Risk and Vulnerability Indicators Dashboard

This document explains the selection of Indicators for the Risk and Vulnerability Indicators (RVI) Dashboard prepared by Hunter College for the Foundation for Puerto Rico (FPR) as a component of the Whole Community Resilience Planning Program (WCRP) as included in the Action Plan approved by the U.S. Housing and Urban Development (HUD) and overseen by the Puerto Rico Department of Housing (PRDOH). The WCRP Program uses Community Development Block Grant – Disaster Recovery (CDBG-DR) funds for the development of comprehensive community resilience plans (CRPs). CRPs will nurture civic engagement and allow communities to develop policy, planning, and management capacity. The goal of the WCRP is for communities to determine their unique needs, set long-term goals and short-term objectives, devise programs and activities to meet these goals and objectives, evaluate the progress of such programs and carry out management, coordination, and monitoring of activities necessary for collaborative and effective planning.

The RVI depicts indicators for six core areas of concern: economic development, education, environment, health, housing, and infrastructure. These indicators are used to estimate an Overall indicator, included as a seventh indicator in the RVI. These indicators are based on GIS data for municipalities and barrios in Puerto Rico. Overall, we considered a total of seventy-six (76) variables for inclusion in the indicators: six (6) for Housing; thirteen (13) for Economic Development & Socioeconomic Vulnerabilities; eighteen (18) for Environment & Natural Hazards; eleven (11) for Infrastructure (& Transportation); eighteen (18) for Health; and, ten (10) for Education. [These variables are listed in Appendix A: Variables considered for aggregate risk and vulnerability indicators.]

Variable Selection Method

Principal Component Analysis (PCA)[1] was utilized as a data exploration tool and as the primary method for reducing the number of variables available for inclusion in the dashboard in situations where the data were complete enough to meet the requirements for analysis. Analysis of indicators using PCA when feasible and a review of the literature narrowed the original list of potential indicators from the original list of variables to the ones selected for the

[1] Principal Component Analysis (PCA) "is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set. Reducing the number of variables of a data set naturally comes at the expense of accuracy, but the trick in dimensionality reduction is to trade a little accuracy for simplicity. Because smaller data sets are easier to explore and visualize and make analyzing data much easier and faster for machine learning algorithms without extraneous variables to process. So, to sum up, the idea of PCA is simple — reduce the number of variables of a data set, while preserving as much information as possible." Source: Zakaria Jaadi, A Step-by-Step Explanation of Principal Component Analysis (PCA). July 23, 2021. Retrieved 8/3/21 from: https://builtin.com/data-science/step-step-explanation-principal-component-analysis. This article presents a brief introduction of the PCA to "those without a strong mathematical background."

RVI. The initial step was to assess the completeness of coverage of each candidate variable to determine if it met the requisite levels of geographic coverage for municipalities and barrios. Data that could not be disaggregated to the base unit of analysis (U.S. Census designated county subdivision or barrio) were omitted from inclusion in the indicator calculation process. Variables were also screened for completeness as measured by the number of Null or No Data values that they contained. If a variable was deemed to be unfit for inclusion, efforts were made to find a proxy or equivalent dataset that could provide a higher level of completeness.

Once the initial screening process was completed, the data was standardized for inclusion in the dashboard depending on the type of layer. For polygon-based layers, the vulnerability of any barrio or municipality would is relative to the vulnerability of other barrios or municipalities. Based on the selected polygon layers indicators for each policy area, we then ranked barrios (i.e., counties subdivisions) across the island to enable mapping and analysis of relative vulnerability in barrios and municipalities. These tract rankings are based on percentiles. Percentile ranking values range from 0 to 1, with higher values indicating greater vulnerability. We then added the percentiles for the variables comprising each policy area for the estimation of an aggregate indicator. For each policy area, the indicator percentiles were converted to a slider or meter gauge divided in fifths ranging from low to high for inclusion in the dashboard.

The methodology for point layers differs from that used for polygon-based layers. For point layers, the count of the number of features within a geographic unit is the base level of analysis. Once a count figure is generated within a geographic region (i.e. Barrio), a min-max normalization or ranked index is applied to transform the range of values to a consistent 0 to 1 score. In doing so, point-based data can be integrated into a broader index that includes numeric data like the data derived from polygon features.

For each of the policy areas, below we are listing the layers for the indicators, whether these variables or similar indices are found in the literature when this information is available, and the sources of information. Information about the source of the data can be found in the RVI Data Dictionary <here>. Counties subdivisions (barrios) with no structures or population have a NULL value and were excluded from the analysis, and are listed in Appendix B; Counties subdivisions (barrios) returning NULL values for PER_ENR_3_24 variable were excluded from the analysis (these are listed in Appendix C) and the indicator adjusted as explained below.

1. Housing

The selection of variables for the Housing indicator was based on an examination of the literature on the topic, especially on other indices measuring these two dimensions of housing vulnerability including the Housing Instability Risk Index[2] by the Urban Institute, the Distressed Communities Index[3] by the Economic Innovation Group, and the Housing & Transportation and Household Composition[4] from the CDC's SVI. Rent burden and overcrowding variables are also utilized in Community Health Rankings (Severe housing problems | County Health Rankings &

[2] Where to Prioritize Emergency Rental Assistance to Keep Renters in Their Homes. https://www.urban.org/sites/default/files/2021/04/02/where_to_prioritize_emergency_rental_assistance_to_keep_renters_in_their_homes_technical_appendix.pdf

[3] Distressed Communities Index. https://eig.org/dci

[4] At A Glance: CDC/ATSDR Social Vulnerability Index. https://www.atsdr.cdc.gov/placeandhealth/svi/at-a-glance_svi.html

Roadmaps) and housing indicator of the California Healthy Places Index (California Healthy Places Index Map).

After an initial examination and testing of the original set of available variables, we selected the rent burden, household overcrowding, vacancy rate, and housing age as variables for inclusion in the experiment. Preliminary PCA was run for vacancy rate, overcrowding, housing units built pre 1991, and rent burden. Examining the model output of the PCA, the first component consists of the rent burden and household overcrowding variables and the second is comprised of the vacancy rate and housing age variables. This finding highlighted an important distinction between tenant/occupant measures of housing security/instability and community/housing market metrics of neighborhood quality. Accordingly, we separated the housing indicator into two distinct sub- indicators: The first sub-indicator includes the variables measuring housing insecurity, the second sub-indicator includes variables measuring neighborhood quality and stability.

After further analysis, the initial variables selected for the housing insecurity indicator lacked the desired geographical coverage. To measure this dimension of housing vulnerability, we use the Severe Housing Problems[5] metric developed by HUD and published in the Comprehensive Housing Affordability Strategy (CHAS) data as a proxy variable.

The Severe Housing Problems variable is a composite measurement that account for four distinct dimensions of housing risk and vulnerability:

1. Housing unit lacks complete kitchen facilities
2. Housing unit lacks complete plumbing facilities
2. Household is overcrowded; or
4. Household is severely cost burdened.

The first sub-indicator includes the variables measuring housing insecurity:

Variable	Source
Severe Housing Problems	2019 5-Year American Community Survey

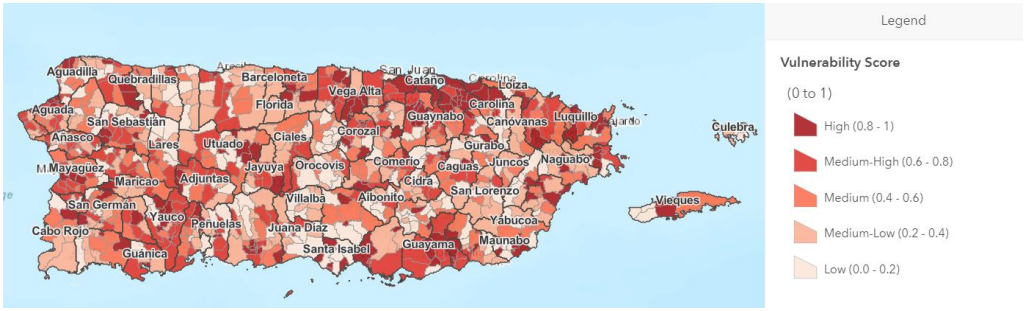
The second sub-indicator includes variables measuring neighborhood quality and stability:

Variable	Source
Vacancy rate (Vacancy/Housing Units)	2019 5-Year American Community Survey
Year Structure Built (% < 1991)	2019 5-Year American Community Survey

[5] Both the American Community Survey (see "Selected Conditions" section American Community Survey and Puerto Rico Community Survey 2019 Subject Definitions https://www2.census.gov/programs-surveys/acs/tech_docs/subject_definitions/2019_ACSSubjectDefinitions.pdf) and the Community Health Rankings and Roadmaps datasets (2021 Measures | County Health Rankings & Roadmaps https://www.countyhealthrankings.org/explore-health-rankings/measures-data-sources/2021-measures) utilize the Severe Housing Problems metric developed by HUD and published in the Comprehensive Housing Affordability Strategy (CHAS) data.

The Housing indicator is based on the sum of both sub-indicators' percentiles. The sum of these values is then aggregated into a percentile ranking values also standardized to range from 0 to 1, with higher values indicating greater housing vulnerability. Standardization of indicators' values is critical for aggregation of these policy areas indicators into an Overall indicator, as we explain below.

The following map depicts the Housing Indicator values at the Barrio Level.



2. Economic Development & Socioeconomic Vulnerabilities

The review of the literature led us to select two indices measuring economic development & socioeconomic vulnerabilities as departing point for the selection of variables for this indicator. The Centers for Disease Control and Prevention Social Vulnerability Index (CDC SVI or simply SVI, hereafter) was developed by the Geospatial Research, Analysis & Services Program (GRASP) of the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Department of Health & Human Services to "help public health officials and emergency response planners identify and map the communities that will most likely need support before, during, and after a hazardous event[6]." The SVI is composed of four summary theme ranking variables, as follows:

- Socioeconomic – RPL_THEME1
- Household Composition & Disability – RPL_THEME2
- Minority Status & Language – RPL_THEME3
- Housing Type & Transportation – RPL_THEME4

Though we consider all the variables used in the SVI to construct these thematic indices, we used specifically the variables contained in the Socioeconomic – RPL_THEME1 as a departure point for the construction of the Economic Development & Socioeconomic Vulnerabilities indicator.

In addition, we also considered variables included in the Opportunity Index.[7] This index was jointly developed by Child Trends and the Forum for Youth Investment's Opportunity Nation Campaign to "provided a snapshot of conditions that can be used to identify and improve access to opportunity—in comprehensive terms—for residents and their communities." As in the case of the Housing indicator, many of the variables in the Opportunity Index in the "Economy" subset of variables considered for measuring economic development & socioeconomic vulnerabilities are included in other indicators for the dashboard.

[6] CDC SVI 2018 Documentation (1/31/2020). https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2018.html

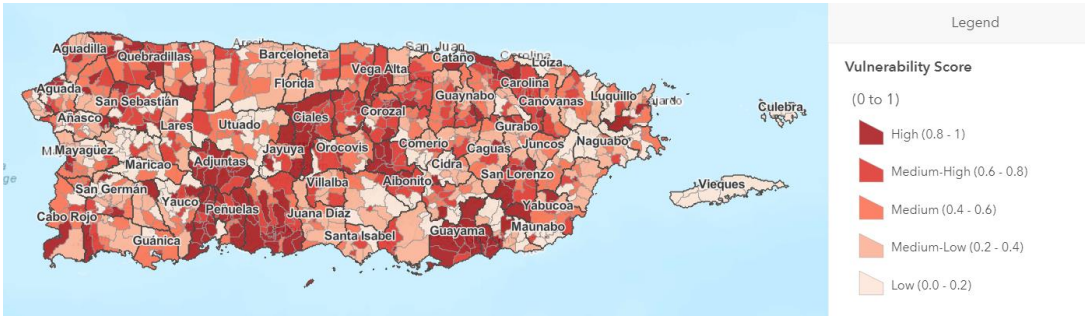
[7] What is the Opportunity Index? https://opportunityindex.org/about/

After an initial examination and testing of available variables for the Economic Development & Socioeconomic Vulnerabilities indicator, we selected the following variables:

Variable	Source
% below poverty threshold (Poverty Status in the Past 12 Months)	2019 5-Year American Community Survey
Public Assistance (% population)	2019 5-Year American Community Survey
Income per Capita	2019 5-Year American Community Survey
% unemployed	2019 5-Year American Community Survey

We found that a model that uses % public assistance, Unemployment rate, Per Capita Income and/or Percent Below poverty line might be best suited. Since per Capita Income and Percent Below poverty level are highly colinear, Percent Below poverty level was selected.

The following map illustrates the layer for the Economic Development & Socioeconomic Vulnerabilities Indicator.



3. Environment & Natural Hazards

Due to the binary nature of many of the variables in our data sets, rather than using PCA for component validation we compared the list of candidate variables with those used in existing environmental indicator methodologies. We found broad agreement about key variables to consider in the environmental risk index literature review that we conducted for the construction of this index.

Two indicators that we considered were the EJSCREEN environmental justice indicator published by the EPA[8] and the Puerto Rico-specific Environmental Indicator published by Sotolongo et al. (2021)[9], which was derived from the EJSCREEN indicator method. In addition to the initial list of variables (TRI, waste disposal facilities, and impaired bodies of water) we also identified and included in the index lead exposure, Air Quality, national priority list (NPL) site count, and risk management plan (RMP) site count. While natural hazards present a form of environmental risk that can compound the environmental indicators that we listed, it is our

[8] EJSCREEN: Environmental Justice Screening and Mapping Tool. https://www.epa.gov/ejscreen.
[9] Sotolongo, Marisa, Laura Kuhla, Shalanda H.Baker. Using environmental justice to inform disaster recovery: Vulnerability and electricity restoration in Puerto Rico. Environmental Science & Policy (122), August 2021, Pages 59-71.

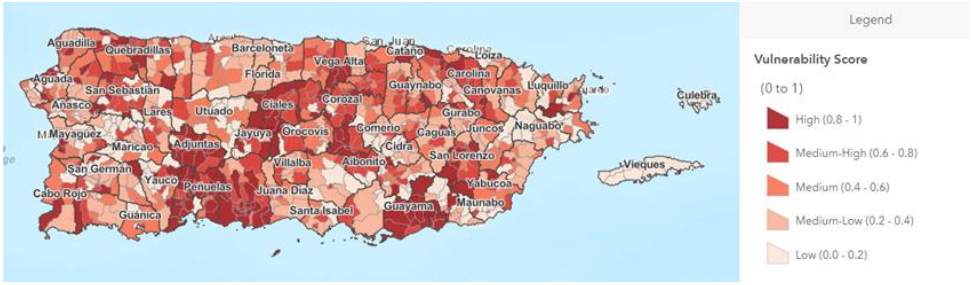
contention that risk variables such as flooding, landslide, earthquake hazard should be contained in separate layers for analysis.

Through the review of the literature, we were able to validate the selection of variables as well as to identify additional data sources and indicators that resulted in a more balanced and representative indicator that is rooted in the existing literature.

Variable	Source
Impaired bodies of water (EPA 303(d) under CWA)	EPA WATERS Geospatial Data Downloads https://www.epa.gov/waterdata/waters-geospatial-data-downloads
TRI facility	EPA Geospatial Data Download Service https://www.epa.gov/frs/geospatial-data-download-service
Inventory of Municipal Landfills and Open Dumps PR, Solid Waste Facilities	Layers provided by FPR
NPL (National Priority List) Sites	EPA
RMP (Risk Management Plan) Sites	EPA
Lead Paint Indicator (% of homes built before 1961)	2019 5-Year American Community Survey
NAAQs non-attainment zones (sulfur dioxide and lead)	EPA

The quantitative methods and data sources utilized in the construction of the environmental vulnerability indicator are meant to reflect the myriad ways pollution is released, dispersed, and absorbed by human-made and natural systems. Exposure to these hazardous compounds is not evenly or equitably distributed and often disproportionately occurs in socioeconomically and racially marginalized communities. Through the variables selected for this analysis, the environmental indicator utilizes variables that account for multiple vectors of pollutant exposure, namely air, water, and the built environment.

The following map illustrates the layer for the Environment Indicator.



4. Infrastructure (& Transportation)

Based on the initial list of variables and a review of the literature, we identified and tested telecommunication and transportation variables for inclusion in the PCA model. The findings of the experiment indicated that there are two distinct components corresponding to each of these dimensions. Based on this finding, we proceeded to estimate two sub-indicators corresponding to telecommunications and transportation vulnerabilities.

To construct the telecommunication and transportation subindices, we departed from the existing literature on the topic and the following digital infrastructure sources:

- Purdue University Digital Divide Index (DDI).[10]
- Sandoval, Catherine JK, and Patrick Lanthier. "Connect the Whole Community: Leadership Gaps Drive the Digital Divide and Fuel Disaster and Social Vulnerabilities." (2021).

Based on the testing of variables in the PCA model, we included the following three variables for the telecommunications subindex:

Variable	Source
percent of households without a computer	2019 5-Year American Community Survey
percent of households without internet	2019 5-Year American Community Survey
percent of households without broadband	2019 5-Year American Community Survey

For the transportation subindex, we selected the following two variables:

Variable	Source
% of HH without a vehicle	2019 5-Year American Community Survey
Intersection Density (See below for description)	2020 TIGER/line Shapefile

Intersection Density was used in the Transportation subindex as measures of network connectivity quality. The number of street intersections within an area is a well-established metric for the "interconnectedness" of a place. Both the EPA (Request for Qualifications – Building a National Dataset for Brownfield Redevelopment Evaluation (epa.gov)) and University of Texas Austin (Texas Transit Deserts (Center for Sustainable Development).pdf (utexas.edu)) utilize transit intersection counts/density as an input variable for their Transit Accessibility and Transit Desert indicators. We incorporated the lower-order street segments (S1400 as mentioned below) to measure barrio-walkability.

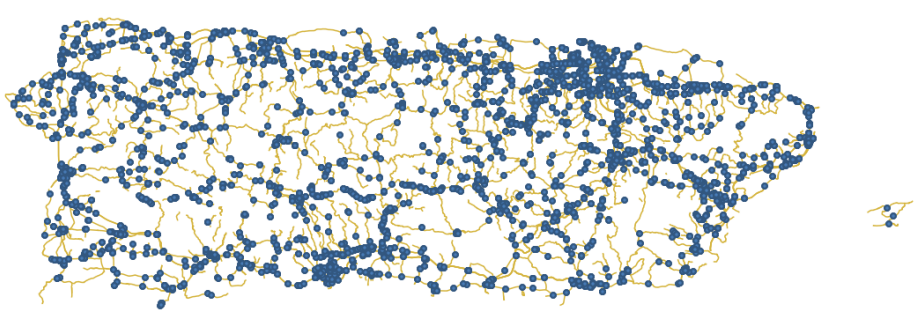
Intersection Density was calculated using the 2020 TIGER/line Shapefile as the number of intersections per square mile. Using QGIS, the number of intersections were extracted by merging TIGER line segments into continuous polylines and converting locations where the polylines intersect to points. The following road types were considered in this process:

MTFCC	Feature Class	Feature Class Description
S1100	Primary Road	Primary roads are limited-access highways that connect to other roads only at interchanges and not at at-grade intersections. This category includes Interstate highways, as well as all other highways with limited access (some of which are toll roads). Limited-access highways with only one lane in each direction, as well as those that are undivided are also included under S1100
S1200	Secondary Road	Secondary roads are main arteries that are not limited access, usually in the U.S. highway, state highway, or county highway systems. These roads have one or more lanes of traffic in each direction, may or may not be divided, and usually have at-grade intersections with

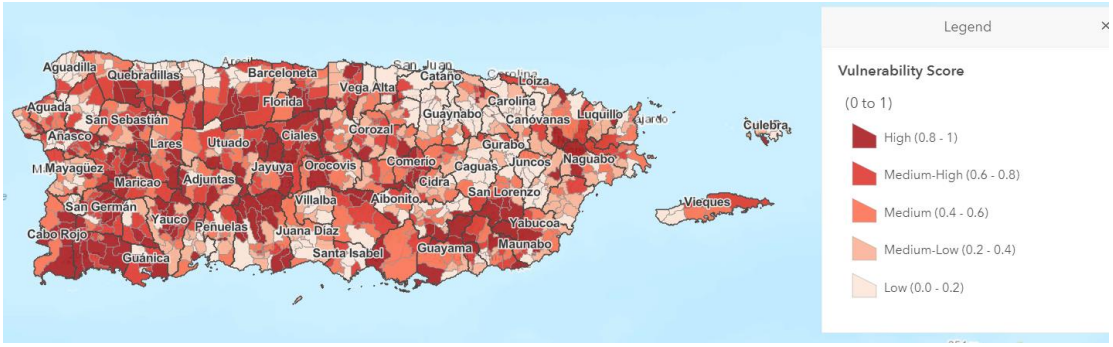
[10] Accessible via https://storymaps.arcgis.com/stories/8ad45c48ba5c43d8ad36240ff0ea0dc7

		many other roads and driveways. Secondary roads often have both a local name and a route number.
S1400	Local Neighborhood Road	A paved (privately or publicly maintained) non-arterial street, road, or byway that usually has a single lane of traffic in each direction. Scenic park roads would be included in this feature class, as would (depending on the region of the country) some unpaved roads.

Using the above road types published by the Census, the number of intersections between Primary and Secondary Road features within a barrio was calculated and ranked to generate an indicator component indicative of road network connectivity and accessibility, and thus transportation access and vulnerability. An image of the intersection analysis output can be found below.



The indicator for Infrastructure (& Transportation) is based on the sum of both sub-indicators percentiles. Then the sum of these values is aggregated into a percentile ranking values also standardized to range from 0 to 1, with higher values indicating greater telecommunication and transportation infrastructure vulnerability. The following map illustrates the resulting layer for Infrastructure (& Transportation).



5. Health

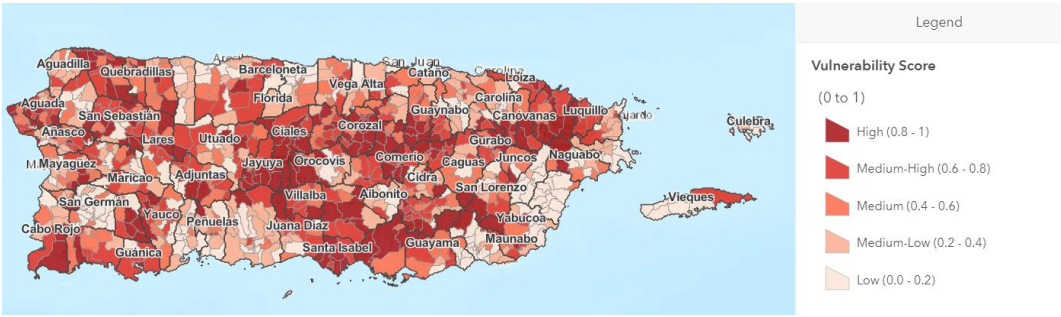
For the construction of the Health index, we examined the COVID-19 Community Vulnerability Index[11], which is available for each state, county, or census tract, but not for Puerto Rico. This index adds Themes 5 and 6 to CDC's SVI, which identify health vulnerabilities and local health infrastructure capacity: Theme 5 measures epidemiological factors, while Theme 6 is a measure of the capacity, strength, and preparedness of health infrastructure. Based on the review of the variables included in these subindices, we identified, retrieved, and tested the

[11] COVID-19 Community Vulnerability Index. https://precisionforcovid.org/ccvi

following variables from the US Census' Puerto Rico Community Survey to estimate proxy variables for the health vulnerability indicator at the barrio level. Three variables were selected, as follows:

Variable	Source
% Individuals with a disability	Puerto Rico Community Survey, 2019.
% Without insurance	Puerto Rico Community Survey, 2019.
Travel time to nearest general hospital	The travel time to nearest general hospital was determined from the centroid of each barrio using a closest facility analysis in ArcGIS Pro.

The following map illustrates the layer for the health vulnerability indicator.



6. Education

Constructing the education index posed some unique challenges given Puerto Rico's current outmigration, population decline and resulting school closure.[12] After two iterations of variable selection, data exploration, and research, we selected the following three variables:

1st Iteration Variables	Source
% Enrolled in k-12 public school **(as PER_ENR_PUBLIC)**	S1401 2019 5-Year ACS Table
Immediate college enrollment rate **(as PER_NOPOSTSEC_18_24)**	S1401 2019 5-Year ACS Table
% Without High School Diploma 25 > years of age **(as PER25_NODI)**	S1501 2019 5-Year ACS Table

Given data-completeness considerations, we made further adjustments to the indicator. **PER_NOPOSTSEC_18_24** uses total population 18 to 24 years as its denominator, and it was found that sixty-one (61 or approximately 6%) of barrios did not have people within this population group. Similarly, **PER_ENR_PUBLIC** resulted in forty-seven (47 or approx. 5%) NULL values. We explored other variables that may be suited for the education index such as postsecondary graduation rate (25+ who reached an associate degree or higher) and preschool enrollment rate as seen in the Opportunity Index (see footnote 7).

[12] Hinojosa, Jennifer, Edwin Meléndez, and Kathya Serevino Pietri. 2019. Population Decline and School Closure in Puerto Rico. New York: Center for Puerto Rican Studies.

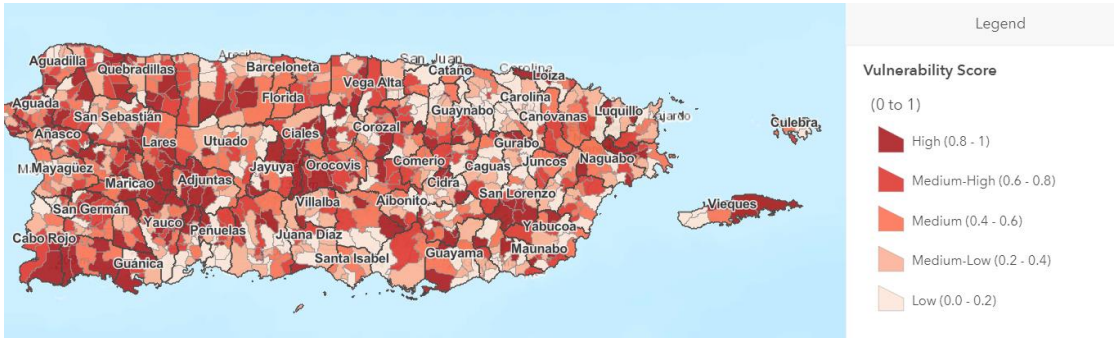
Postsecondary graduate rate was found to be highly correlated with **PER25_NODI** which implied that including it would not add any additional information to the PCA analysis and education indicator. Preschool enrollment rate presented a similar data-completeness problem as **PER_NOPOSTSEC_18_24** and **PER_ENR_PUBLIC:** Two hundred Fifty-Nine (259 or approx. 29%) of barrios did not have people within the age group of 3 to 4 years.

Attempting to rectify the data-completeness issue laid out above, we created and included the variable **% age 3 to 24 years enrolled in school** (**PER_ENR_3_24**) as a substitute for **PER_NOPOSTSEC_18_24** and **PER_ENR_PUBLIC**. Despite this change, twenty-one (21) barrios still resulted in NULL values (See Appendix C for a listing of the 21 barrios). These barrios were excluded from the ranking of **PER_ENR_3_24** variable. To compensate for this exclusion of barrios with NULL values, the **PER25_NODI** ranking were multiplied by 2 prior to creating the Education Indicator.

After adjusting for data comprehensiveness, the education index is composed of the following variables:

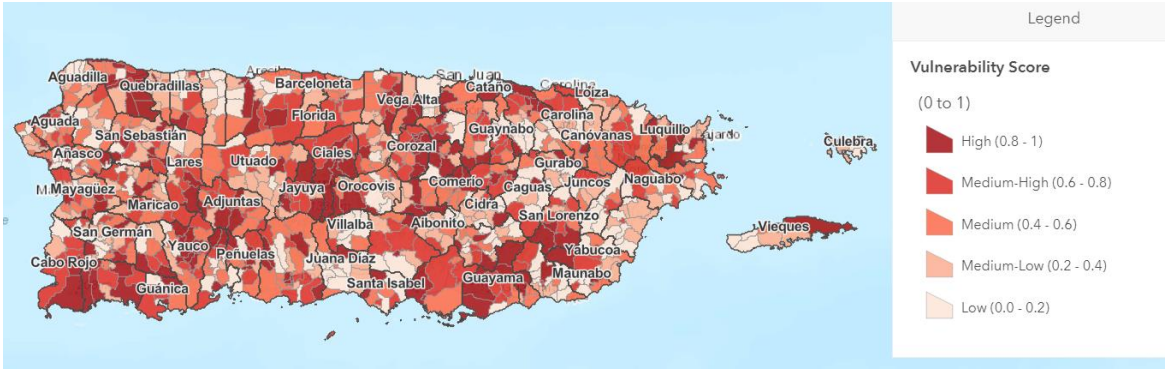
Variable	Source
% 3 to 24 years enrolled in school **(PER_ENR_3_24)**	S1401 2019 5-Year ACS Table
% Without High School Diploma 25 > years of age **(as PER25_NODI)**	S1501 2019 5-Year ACS Table

The following map illustrates the layer for the education vulnerability indicator.



Conclusions

In this document, we have presented and discussed literature, methodologies and tools used to evaluate and select variables for inclusion in six indicator categories. With the selection of these variables and the creation of the policy area indicators, we created an Overall Indicator. The Overall Indicator is based on the sum of the percentiles for six policy area indicators as described above. The sum of these values is then aggregated into a percentile ranking also standardized to range from 0 to 1, with higher values indicating greater overall vulnerability. The following map illustrates the resulting layer for the Overall Indicator.



It is evident from this map that there is great variation in the overall vulnerability of barrios across the island. Similarly, Appendix D depicts a table with the Overall Risk and Vulnerability Indicators by Municipality. Municipalities are ranked from high to low vulnerability. It is evident that there is great variation in the components of vulnerabilities affecting municipalities.

In sum, the RVI assists communities in determining their unique needs based on empirical data illustrating the sources of vulnerability. The analysis of the sources of community vulnerabilities, in turn, helps communities set long-term goals and short-term objectives as part of the development of comprehensive community resilience plans (CRPs). These plans serve to devise programs and activities to meet communities' goals and objectives, evaluate the progress of such programs and carry out management, coordination, and monitoring of activities necessary for effective planning collaboratively and effectively. It all begins with a thorough understanding of specific community vulnerabilities in the six policy core areas of concern (economic development, education, environment, health, housing, and infrastructure). The Risk and Vulnerability Indicators (RVI) Dashboard is created to support post disaster community planning and development.

Appendix A: Variables considered for aggregate risk and vulnerability indicators

Note: Highlighted indicators are those both organizations (FPR, HC) originally, before testing, agreed upon for consideration and testing. Additional variables for consideration identified through the review of the literature are included in the "HC Team" column.

1. Housing

FPR	HC Team
• Vacancy rate (Vacancy/Housing Units) • Year Structure Built (% < 1991) • Gross Rent as Percentage of Income (burden if > 30%; severe if > 50%) • Housing Assistance (% housing units)	• Gross Rent as Percentage of Income (burden if > 30%) • Crowding: persons in unit > rooms 2
Others: • Crowding: persons in unit > rooms 2 • Proxy for % units w/o titles	

2. Economic Development & Socioeconomic Vulnerabilities

FPR	HC Team
• Single Parent HH, • Per Capita Income • % Public Assistance Economic development: • Income per capita • Pop with income from public assistance Socioeconomic vulnerabilities: • Pop below poverty threshold • Households with a woman as HOH • Vulnerable populations (children, elderly, disabilities) • Crime rates • Race • Citizenship	• Public Assistance (% population) • Income per Capita • % unemployed • Employment Status for Pop Over 16) [MR: Could participation rate be used in lieu of unemployment rate?] • % below poverty threshold (Poverty Status in the Past 12 Months)
Others: • % Out of school/work youth 18 to 25 years of age • % Single-Parent Households	

3. Environment & Natural Hazards

FPR	HC Team
Environment: • TRI • Impaired Bodies of Water (Flood Hazard Zones 100, 500 floodplains) • Inventory of Municipal Landfills and Open Dumps PR, Solid Waste Facilities • Natural reserves Natural hazards: • Flooding • Landslides • Sea-level rise • Droughts For testing: • Air Quality Index Values Report • Disaster Debris Tool • Recycling Rates by Municipality • Surface Water Quality Results Per Municipality • Toxic Release inventory Others: • Superfund Sites • Tropical Storms • Seismic Hazards (earthquake) • Wastewater Treatment Plants • Community aqueducts	• Impaired bodies of water (EPA 303(d) and 305(b) impaired bodies of water under CWA) • TRI facility • Inventory of Municipal Landfills and Open Dumps PR, Solid Waste Facilities Others: • NPL (National Priority List) Sites • RMP (Risk Management Plan) Sites • Lead Paint Indicator (% of homes built before 1961) • NAAQs non-attainment zones (sulfur dioxide and lead)

4. Infrastructure (& Transportation)

FPR	HC Team
Utilities: • PRASA infrastructure • Community aqueducts • PREPA infrastructure • Alternate energy hubs Transportation: • Pop dependent on public transportation Telecommunications: • % pop with internet access Others: • Wi-fi Públicos • Means of Transportation to Work (% No Vehicle) • Travel Time to Work • % broadband (Presence of Computer and Types of Internet for Household • % HH with at least one computer (Presence of A Computer and Type of Internet)	- % of HH without a computer - % of HH without internet - % of HH without broadband Transportation vulnerability: • Means of Transportation to Work (% No Vehicle) • Travel Time to Work

5. Health

FPR	HC Team
• Pop with health insurance (with or without sufficient coverage) • Pop affiliated to Plan Vital (ASES) • Pop receiving Medicaid, CHIP, State benefits • Access to medical facilities • Access to medical providers Others: • % Civilian with a Disability • high risk populations as elderly adults and individuals with underlying conditions including respiratory conditions, heart conditions, obesity, diabetes, and conditions related to immunodeficiency. • Influenza and pneumonia death rates and population density • Hospital beds • Density of doctors/population For testing: • Health insurance Coverage by Age • Cuidado Prenatal y Nacimientos Bajo Peso • Inmunizaciones y Vacunas • Llamadas PAS, Sobredosis, Suicidios • Medicaid, CHIP, State Health Insurance • Mortalidad Cinco Primeras Causas de Muerte • Mortalidad Materna	• % persons with disabilities • % persons without health insurance • Travel Time to nearest General Hospital

6. Education

FPR	HC Team
Education: • Public schools • School enrollment • Pop with/without HS diploma For testing: • Postsecundary institutions • Private Schools • Public Schools • Technical or Vocational Institutions Others: • Educational Attainment for Pop 25 years and over (% No High School Diploma 25 > years of age) • School Enrollment (% Pop 3 Years and Over < 25 years) • FAFSA Submission (% of population in college)	% Enrolled in public school (as PER25_NODI) Immediate college enrollment rate (as PER_NOPOSTSEC_18_24) % Without High School Diploma 25 > years of age (as PER_ENR_PUBLIC)

Appendix B: NULL Barrios

Below is the list of the fourteen (14) county subdivisions (barrios) identified as not having a presence of structures (houses, communities, buildings), thus identified with NULLs as a value by the GIS app. Based on a visual inspection using aerial images from Google maps, we categorized these areas as rural areas, natural reserves, forests, and former military sites as follows.

	NAME	GEOID	Description
1	Añasco Abajo barrio, Añasco	7201102723	Rural area
2	Guayacán barrio, Ceiba	7203732178	Roosevelt Roads Military base area
3	Torrecilla Alta barrio, Loíza	7208783090	Natural Reserve
4	Mameyal barrio, Dorado	7205149808	Rural area
5	Cedro barrio, Guayanilla	7205915795	Rural area/Natural Reserve
6	Santa Rosa barrio, Utuado	7214179134	Rural area - part of National Forest Rio Abajo
7	Cambalache barrio, Arecibo	7201311323	Rural area/Wetlands - Rio Grande de Arecibo
8	Punta Arenas barrio, Vieques	7214766148	Natural Reserve
9	Llave barrio, Vieques	7214746196	Rural area
10	Arena barrio, Guánica	7205503454	Rural area
11	Mosquito barrio, Vieques	7214755312	Natural Reserve
12	San Isidro barrio, Culebra	7204976382	Rural area
13	Isla de Mona e Islote Monito barrio, Mayagüez	7209736650	Natural Reserve
14	Emajagual barrio, Juana Díaz	7207526588	Rural area

Appendix C: Barrios returning NULL values for PER_ENR_3_24 variable

The 21 barrios below do not contain anyone in the age group 3 to 24 years old. Dividing by 0 led to NULL values.

1	7201114978	Casey Abajo barrio, Añasco Municipio, Puerto Rico
2	7210719364	Collores barrio, Orocovis Municipio, Puerto Rico
3	7214145594	Limón barrio, Utuado Municipio, Puerto Rico
4	7203561676	Piedras barrio, Cayey Municipio, Puerto Rico
5	7203560644	Pedro Avila barrio, Cayey Municipio, Puerto Rico
6	7203537854	Jájome Alto barrio, Cayey Municipio, Puerto Rico
7	7207338198	Jauca barrio, Jayuya Municipio, Puerto Rico
8	7214170018	Río Abajo barrio, Utuado Municipio, Puerto Rico
9	7215301777	Algarrobo barrio, Yauco Municipio, Puerto Rico
10	7215372684	Rubias barrio, Yauco Municipio, Puerto Rico
11	7200755527	Mulita barrio, Aguas Buenas Municipio, Puerto Rico
12	7206707453	Benavente barrio, Hormigueros Municipio, Puerto Rico
13	7209749378	Malezas barrio, Mayagüez Municipio, Puerto Rico
14	7208366621	Purísima Concepción barrio, Las Marías Municipio, Puerto Rico
15	7211122460	Cuebas barrio, Peñuelas Municipio, Puerto Rico
16	7210924481	Egozcue barrio, Patillas Municipio, Puerto Rico
17	7203522761	Culebras Bajo barrio, Cayey Municipio, Puerto Rico
18	7204929426	Fraile barrio, Culebra Municipio, Puerto Rico
19	7203541638	Lapa barrio, Cayey Municipio, Puerto Rico
20	7214517988	Cibuco barrio, Vega Baja Municipio, Puerto Rico
21	7209308872	Bucarabones barrio, Maricao Municipio, Puerto Rico

Appendix D: Overall Risk and Vulnerability Indicators by Municipality and Ranking

County	Economic_Index	Education_Index	Environmental_Index	Health_Index	Housing_Index	Infrastructure_Index	Overall_Index	Overall_Index
Catano	0.954	0.626	0.953	0.459	0.883	0.589	0.923	High
Guayama	0.897	0.400	0.687	0.567	0.679	0.586	0.761	High
Ciales	0.817	0.617	0.445	0.764	0.428	0.684	0.746	High
Corozal	0.675	0.556	0.472	0.806	0.605	0.554	0.735	High
Isabela	0.696	0.651	0.472	0.742	0.521	0.570	0.722	High
Salinas	0.380	0.398	0.874	0.741	0.640	0.578	0.721	High
Lajas	0.408	0.732	0.558	0.526	0.491	0.836	0.697	High
Naranjito	0.516	0.562	0.688	0.792	0.477	0.584	0.690	High
Barranquitas	0.827	0.526	0.435	0.659	0.592	0.572	0.687	High
Adjuntas	0.799	0.615	0.461	0.561	0.496	0.592	0.682	High
Luquillo	0.431	0.548	0.584	0.721	0.711	0.472	0.677	High
San Lorenzo	0.751	0.568	0.671	0.472	0.386	0.655	0.674	High
Jayuya	0.529	0.528	0.433	0.834	0.491	0.640	0.660	High
Arroyo	0.933	0.408	0.578	0.165	0.843	0.492	0.655	High
Cabo Rojo	0.533	0.551	0.663	0.433	0.480	0.744	0.654	High
Toa Baja	0.531	0.371	0.846	0.407	0.759	0.501	0.651	High-Med
Aguas Buenas	0.399	0.612	0.616	0.812	0.419	0.503	0.643	High-Med
Sabana Grande	0.483	0.674	0.385	0.693	0.608	0.617	0.641	High-Med
Yauco	0.400	0.607	0.539	0.537	0.652	0.628	0.640	High-Med
Guanica	0.473	0.560	0.340	0.667	0.641	0.658	0.638	High-Med
Vega Alta	0.802	0.644	0.395	0.386	0.654	0.492	0.623	High-Med
San Sebastian	0.564	0.556	0.345	0.661	0.575	0.688	0.618	High-Med
Vega Baja	0.569	0.538	0.515	0.435	0.614	0.632	0.604	High-Med
Comerio	0.311	0.461	0.412	0.727	0.564	0.778	0.599	High-Med
San Juan	0.592	0.304	0.857	0.331	0.813	0.413	0.596	High-Med
Toa Alta	0.671	0.448	0.673	0.594	0.480	0.398	0.588	High-Med
Ponce	0.797	0.500	0.507	0.292	0.554	0.582	0.587	High-Med
Bayamon	0.541	0.464	0.727	0.721	0.598	0.196	0.586	High-Med
Penuelas	0.856	0.415	0.685	0.382	0.485	0.423	0.584	High-Med
Rio Grande	0.416	0.443	0.377	0.831	0.614	0.489	0.575	High-Med
Manati	0.411	0.594	0.511	0.287	0.679	0.695	0.554	High-Med
Coamo	0.351	0.447	0.555	0.717	0.434	0.648	0.546	Medium
Maricao	0.293	0.673	0.470	0.360	0.553	0.733	0.535	Medium
Aguada	0.472	0.557	0.313	0.643	0.641	0.447	0.524	Medium
Guaynabo	0.586	0.429	0.645	0.583	0.581	0.211	0.521	Medium
Guayanilla	0.916	0.440	0.567	0.168	0.539	0.438	0.519	Medium
Lares	0.415	0.650	0.417	0.576	0.388	0.605	0.518	Medium
Mayaguez	0.436	0.484	0.606	0.485	0.620	0.406	0.514	Medium
Arecibo	0.408	0.484	0.730	0.444	0.423	0.546	0.508	Medium
Morovis	0.694	0.494	0.380	0.697	0.248	0.453	0.488	Medium
Santa Isabel	0.394	0.291	0.572	0.873	0.442	0.363	0.488	Medium
Loiza	0.372	0.471	0.323	0.697	0.572	0.473	0.470	Medium
Orocovis	0.487	0.723	0.253	0.537	0.279	0.614	0.469	Medium
Florida	0.319	0.595	0.940	0.320	0.246	0.465	0.452	Medium
Camuy	0.483	0.673	0.263	0.549	0.366	0.488	0.447	Medium
Rincon	0.388	0.585	0.138	0.701	0.562	0.542	0.442	Medium
Quebradillas	0.790	0.489	0.339	0.534	0.388	0.435	0.439	Medium
Utuado	0.280	0.437	0.447	0.465	0.518	0.615	0.424	Low-Med
Anasco	0.349	0.515	0.271	0.566	0.526	0.508	0.417	Low-Med
Caguas	0.483	0.382	0.675	0.482	0.420	0.276	0.413	Low-Med
San German	0.400	0.534	0.449	0.111	0.520	0.740	0.413	Low-Med
Carolina	0.763	0.216	0.696	0.471	0.460	0.166	0.412	Low-Med
Ceiba	0.217	0.579	0.575	0.199	0.676	0.455	0.410	Low-Med
Vieques	0.123	0.742	0.437	0.204	0.706	0.557	0.408	Low-Med
Yabucoa	0.544	0.483	0.440	0.318	0.391	0.550	0.400	Low-Med
Juncos	0.356	0.507	0.637	0.577	0.415	0.207	0.393	Low-Med
Aibonito	0.629	0.428	0.644	0.288	0.296	0.443	0.393	Low-Med
Naguabo	0.260	0.484	0.679	0.397	0.472	0.403	0.390	Low-Med
Las Marias	0.214	0.578	0.278	0.364	0.464	0.730	0.389	Low-Med
Canovanas	0.490	0.444	0.482	0.623	0.348	0.263	0.379	Low-Med
Maunabo	0.206	0.496	0.390	0.559	0.475	0.535	0.372	Low-Med
Fajardo	0.398	0.340	0.567	0.373	0.575	0.324	0.366	Low-Med
Cayey	0.353	0.436	0.482	0.635	0.289	0.379	0.364	Low-Med
Gurabo	0.399	0.454	0.580	0.666	0.361	0.227	0.360	Low
Cidra	0.315	0.446	0.535	0.434	0.446	0.437	0.354	Low
Moca	0.486	0.605	0.439	0.314	0.304	0.358	0.340	Low
Juana Diaz	0.378	0.394	0.523	0.551	0.336	0.298	0.339	Low
Hormigueros	0.470	0.257	0.570	0.420	0.557	0.201	0.313	Low
Trujillo Alto	0.370	0.154	0.574	0.607	0.484	0.251	0.309	Low
Patillas	0.303	0.405	0.387	0.250	0.462	0.569	0.306	Low
Barceloneta	0.414	0.401	0.526	0.377	0.362	0.402	0.303	Low
Aguadilla	0.455	0.429	0.483	0.353	0.426	0.289	0.303	Low
Villalba	0.444	0.426	0.274	0.738	0.177	0.271	0.278	Low
Culebra	0.199	0.484	0.354	0.137	0.413	0.530	0.248	Low
Las Piedras	0.338	0.395	0.522	0.157	0.355	0.320	0.247	Low
Dorado	0.252	0.270	0.444	0.410	0.501	0.445	0.241	Low
Humacao	0.408	0.436	0.436	0.083	0.545	0.292	0.219	Low
Hatillo	0.425	0.564	0.141	0.242	0.263	0.395	0.199	Low