

Paper 5205-2020

Economic Impacts of Sea Level Rise on Coastal Real Estate

Austin Willoughby, Emma Delehanty, and Victoria Mullin
University of North Carolina at Wilmington

ABSTRACT

As a result of the industrialized global economy, an increase of carbon and methane gas concentrations in the atmosphere has contributed to an overall warming climate, and in turn, global sea level rise. Such a change has vast implications for coastal communities. This study models the potential loss of value coastal properties in New Hanover County, North Carolina will experience due to sea level rise. The methods used were linear regression to predict the future value of properties in addition to methods used in ArcGIS in order to find the parcels affected by different increments of sea level rise. This analysis could be used to inform coastal residents on the potential loss in value of their property and what to expect in future years.

INTRODUCTION

Due to increasing concentrations of carbon dioxide and methane gases in the atmosphere, average global sea level has increased three inches in the last 25 years ("Global Greenhouse"). Appendix A visualizes this rapid increase in sea level and displays future projection. The three primary factors are thermal expansion, melting glaciers, and the loss of Greenland and Antarctica's ice sheets. The main risks resulting from a rising sea level are shoreline erosion and degradation, amplified storm surge, permanent land inundation, and saltwater intrusion. Shoreline erosion can occur since rising seas cause waves to push further inland, even during calm conditions. The effects of storms will be amplified as storm drains are unable to drain into the ocean because the sea water will be flooding up into them. The water table will also rise, and between the higher water table and ineffective drainage systems permanent inundation or chronic flooding will occur. Saltwater intrusion may also occur leading to contamination of water supplies and damage to local agricultural. All these risks add up to loss of property, property damage, and an increase in insurance rates.

PROBLEM

This project investigates the monetary impact of sea level rise on coast real estate in New Hanover County. The first objective is to identify and quantify the monetary value of real estate within New Hanover County that will experience increased flood risks as sea level rises. The next objective is to find the potential loss in monetary value of these properties for different increments of sea level change. The final objective of this project is to calculate the difference in property value predictions with and without sea level rise. All results will be grouped by zip code and then displayed on an interactive map in which any zip code in New Hanover County can be clicked on and the number of homes affected and the total value at risk will be shown.

METHODS

DATA COLLECTION

Flood zone and geographical data were collected from USGS and NOAA, property data from New Hanover County tax department and Zillow, and sea level projections data were collected from IPCC. Lastly, USGS data was used to compare the results of this project to see if they are similar.

From the Zillow dataset, the variables used were Zillow home value index (ZHVI), date, and zip code. The Zillow home value index is the median of estimate and actual home values from a given geographic area at a given time. From the New Hanover County tax parcel dataset, the variables used were the appraised total value, parcel ID, neighborhood, street, zip code, elevation, and acreage. Finally, with projection of sea level rise from NOAA, ArcGIS was used to determine which parcels in New Hanover County would be affected by a one and two-foot increase in sea level. Affected parcels were identified by geographically merging the NOAA sea level rise database with the tax parcel database. This created two new databases which include parcels that will reside within the NOAA's estimate of future coastal boundaries. These sea level elevation projections were then tied to a temporal scale by associating them with the IPCC's model for future sea level rise. According to IPCC, in the high scenario, one foot of sea level rise is projected to occur around 2060 and a two-foot rise is projected to occur around 2100 (Church et al.).

DATA CLEANING AND VALIDATION

The first step in the data cleaning process was determining how to handle missing values in variables needed to make predictions. There were many missing values for the appraised total value in the New Hanover County (NHC) tax parcel dataset. In order to estimate these missing values, the median appraised total value by neighborhood was calculated as a substitute. There were still some missing values for records that also had a missing neighborhood. In these cases, the median appraised total value by street was used in order to fill in the remaining missing values. The tax parcel dataset was also missing the zip code of each property. ArcGIS was used in order to find the zip code for each parcel which was then exported as a new dataset and merged with the tax dataset. Finally, the Zillow data does not include information on the zip code 28480 which contains Wrightsville Beach and thus regression and ARIMA models could not be generated. In order to avoid data gaps, the regression and ARIMA models from the Carolina Beach zip code with real estate considered similar to that of Wrightsville Beach was fit to 28480's present day values. ArcGIS was also used to merge databases based on geospatial attributes, which isolated parcels affected by given increment of sea level rise and used the intersect functions to effectively combine flood data with tax parcel data.

To find what properties would be affected by the different increments of sea level rise, the tax parcel dataset was merged with the two ArcGIS datasets: one included the parcels that would be affected by one-foot increase in sea level and the other included parcels that would be affected by a two-feet rise in sea level. The Zillow data set originally had the zip code as the rows and the date as the columns. This was transposed so that zip code, date, and ZHVI were the columns, putting it in a form for building a model, where ZHVI is the response variable and zip code and date are the predictors.

ANALYSIS

There are several assumptions in this analysis, the first being that properties in proximity have similar values, since the missing appraised total values were estimated by finding the median value of nearby properties. Another assumption is that the tax data and Zillow data are accurate since both were used to make the predictions. A final assumption, as stated earlier, is that the number of homes and value of homes in Carolina beach are similar enough to Wrightsville that the data from Carolina beach can be used as a substitute for the

missing Wrightsville beach data.

The real estate value projection effort required two datasets because the New Hanover Tax data only contained present day values, making a model fit over time impossible. The Zillow dataset offered valuation data from the past 20 years and could be used to create the linear regression and ARIMA models with value and time variables. To model property valuation with linear models, proc glm was used to create a linear regression model for each zip code. Each regression line was then applied to the New Hanover County Tax valuation data in order to project real estate valuations from present day values. These regressions were then used as a baseline for future real estate valuations without sea level rise. Depreciation due to sea level rise was then determined based off which parcels were inundated with sea water. Parcel valuation upon permanent sea level inundation was assumed to be zero (Bernstein et. al, 2018). This value lost was then summed up for each zip code, and subtracted from the linear regression model to obtain an adjusted model accounting for sea level rise.

To estimate future property valuation with ARIMA models, proc arima was used with the Zillow dataset to create a time series forecast model. Due to the cyclical nature of the real-estate market and the large time horizon involved in this model, a model emphasizing the moving average was generated. Once created the ARIMA model was applied to the New Hanover County Tax valuation data in order to project real estate valuations from present day values. Upon viewing the results, it was determined that the ARIMA model likely overestimated future property valuations. Due to this model error, no adjusted model accounting for parcel depreciation was created, as results would not be accurate.

RESULTS AND VISUALIZATIONS

When assessing the adjusted linear regression model, the zip codes with the greatest value at risk are 28409 and 28411, or Myrtle Grove and Figure Eight Island areas respectively. The zip code with the lowest value at risk is Kure Beach, which although is a coastal zip code, has a significantly higher elevation compared to others in the area. These homes are thus less susceptible to flooding and have a lower risk of depreciation. The zip codes with the greatest number of homes at risk are all the coastal zip codes except for Kure Beach. Wrightsville Beach and Carolina Beach have more homes at risk than inland zip codes, but Figure Eight Island area and Masonboro Area have the most homes at risk.

The ARIMA regression models generated are visualized in Appendix G. The models were determined to greatly overestimate likely future mean home values for each zip code. This overestimation can be observed in Appendix G, where mean property values in most zip codes are often over \$14million in 2100.

Choropleth maps were created to visualize the results. The MAPIMPORT procedure was used to import the shapefile data of NHC in order to generate choropleth areas and draw outlines of the NHC zip code areas. Also using the SGMAP procedure, the choropleth areas have filled colors based on numeric or character response variables of zip code and value at risk. Refer to Appendix D for a bar chart of the total value at risk for each zip code for both increments of sea level rise, one-foot and two-feet.

Refer to Appendix B for the map of the number of homes at risk for each zip code in which the sea level rose 2 feet. Each block represents numbers of houses at risk in an individual zip code. Along the coast, the numbers are much higher than of inland areas. A bar chart of these results for both scenarios can also be seen in Appendix C. By showing how data collected over time changes and transitions, USGS predictions were used to make animated bar charts of the value at risk within each zip code.

FUTURE STUDIES

The efforts described above describe the state of this study's analysis at the time of writing; however, additional techniques will be implemented. SAS® offers a SAS-Esri Bridge package which is capable of more efficiently exchanging data between ArcGIS and SAS. This package will be implemented in time for the SAS Student Symposium.

Aside from strictly economic impacts, additional efforts will be made to quantify the human aspects of sea level rise. In particular, the future displacement of people and homes will be estimated.

The limitations of this study offer many opportunities for future study that are out of the current scope. Of note, flood zone classifications can affect the valuation of real estate; however future flood zones could not be estimated. Further research is needed to determine the change in flood zone delineations with sea levels rise. This study initially attempted to estimate future flood zone delineations based off elevation and topology data; however, current conditions could not be accurately estimated. The takeaway from the effort was that flood zone delineation acted differently with different coastal flood sources (e.g. coastal river channels, intracoastal channels, and oceans). This intuitively makes sense when considering that storm surges would flood more aggressively in areas receiving coastal flood water from an open ocean, verses a flood surge from a coastal river.

To account for this natural geographical variance, in depth statistical analysis of present-day flood zones are needed to determine just how a flood zone will be delineated based on its hydrologic source. With such an analysis, future flood zone delineations could be accounted for, and monetary real estate depreciation based off of 100 and 500 year flood zones could be accounted for.

In addition to the need for more accurate future flood zone delineation, more accurate monetary depreciation estimates are needed for inundated parcels. More accurate depreciation values could be determined with fixed floor elevation data for each structure on a parcel. Such data would allow one to determine if the structure itself is inundated, giving insight into the full depreciation. For instance, if a structure's fixed floor is raised to account for flooding, the structure may depreciate less quickly than non-raised structures.

Our current model assumes other criteria which would affect flooding in coastal areas are fixed. Such simplicity will likely not be the case in real world events. Variables such as rainfall, storm surge intensity, and coastal infrastructure could all affect the impact of sea level rise on coastal real estate and may all be subject to change over such large timescales. These variable changes are outside the scope of this study; however, further research into their respective changes would assist in the development of future real estate models.

CONCLUSION

This study provides an estimate of the potential economic cost sea level rise will have on real estate in New Hanover County, North Carolina, purely due to coastal inundation. Results indicate that highly impacted areas are generally closer to coastal waters and are conservative because they do not include the depreciative effect expanding flood zones would have on real estate. These calculated costs could be used as a guidance for local policymakers and municipalities in their efforts to mitigate the localized effects of sea level rise. In particular, this measurement of impact over time gives local governments the opportunity to invest, plan, and implement new policies and infrastructure that will mitigate damage from seawater inundation.

REFERENCES

Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer and A.S. Unnikrishnan, 2013: Sea Level Change. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

(Bernstein et. al, 2018)

Bernstein, A., Gustafson, M., Lewis, R., 2018. "Disaster on the Horizon: The Price Effect of Sea Level Rise," *Journal of Financial Economics*, Volume 134, Issue 2.

"Global Greenhouse Gas Emissions Data." *EPA*, Environmental Protection Agency, 13 Sept. 2019, <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>.

"Housing Data." *Zillow Research*, <https://www.zillow.com/research/data/>.

"Creating Great Maps in ODS Graphics using PROC SGMAP" Paper SAS3314-2019

Kelly Mills, SAS Institute Inc.

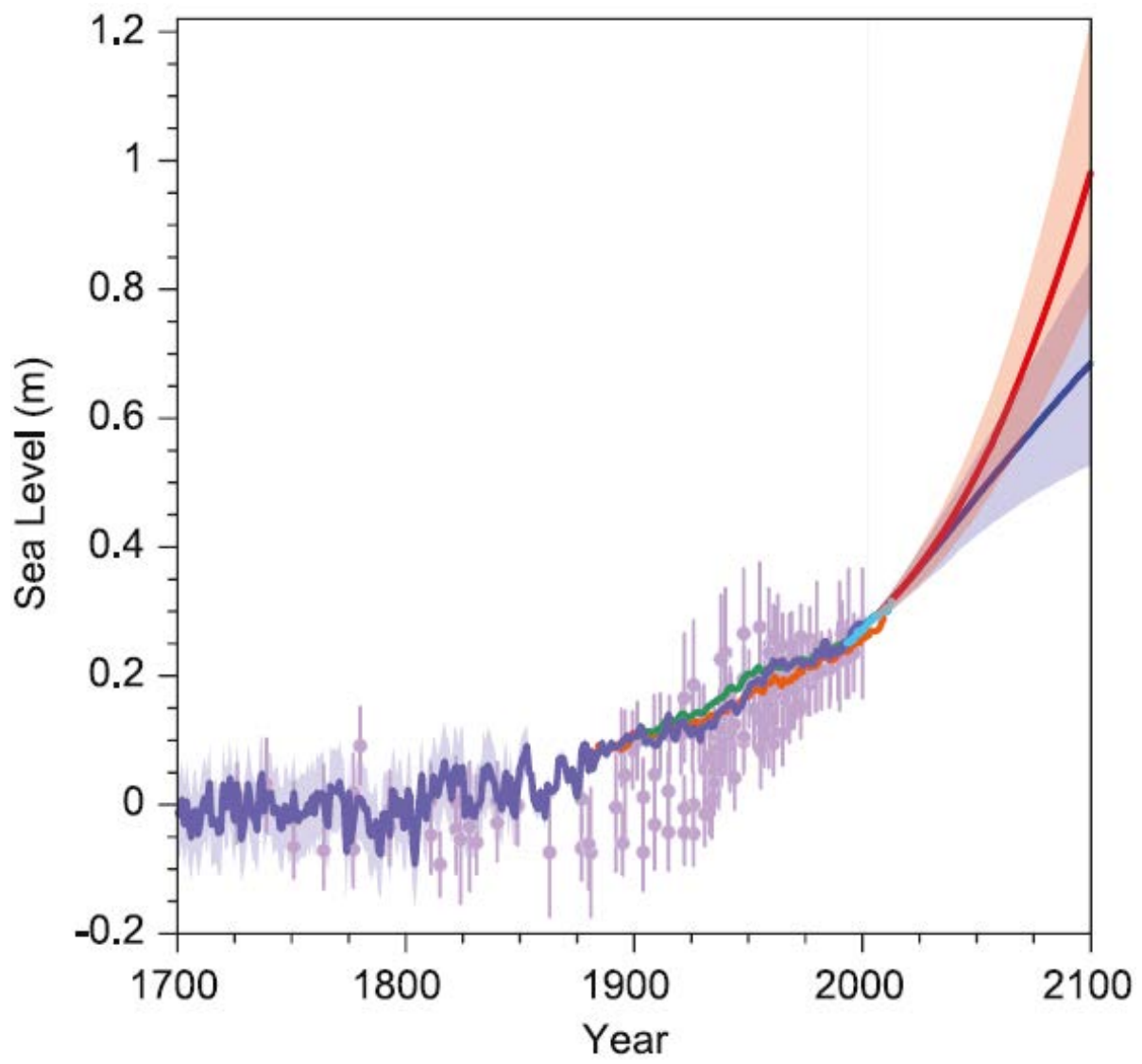
CONTACT INFORMATION

Emma Delehanty
University of North Carolina Wilmington
ed2489@uncw.edu

Austin Willoughby
University of North Carolina Wilmington
awilloughby14@gmail.com

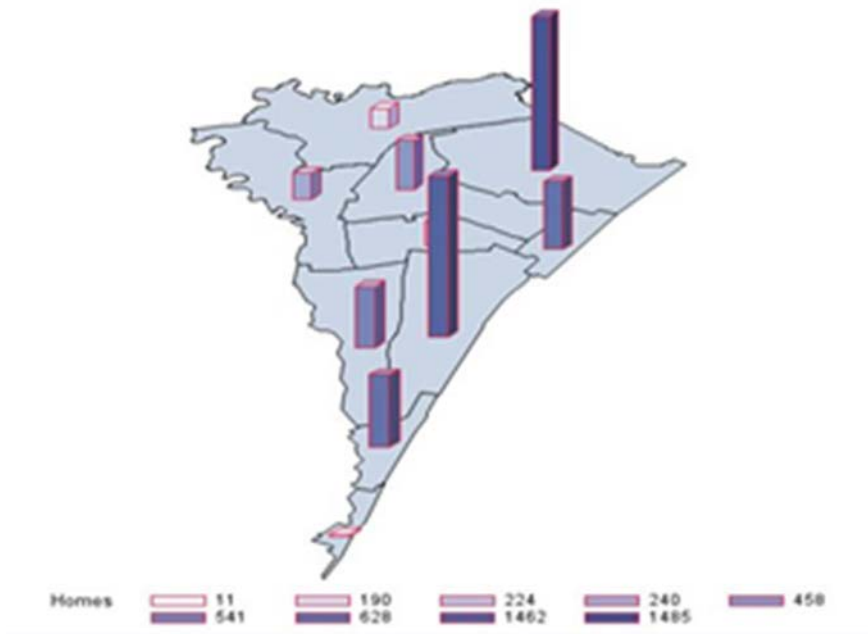
Victoria Mullin
University of North Carolina Wilmington
vrm8601@uncw.edu

APPENDIX A

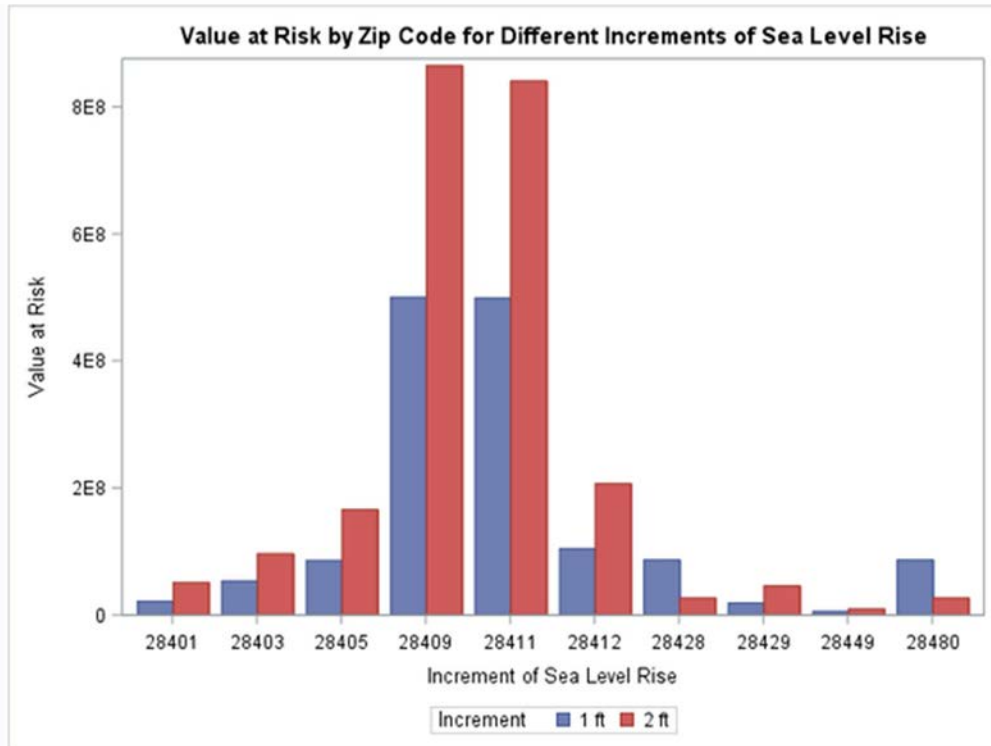


APPENDIX B

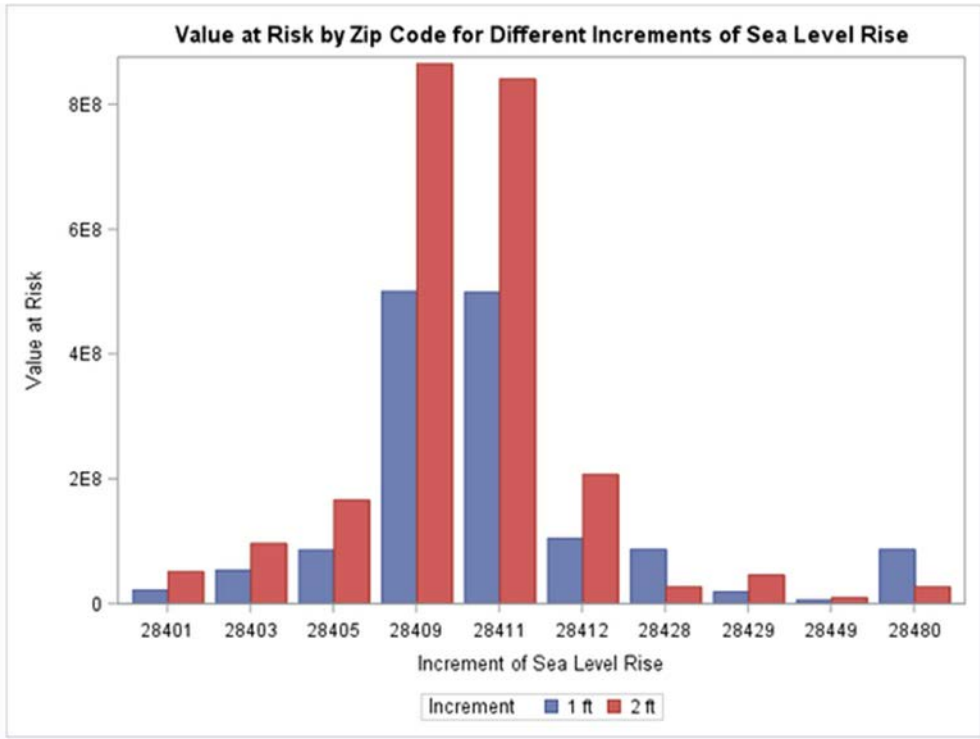
Number of Homes at Risk of Each Zipcode(2ft)



APPENDIX C

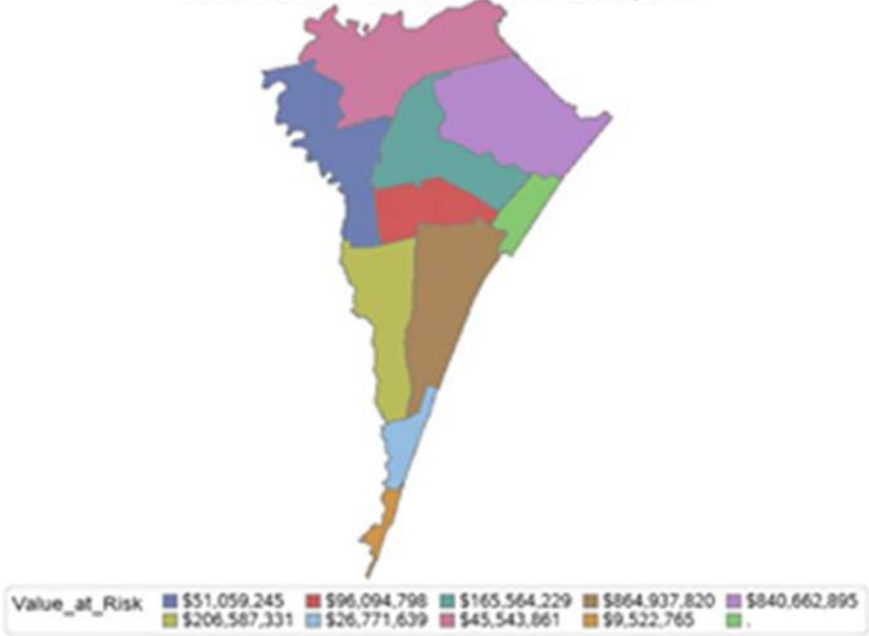


APPENDIX D



APPENDIX F

Value At Risk if sea level rise 2 ft in Each Zipcode



APPENDIX G

