussions of livability and transportation demand management highlight the importance of the transportation and land use linkages. In the new era of reduced construction funding, rising costs for transportation projects, managing an aging population Rico and considering the impacts of natural disasters in accessibility, focusing a portion of transportation project investment on projects that support community development, economic revitalization, and multimodal accessibility can be more effective than conventional roadway capacity projects. These initiatives must be coupled with land use projects that promote affordable housing with mixed land uses and access to transit, in order to effectively reduce the amount of travel needed per person and increase modal split reducing auto dependency. This in turn reduces pollution and energy use. More use of active transportation, such as walking and bicycling, also generates benefits to personal health. Interactions between transportation and land use enhances quality of life, reduces public infrastructure costs, and makes the transportation system more efficient.

One of the challenges is taking the first few steps toward livability and sustainability. The existing transportation and land use fabric has evolved over decades and represents the collective result of millions of individual decisions about where employment is located, where people choose to live, where they shop and go to school, and how they choose to travel between these places. Changing the shape and character of this urban landscape likewise will require the first successful steps on prototype projects under improved economic and real estate market conditions. Unfortunately, Puerto Rico has experienced a population decline over the last decade, and continued reporting indicates that the decline has continued. The population forecasts for the Island through year 2045, as prepared for this LRTP, do forecast an eventual return to a population growth trend, albeit a modest one compared with the present. This will limit to some extent the opportunities for development. There is always, of course, movement in the housing, retail, and employment market places even with a stable population as housing stock ages and younger consumers seek different housing and lifestyle options.

Cities across the Island are investigating and investing in the reinvigoration of their traditional town centers, either by renovation of old underutilized buildings or by planning and developing “in-town” projects that offer new development in the city center on vacant and underused land. Some of the several examples across the Island include Fajardo, Bayamón, Caguas, San Juan, Humacao, Carolina, Ponce, and Aguadilla. As noted, even in no growth or slow growth situations, submarkets of the population can be looking for these types of live-work-shop-play walkable community lifestyles. Often such projects can serve as the nucleus for adjacent redevelopment that expands on the success of the initial phase.

Public Health

Numerous studies exist that corroborates the relationship between transportation and health. There is an overall notion that recognizes the importance of promoting active transportation, walking and bicycle riding to develop healthier and more sustainable societies.

The American Public Health Association (APHA)[103] reasserts this principle by stating that transportation related decisions affect the citizen’s quality of life: “poor transportation decisions can harm health and are not always fair across all communities”

The APHA has drafted a document[104] to suggest the collaboration that needs to exist between this institution and the Metropolitan Planning Organizations (MPOs). Its main objective is to establish a symbiotic relationship between the public health and the transportation sectors. This relationship can be summarized as follows: persons are inclined to walk or use a bicycle if there are (1) available facilities and (2) adequate and safe environments to perform the activity.

On the other hand, the Federal Highway Administration (FHWA) also recognizes the relationship between transportation and public health. The FHWA highlights the importance of working with professionals in both transportation and health fields to make better decisions in transportation related matters. There is a plan to develop transportation options that help provide citizens with a better quality of life. A resulting healthier society is part of this goal. The referred plan needs to focus in the following[105].

- Promote safety;
- Improve air quality;
- Respect the natural environment;
- Improve social equity;
- Create additional opportunities for the positive effects of walking, biking, public transportation, and ride-and vehicle-sharing; and

[103] https://www.apha.org/topics-and-issues/transportation..

[104]https://www.apha.org//media/files/pdf/topics/transport/health_primer_designed.ashx?la=en&hash=532EC626D143DF99445C0726665550CC9BEB0CAD.

[105] https://www.fhwa.dot.gov/planning/health_in_transportation/

- Conduct research on transportation's role in improving quality of life.

The FHWA, in collaboration with the Center for Disease Control and Prevention (CDC), has created an important instrument, the Transportation and Health Tool (THT), to provide access to data that can be useful to study how the transportation system is affecting the citizen's health.

Both The Complete Street Plan and Guides and The Cyclist and Pedestrian Integral Plan recognize the benefits of using alternative modes of transportation to help improve people's health and overall quality of life. These plans seek to improve physical and mental health while promoting more accessible facilities and nonpolluting activities.

The LRTP's recognition and promotion of the relationship between alternative modes of transportation and public health through its goals, objectives, The Complete Street Plan and Guides and The Cyclist and Pedestrian Integral Plan, contributes to achieve the intent stated by the Puerto Rico's Land Use Plan[106], which also advances better health possibilities.

Economic Sustainability

The PRTHA has the duty to develop multimodal transportation projects for the entire Island of Puerto Rico. This agency has faced important challenges in recent years, due to lack of funding for project maturation or expansion.

The PRTHA's revenue comes primarily from petroleum taxes. This revenue is adversely affected by inflation over time, but also by the development of new technologies that promote more efficient use of fuels. Together with the Island's economic depression for the last years, the increase in preservation costs and project growth and the agency's debt that requires large budget designations are some crucial issues affecting multimodal transportation these days.

In order to improve its fiscal stance, the PRTHA has to comply with the Certified Fiscal Plan from the Fiscal Control Board of Puerto Rico. This certified plan provides special guides to transform the agency's structure along with the transportation facilities in the Island. The plan establishes that the PRTHA must:

- Transform drastically to achieve its goals;
- Improve governance and performance management;
- Pursue grater revenue opportunities;
- Focus on operational excellence including capital efficiency; and
- Reduce traffic to drive economic growth.

To continue developing cost management and debt reduction strategies will help the agency to achieve better financial status in the long term.

[106] Puerto Rico's Land Use Plan – Territory Organization Guides (Board of Planning, 2015).

LOOKING FORWARD

The plan's main goal is that all users and interested parties benefit from its results. Beyond all financial challenges presented, the LRTP has the interest of improving the transportation system in the Island.

It is crucial to be aware of new legal requirements and federal politics regarding transportation. In this context, the most recent federal transportation legislation, The FAST-Act, in force since December 4, 2015, contains updated guides to assign and manage transportation funds. This recent legislation also presents new concepts to include in the transportation planning process.

The PRTHA needs to improve its financial status to fulfill its role to maintain, administrate and develop the Island's transportation system. Once a reasonable financial status is achieved, other important actions can be managed through the MPOs. These actions will promote better land use, transportation politics and the foundation for a multimodal transportation orientation. Evolution is always required to continue improving investment capabilities and the transportation system in general.

The following are some important initiatives that the MPOs can trigger in the future:

- Project funding
    - Identify local financial sources to assist with federal investment; and
    - Identify new opportunities in the private and public sectors to finance projects and accelerate implementation.
- Transportation management
    - Maintain the non-motorized transportation crew in order to promote pedestrian and bicycle network improvements, requirements and programs;
    - Monitor The Complete Street Plan and Guides and The Cyclist and Pedestrian Integral Plan implementation;
    - Create, formalize and administrate a freight transportation work crew;
    - Active participation in the development of collective and non-motorized transportation plans;
    - Coordinate CMP's integration in transportation planning;
    - Promote the implementation of ITS applications; and
    - Support the coordination between DTPW/PRHTA, transportation agencies and the MPO to improve performance metrics and monitoring, as stated by federal requirements.
- Sustainability and Livability
    - Establish a work crew to help improve land use planning while allowing the PRTHA and the Board of Planning to continue their efforts;
    - Identify strategies to promote an intelligent and sustainable growth; and
    - Promote coordination with federal programs such as the habitability initiative from HUD/DOT/EPA.
- Communication and Coordination
    - Continue developing the Citizen's Participation Plan (CPP) to incorporate initiatives in the Island's communities;

- Develop a digital communication program to allow access to information, meeting coordination and record keeping of programs and activities; and
- Allow the MPO to serve as an information center and as a coordination entity through its committees, by defining its new capabilities.

CONTROL INFORMATION

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