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## Abstract

This investigative project proposes a tax collection model based on a property value homogeneous area using the U.S. Census block group as the base region for residential tax type. Geospatial technology was used to compare market value sales with owner-occupied dwellings Census data applying geostatistics, spatial join visualization, and spatial distribution. The developed model uses the Census block group as geographic region with the market property sales as baseline for current fiscal economy. A sample of 288 records of 5,614, for years 2013 – 2018, was set aside to calculate the Root Mean Square Error after comparing each set of data. This model confers an improvement in out-of-sample prediction accuracy of up to 5% proving that market value sales resembles current fiscal economy reality.

## Introduction

Applying geospatial science through a Geographic Information System (GIS) software is undoubtedly useful on mapping, displaying patterns, and detecting deficiencies any property tax system may have [1]. In the last decade, high-rise housing developments proliferation targeting high purchasing power sectors have gained most of the market scenario in San Juan. Newer housing developments are capitalized for high income individuals leaving the lower- and middle-class group looking for property locations out of the San Juan Metropolitan Area where housing sales price are more suitable to their income [2].

## Background

The formula used to calculate property taxes in Puerto Rico does not come from what is commonly known as real-estate appraisals based on current market values, but rather on property values dating back to 1957. There is a need to bring up-to-date property value in Puerto Rico, as appraised by the local agency in charge. Market appraised properties use the comparable method to assign value. The comparable method of appraisal presents a realistic and applicable method to the development of the model applied in this investigation [3]. Property development in Puerto Rico shows scatter pattern for value. This scatter behavior could be corrected by using the U.S. Census Block Groups (BG). A BG generally contain between 600 and 5,000 people, and usually covers a contiguous area but never crosses county or census tract boundaries. San Juan is the area of interest of this investigation.



Figure 1  
78 Municipalities of Puerto Rico

## Problem

Municipal governments are collecting property revenues based of a formula from 1957. The formula used to calculate the property taxes does not comes from what is commonly known as real-estate appraisals based on current market values, but rather on property values dating back to 1957. This scenario presents an outdated methodology [4].

## Methodology

Market values from Comparable layer, and U.S. Census owner-occupied property value layer were deflated using the Consumer Product Index (CPI) from 2013 – 2018 to reflect the changes in the economy, to make a valid comparison. After values were adjusted on each appropriate layer, the exploratory techniques began (Table 1).

Table 1  
Exploratory Techniques for Geospatial Data

Data Preparation	<ul style="list-style-type: none"> <li>Census Tiger BG shapefile → Clip tool → input: San Juan Municipality</li> <li>Census BG → Project → output: NAD 83</li> <li>Parcel map → Join → Market Value Sales</li> <li>Deflate Market Value Sales (every year) → Calculate Field → output: expression</li> <li>Get a sample from Market Value Sales → Python_9.3 Code Block: import random def rand(): return random.random(), Exprt → output: new layer</li> <li>Deflate Census Median Average (every year) → Calculate Field → output: expression</li> <li>Calculate average for Median Sale Category per BG → Calculate Field → output: expression</li> </ul>
Spatial Distribution Visualization	<ul style="list-style-type: none"> <li>Aggregate features based on BG</li> <li>Market Value → Dissolve &gt; optional statistics field &gt; MEAN → output: new layer</li> </ul>

The Root Mean Square Error (RMSE) was obtained by simply subtracting one set of values from the other in Excel, and applying the square mean root to all records operations (Table 2).

Table 2  
RMSE Calculation for Sample vs Market Value & Sample vs Census Median

Sample vs Market Value	Sample vs Census Median
\$112,150.21	\$263,753.05

## Results and Discussion

The geovisualization process discovered and punctuated on the initial assumption: market value sales are closer to reality and tax type can be applied using the Census BG as homogeneous zone. The RMSE value closest to the sample corresponds to the calculation between Sample and Market Value: \$112,150.20. RMSE quantified how much different census median is to residential properties real estate value. All datasets were divided into five classes for property value [3] were used: less than \$155,000, between \$155,000 and \$200,000, between \$200,000 and \$250,000, between \$250,000 and \$300,000, and greater than \$300,000.

## Results and Discussion (cont.)

The sample taken aside from the rest of the data (Figure 2) displays the market value and was exported for comparison. A margin of error of 5% and a confidence level of 95% provided a sample size of 288 records from a universe of 5614. This sample will served as reference for each dataset; the value closes to the sample is the closest to reality.

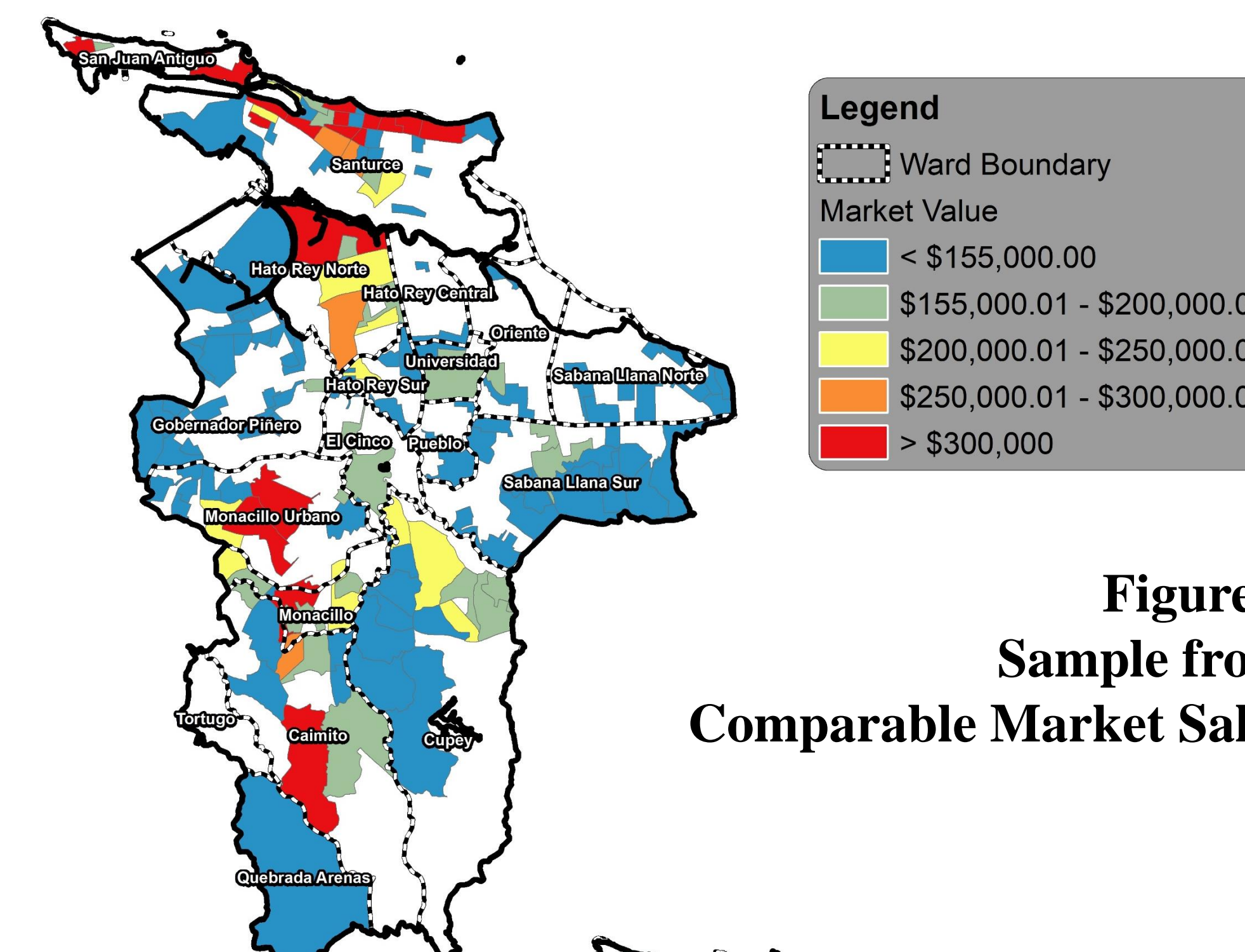


Figure 2  
Sample from Comparable Market Sales

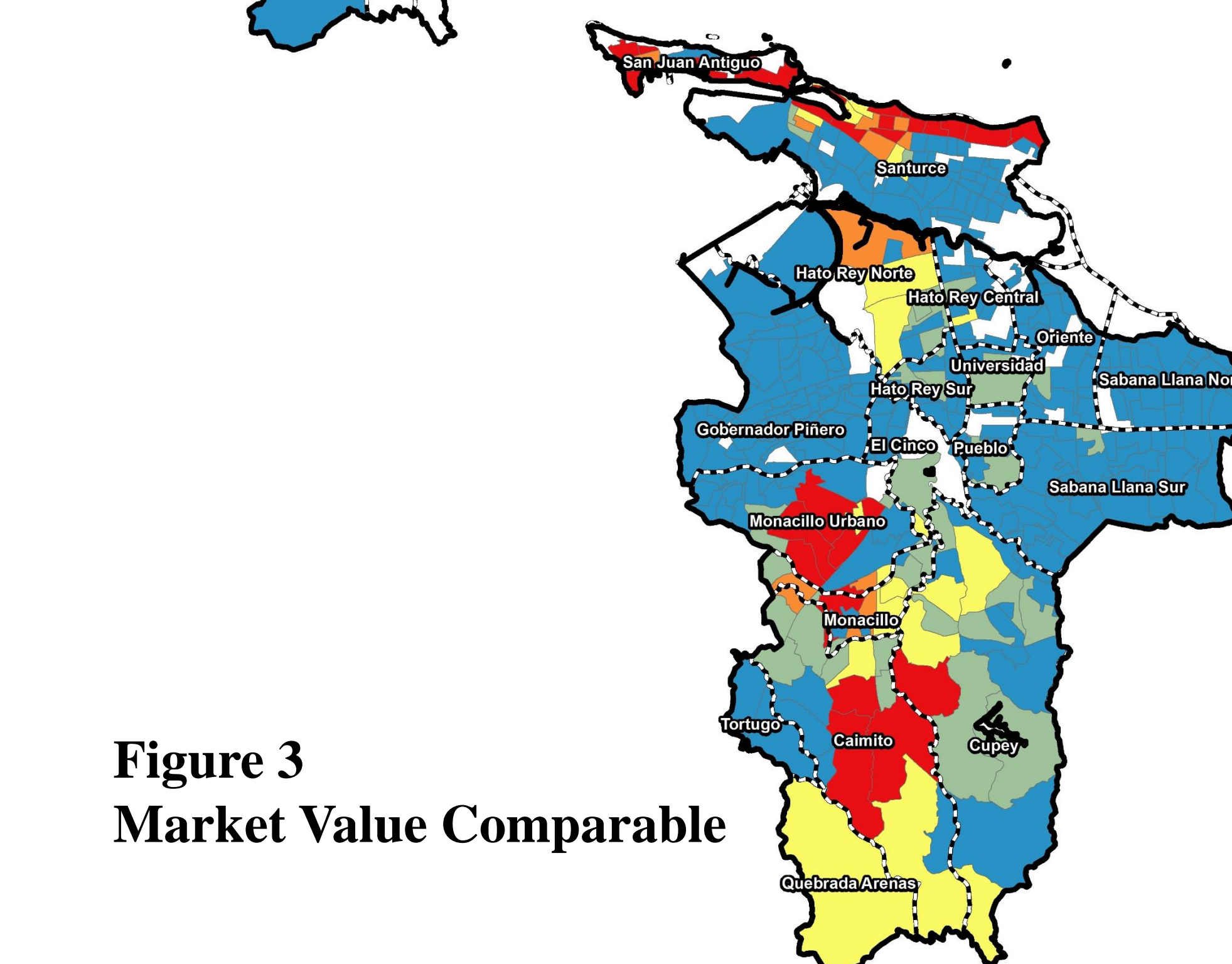


Figure 3  
Market Value Comparable

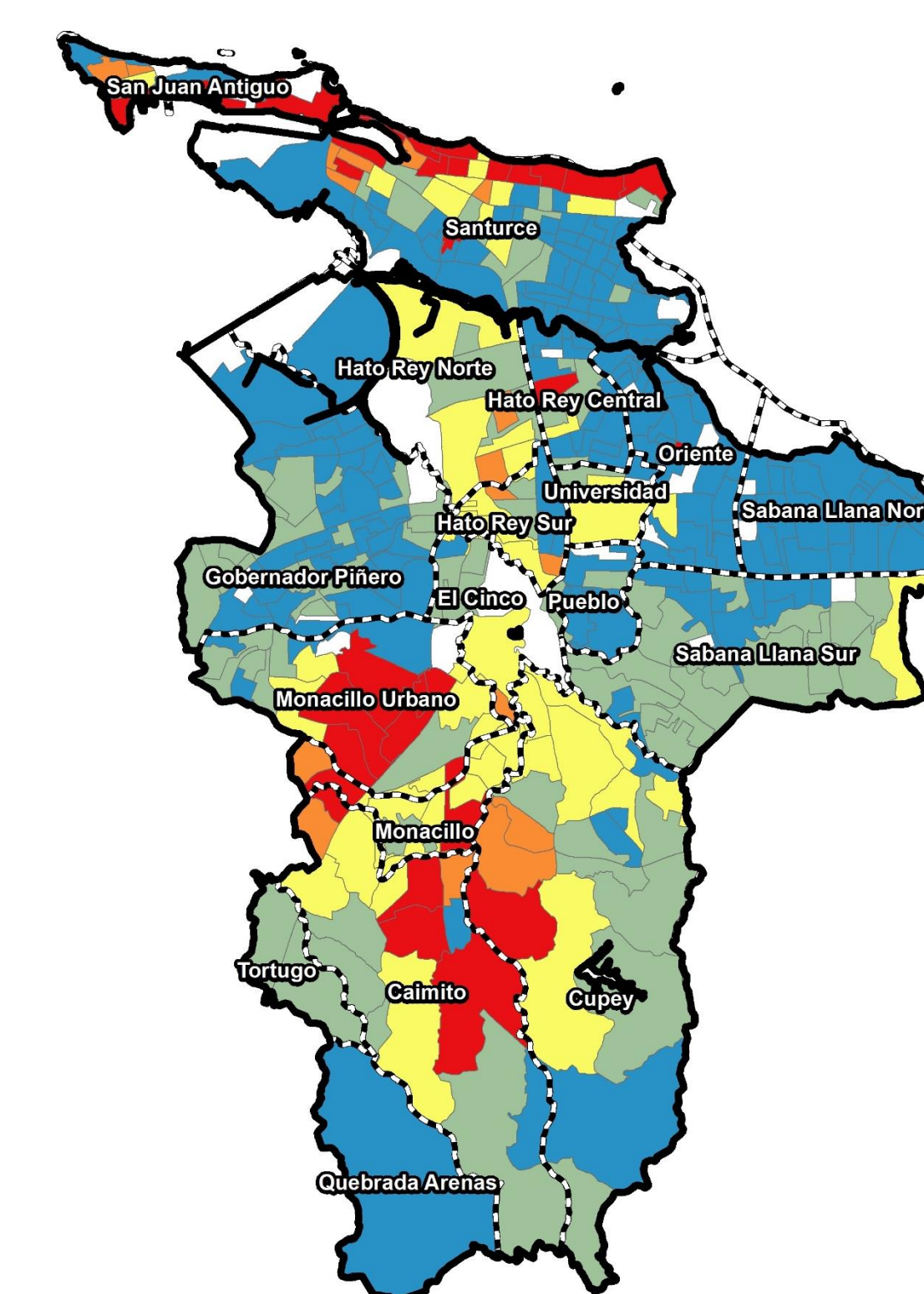


Figure 4  
Median Census

## Results and Discussion (cont.)



Figure 5  
Aerial Photograph with geospatial analysis result layer. Average property value sums show the difference.

## Conclusions

This investigation concludes that a homogeneous zone for tax type and real estate is suitable to bring up-to-date revenue from residential property sales. An institutional region exists within the U.S. Census and it is used for gathering owner-occupied information regarding the housing sales price. Although median value proved to be far from residential property value reality, the geographic region serves its purpose for classification of tax type. Market sales data provided clarity as of what patterns housing development are following, the block group gathers inhabitants per unit. Geospatially speaking, “The key to developing an accurate land-value assessment roll is the process of land-value mapping.” (Oliver Oldman, Harvard Law School). [4] Mapping homogeneous zones and passing Public Policy over this investigations model, is a step forward in bringing up-to-date municipal finances.

## Future Work

Planned development is critical in an economy of uncertainty. The alternative presented in this investigation should be evaluated at depth including other factors not approached, like CRIM tax formula and home improvements.

## Acknowledgements

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## References

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