Emergency Planning: Mapping Socioeconomic Vulnerabilities in Southern Florida USA

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Abstract

There are many facets of human vulnerability related to natural hazards. This study focuses on socioeconomic vulnerabilities in Florida's southern counties. Using census data, Broward county, Miami-Dade county, and Monroe county were analyzed. Many socioeconomic factors can be used to determine vulnerability; the following were studied and analyzed based on their prominent themes in emergency planning literature: (a) age (b) disability (c) poverty level (d) women, and (e) language. Each variable was mapped and compiled in a ranked system to depict areas of high vulnerability. Knowing which areas are more vulnerable contributes to mitigation stages of emergency management.

Introduction

There is little doubt natural disasters can destroy a community. Florida has a long history of hurricanes, tropical storms and flooding (Eakin and Lauers, 2006). The population as a whole is vulnerable to natural disasters. However, some communities are more vulnerable than others when spatial components are taken out of the equation (Morrow, 1999). Vulnerability in itself is a vague term. Morrow splits vulnerability into three categories: 1) household vulnerability, 2) personal vulnerability, and 3) family and social vulnerability. Cardona (2004) posits vulnerability is predisposed as a reduced ability to adapt to a new situation. Similarly, vulnerability can be viewed as having the 'fewest defenses' (Enarson, 2007).

Although there are differences in definitions of vulnerability, it is clear that in the case of natural disasters, there are both spatial vulnerabilities and social vulnerabilities (Enarson, 2007). Bogard (1989) describes vulnerability as the failure to prepare yourself and your property against loss. Emphasis has recently been placed on the merge between social and spatial systems during disaster events (Chakraborty, Tobin, and Montz, 2005). The research literature on socioeconomic vulnerabilities is vast and includes many groups of people. With correlation to hurricanes, many people are unable to prepare properly, evacuate in a timely manner, or acquire the assistance needed (Morrow, 1999). Bogard's (1989) definition best fits the analysis conducted in this study.

The three southern counties of Florida; Broward, Miami-Dade, and Monroe are areas that have encountered the greatest number of hurricanes within the state of Florida (National Ocean and Atmospheric Administration [NOAA], 2015). Since the likelihood of Southern Florida experiencing another hurricane or flood is high, it is a pertinent study area

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for examining socioeconomic factors including household, personal, family and social vulnerabilities as was found in Morrow's study (Morrow, 1999).

In completion of this analysis, areas of peak vulnerability will be identified as a means to better mitigate, and plan for natural disaster events.

Methods

Broward, Miami-Dade, and Monroe counties were selected for this analysis. They comprise the southern tip of the Floridian peninsula.

Broward county is a very urban county averaging 1477 persons per square mile, most of which who are confined to the coastal areas of Fort Lauderdale, Pompano Beach, and Boca Raton (City-Data, 2015). Broward county has experienced 22 hurricanes between 1900 and 2010 (NOAA, 2015).

Miami-Dade county is also very urban, much of the population resides in or around Miami with an average of 1313 persons per square mile (City-Data, 2015). Sixty-five percent of the county's population is Hispanic or Latino (City-Data, 2015). Miami-Dade county covers the eastern tip of the Floridian peninsula, which consists of many islands. This area has encountered 25 hurricanes between 1900 and 2010 (NOAA, 2015).

Monroe county is located on the Gulf of Mexico coast of southern Florida including the Florida Keys. The population density is the lowest in the area of study with just 74 persons per square mile (City-Data, 2015). This county contains no major cities, and has encountered 32 hurricanes between 1900 and 2010 (NOAA, 2015).

The Everglades Wildlife Management Area, Everglades National Park, and Big Cypress National Park covers much of the interior land within the study area, which affected the outcome of the study, however Monroe county was included because of its high number of hurricane events in the past and the possible number of visitors at the time of a hazard event.

A thematic map of the study area was created from census tract data for each of the variables. Each variable was analyzed for patterns before being ranked and summarized and depicting the total amount of vulnerability per census tract.

Age

There are two major vulnerabilities within the age category, people under the age of 18 and people over the age of 65. Both children and elderly are more susceptible to natural hazards because of their potential lack of mobility and often, a dependency on others for assistance. Both of these demographic groups are more likely to experience respiratory distress due to toxins in the air and much longer recovery period after a disaster event (Cutter, Mitchell, and Scott, 1997).

Although elderly could be capable of preparing their home on their own, in many cases they lack mobility, resources, or strength to do so. Florida's elderly population is increasing, with a projected 80 million adults by 2050; this may result in medically vulnerable people that may lack resources in an emergency (Morrow, 1999). This population can be reluctant to evacuate, lack mobility, and may need medical assistance (Morrow, 1999). Consideration of this group has been a part of community education and planning for many years and is already a big part of the mitigation and preparation efforts of emergency planning (Enarson, 2007).

Special needs locations were also considered for this analysis. Daycare centers, schools, and adult care centers are all locations of vulnerability. Many of these facilities will need advanced evacuation warning, additional support in terms of mobility and medical fragility, and a suitable final destination of transport (Cutter *et al*., 1997).

Hurricane Andrews unexpectedly produced many child victims (Morrow, 1999). Child care centers are often created as needed in evacuation situations and leave children with less support than if they were with their families (Morrow, 1999). Over seventy percent of children are in daycare, or at school while parents work during the day in the United States (Enarson, 2007). If children are found alone during an emergency situation, they would unlikely be able to care for themselves.

Census data collected in 2010 was used to create a thematic map depicting the percentage of child and elder populations within census blocks (Figure 1). Natural breaks were used to divide the data into five classes. The result was then analyzed using hotspot analysis in order to recognize patterns in the data with statistically significant clusters, calculated with z-scores, and p-values.

From the hotspot analysis, the 99 percent confident hotspots were selected to represent the variables within the age vulnerability of the study area. By intersecting the child vulnerability, and elderly vulnerability layers, twelve census tracts were identified having both vulnerable elderly and child populations. The remaining census tracts diverged from each other, and covered wide areas between the cities of Homestead, and Fort Lauderdale.

In addition to demographic data, point data was also used to analyze the age variable of vulnerability. Points representing both schools and adult care

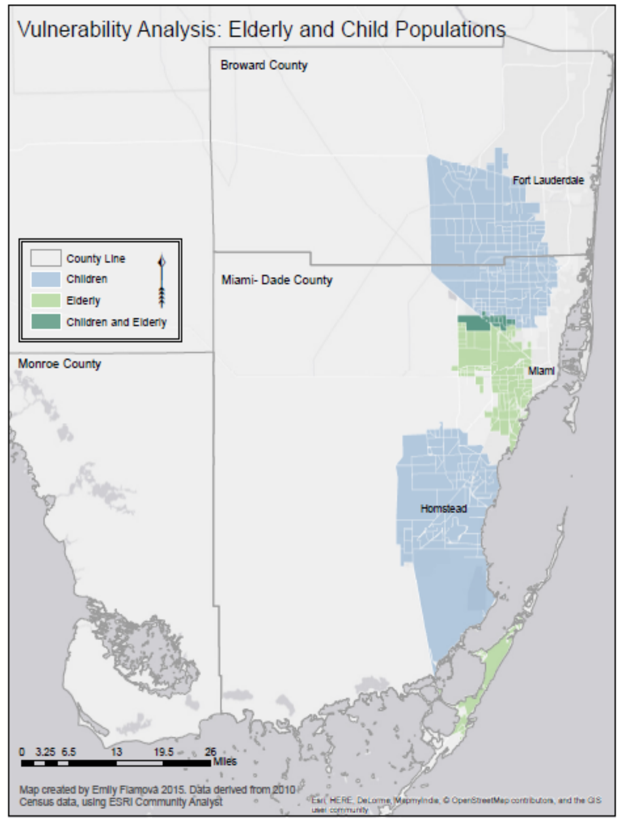

Figure 1.Vulnerability mapping: Elderly and Child population hotspots are shown. Child (blue), elder (green) and overlapped (dark green) populations indicate areas of age vulnerability. These areas are 99 percent confidence hotspots for the age demographic.

facilities were added to the vulnerability map (Figure 2). Schools are distributed across all of the child hotspots and many schools are located outside of the vulnerability hotspots. Depending on the type, location, and time of the disaster, schools may either need assistance evacuating, or they could be used as temporary shelters. Knowing the location of each school is essential in emergency planning.

Similar to school distribution, many of the adult care facilities are outside of the elderly vulnerability areas (Figure 2). Emergency planners could facilitate additional assistance, or advanced warning during a hazard event, specifically to the centers within the vulnerable area.

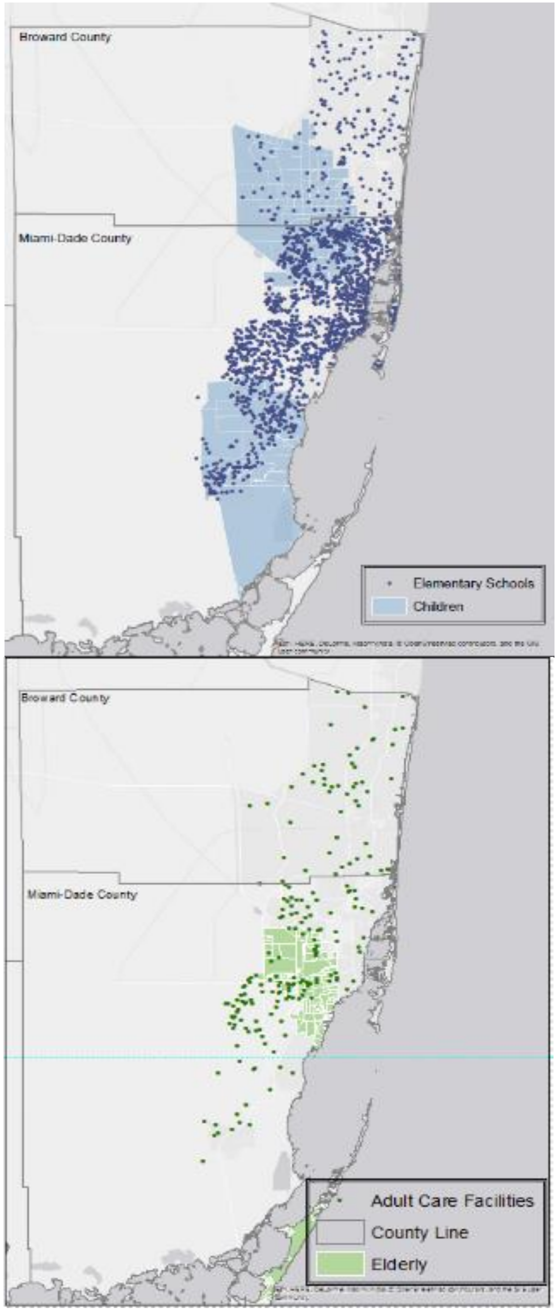

Figure 2. Vulnerability Mapping: point data indicating schools (dark blue) and adult care (dark green) are shown with the vulnerability areas for children (blue) and elderly (green).

Disability

Nationally, medical technologies have led to increased survival rates in infants and children with critical diseases and accidents has increased the number of people living with disabilities (Morrow, 1999). Disabled populations are at a higher risk because of physical or mental limitations, and lack of mobility (Cardona, 2004). This population involves much more planning and mitigation than others during a disaster. Emergency planners take into account the amount and type of life preserving medical equipment and services needed for disabled populations, however, shortages of these types of necessities are likely in a hazardous event (Enarson, 2007). Hotspot populations with disability are shown in Figure 3.

During analysis, a thematic map was made depicting households with one or more persons with disability. This data includes group homes and family homes. Natural breaks were used to separate the data into five classes.

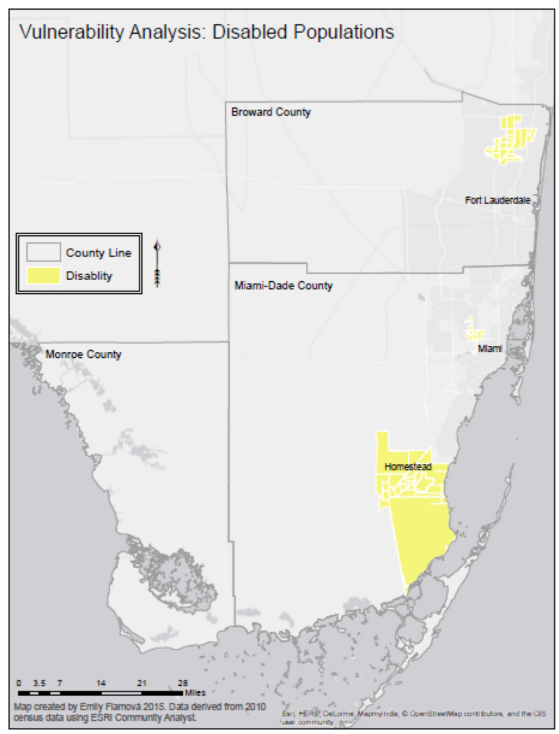

Figure 3. Vulnerability Mapping: disability areas are shown (yellow) for Broward county, Miami-Dade county, and Monroe county.

A hotspot analysis was conducted and the census tracts containing a 99 percent confidence level were chosen to represent this variable in the final map. Three areas were outstanding in the analysis are shown, a large area encompassing the city of Homestead, a small area west of Miami, and in the northern area of scope, Pompano Beach (Figure 3).

Although there are many different facets of defining disability, the Census Bureau includes six disability categories: hearing, vision, cognitive, ambulatory, self-care difficulty, and independent living difficulty (US Census Bureau, n.d.).

Poverty Level

Populations living in poverty are often most impacted during a disaster event, more often than not, poor communities have more exposure to hazard (Eakin and Lauers, 2006). Over 13 percent of the US population lives below the poverty line (Chakraborty *et al*., 2005). These populations often occupy poorly constructed and maintained homes, mobile homes, or are homeless (Morrow, 1999). Poverty stricken households also have increased mortality rates and are rarely prepared for emergency events (Morrow, 1999). Many times these populations consist of underprivileged, minority, or runaways who do not seek assistance in fear of government harassment or discrimination (Enarson, 2007).
A thematic map was created depicting adults between 18 and 65 living below the poverty line per census tract. Natural breaks were used to create five data classes (Figure 4). A Hotspot analysis was then undertaken to highlight the patterns of poverty within the study area. Finally, the 99 percent confident hotspots were used to represent poverty.

There were two main concentrations of vulnerable populations within the study area; Homestead and Miami. Since the Miami hotspot is consistent with population density and urban statistics, it makes sense that much of the poverty in South Florida lies within the Miami urban area. Twenty one percent of Miami-Dade county's residence live below the poverty line compared to 19 percent in Monroe county, and 15 percent in Broward county, Florida (City-Data, 2015).

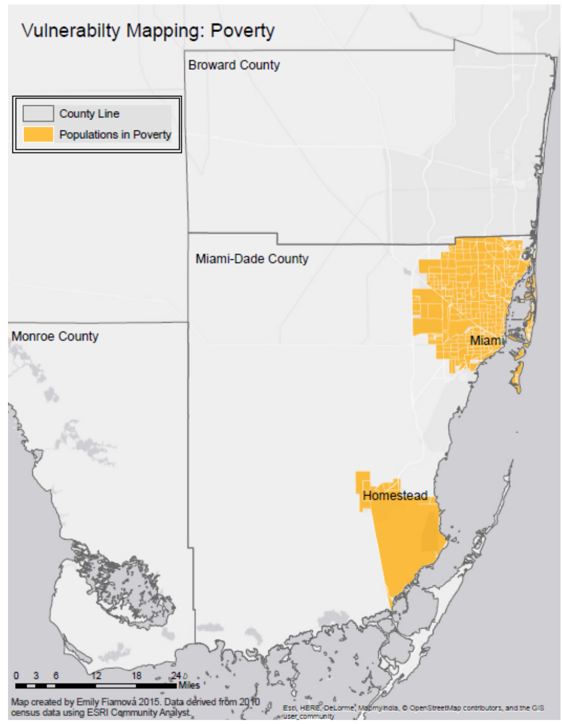

Figure 4. Vulnerability Mapping: Poverty vulnerability areas are shown (gold) for Broward, Miami-Dade, and Monroe Counties in Florida.

Women

Women fall into many categories of vulnerability, they are susceptible to poverty and often are the single caregivers of children. Eleven percent of the United States population are women caring for children without a husband (Enarson, 2007). A majority of the eleven percent live below the poverty line as well (Enarson, 2007). Because of their often limited power, and resources, women often lack assistance during emergency events. Since the rising cost of living, it is very difficult to run a household on one income thus, women raising children independently have many more obstacles to overcome. These households tend to be less prepared when a storm occurs, much of the preparation requires heavy lifting, time, and money (Morrow, 1999).

For this analysis single mothers became the focus of the gender vulnerability (Figure 5). Census tract data containing the percentage of female head of household with one or more children was used to create a thematic map of the single mother demographic using five classes, and natural breaks.

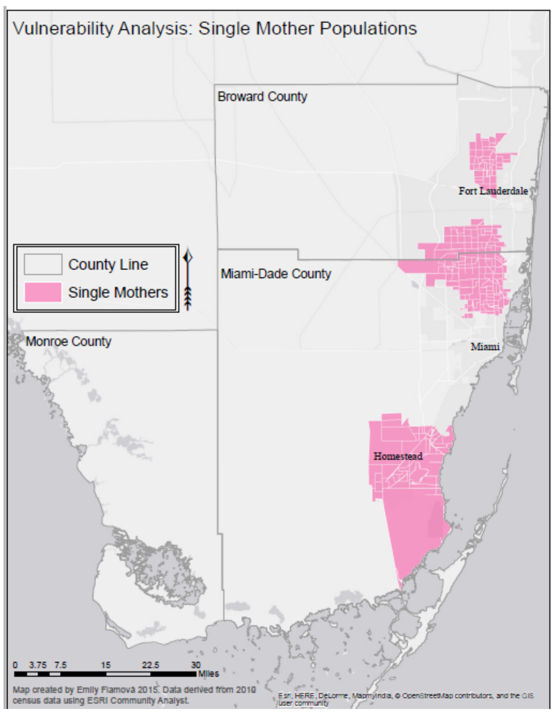

Figure 5. Vulnerability Mapping: Single Mother vulnerability areas are shown (pink) for Broward, Miami-Dade, and Monroe counties.

From this depiction, a hotspot analysis was conducted to create a layer of single mothers with a 99 percent confidence interval to represent this variable. There were three major groupings of single mothers, the city of Homestead, North Miami, and west Fort Lauderdale. These areas were much larger in comparison to the other variables. As expected, the single mother and child hotspots have an enormous overlap. The child variable encompasses both the Homestead hotspot, as well as the North Miami hotspot.

Language

Tight-knit communities of similar language and culture benefit from each other in emergency situations. Communities like this tend to care for their elderly, disabled, and poor as a group (Morrow, 1999). New immigrants however, can have a difficult time assimilating to an area and language. These communities are often left out of the preparation process due to language differences and lack of communications. Over 20 percent of the US population speaks a language other than English (Enarson, 2007). Many of these communities lack assistance purely because they do not know where to go for help. New immigrants have a particularly hard time because they have not established a community base and often do not live near family or friends (Morrow, 1999).

According to the census bureau, there are three language groups spoken in southern Florida: Indo-European, Asian Pacific, Spanish, and “other.” Indo-European languages include English, European languages and a variety of Middle Eastern dialects. Asian Pacific include Hawaiian, Native island languages, Chinese, and other Asian dialects. There was a third group of languages entitled “other,” however the numbers were too small to be visible at the scale used. Figure 6 shows language groups that had little to no English skills, and spoke only foreign languages.

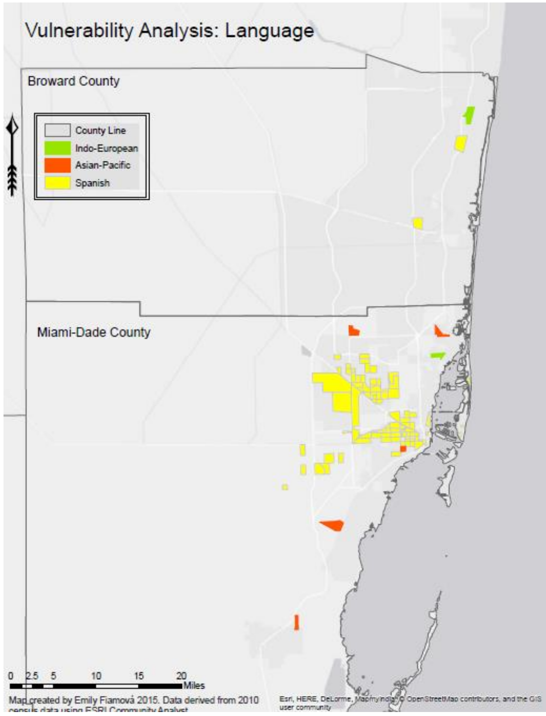

Figure 6. Vulnerability Mapping: Language vulnerability areas are shown categorized by language group; Indo-European (green), Asian Pacific (orange), and Spanish (yellow).

Of languages spoken at home, Spanish was the highest percent other than English. There were also groups of Indo-European and Asian-pacific groups found. Instead of grouping languages together, they were categorized to determine differences in language areas and what languages were prevalent in those locations.

From census tract data, a thematic map was created for each language group. The data used represented the number of people within the census tract that spoke a language with no English. Natural breaks were used to create five data classes. After a hotpot analysis was conducted the areas of 99 percent confidence intervals were used to represent the language group. It should be noted that the 99 percent confidence levels for Asian-pacific and Indo-European language groups contained just over one percent of the population. The Spanish language group hotspots contained ten percent of the population. Although Spanish was a very large majority, there were also many people who speak both English and Spanish that this was not as concerning as other language groups. Much of the media in southern Florida is in both languages already whereas there are no resources for someone who speaks Korean, or Slovak, for example.

Vulnerability Mapping

Emergency planning consists of four major actions: 1) Mitigation 2) Preparedness 3) Response and 4) Recovery (Cova, 1999; Federal Emergency Management Agency [FEMA], 2015). Each of these actions aid in reducing the damage and risk for people enduring a natural disaster. Analytical modeling using GIS often a large part of the mitigation process. Long term assessment, planning and forecasting takes place in this phase (Cova, 1999). GIS is currently used to identify hazards, critical infrastructure and assess the risks of hazards to residents in the area (FEMA, 2015). The majority of the analysis being used is focused on infrastructure and the hazard itself. Vulnerability mapping provides an analytical way to assess the needs of the populations in danger of a hazard.

Cova (1999) uses an equation to show the relationship between vulnerability, risk, and hazards:

$$Risk=R(H(E_h),(E_v))$$

where the results (R), are a function of the hazard (H), vulnerability (V), the elements of hazard ($E_{h,}$) and the elements of vulnerability (E_v). An adaption of this equation was considered during this analysis where $E_{h,}$ was removed and the focus was on $E_{v.}$

Many risks factors and vulnerabilities that were discussed could be dissolved through communication and localized education (Cardona, 2004). Through communication and education programs, preparation and recovery can quickly be attained for many people. Risk could be reduced by pinpointing communities that require more education and resources (Chakraborty *et al*., 2005). In addition, tight knit communities can benefit greatly during hazardous events as well as family groups. These types of communities are much less at risk when a disasters occur because they can rely on others outside of their home (Enarson, 2007). Encouraging community development may contribute to these types of benefits.

Mapping populations who need more or specialized assistance would be beneficial to emergency planners to allocate their time and resources during mitigation and preparedness actions. Vulnerability maps help emergency planners see the areas where there is accentuated risks and vulnerability (Morrow, 1999). Researchers suggest programs like GIS, Hazus, and TAOS be used to merge demographic and hazard data together to better understand the natural disaster as a social phenomenon (Morrow, 1999). Using these techniques, one could better anticipate the needs of local populations during an event.

Mapping the distribution of vulnerability has proven effective in researching community resilience and risk (Eakin and Lauers, 2006). Creating local maps of highly geographically vulnerable areas would further the study of risk analysis, vulnerability mapping, and better plans for mitigation, and recovery of a location.

Adding Variables of Vulnerability

Two maps were created with the compiled variables. The first, is a general vulnerability map, and the second is a map representing each variable and the overlaps. These two maps represent the data but are useful for different purposes. The general vulnerability map (Figure 7*)* is a thematic map representing the vulnerability per census tract. All variables were combined using a ranking method. Each variable was equally ranked because of its representation of people and it did not seem ethical to weight one person's risk over another. The census tracts contain between 0 and 14 vulnerabilities. They were classified with natural breaks, and divided into five classes. The largest area of vulnerability occurred near Homestead with a second in the heart of Miami. Other areas include Hialeah, and the center of Fort Lauderdale. The higher rankings all occurred along the Atlantic coast and the low rankings were noted within the everglades, and inland portions of the counties. This is consistent with the population density and urbanization of the southern tip of Florida. Since this layer shows general vulnerability, emergency management entities could reference this map to get an idea of what areas would need the most help in mitigation and response during an emergency event.

The second map contains a greater level of detail in its analysis (Figure 8). Each of the variables are represented. This interpretation could be used to send specific resources to the areas in need; for example, resources may be sent to areas with language vulnerability, or transportation/medical assistance to areas with elderly and disability vulnerabilities.

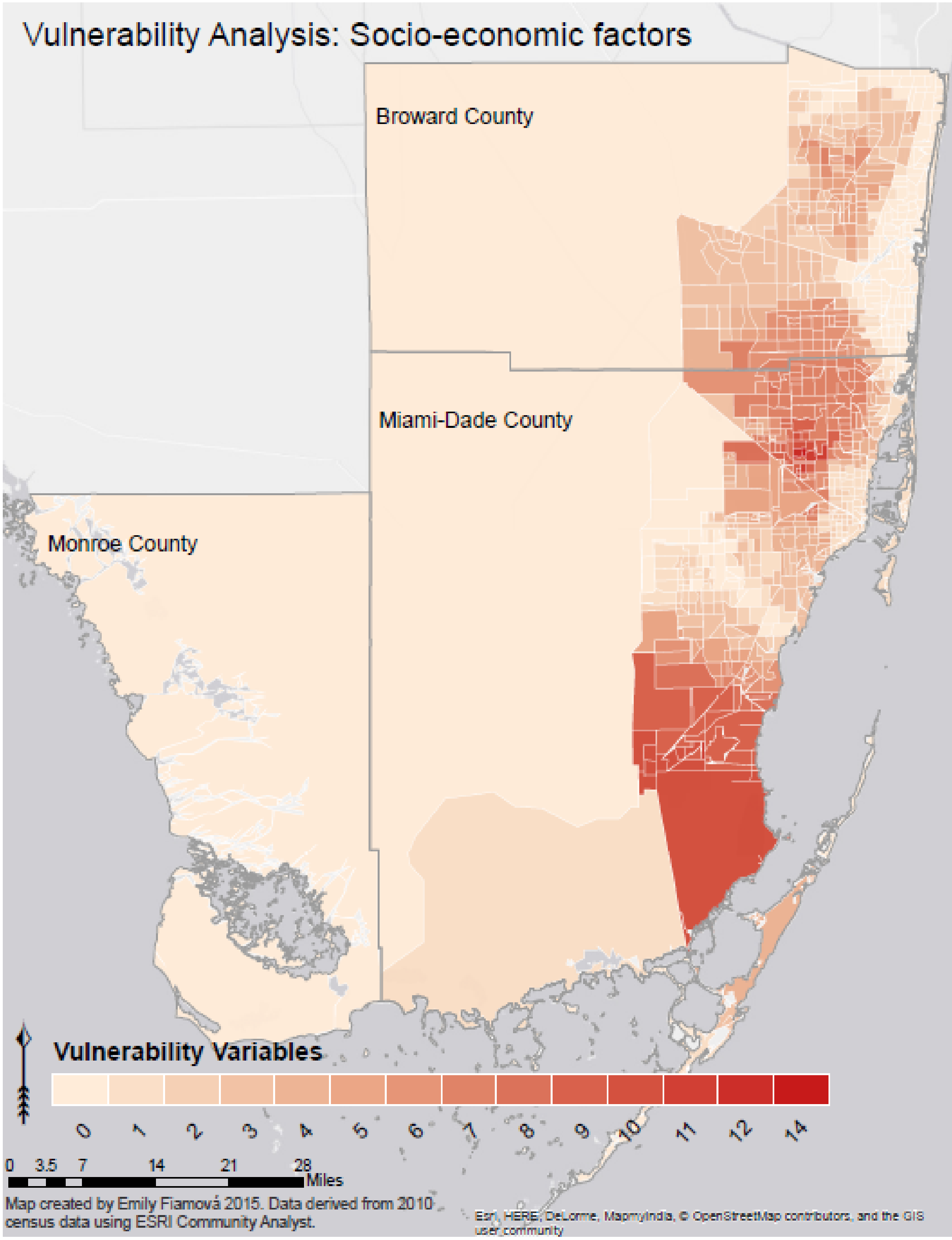

Figure 7. Vulnerability Analysis of Socioeconomic factors are shown in red gradient scale with high vulnerability represented in dark red and low vulnerability as tan.

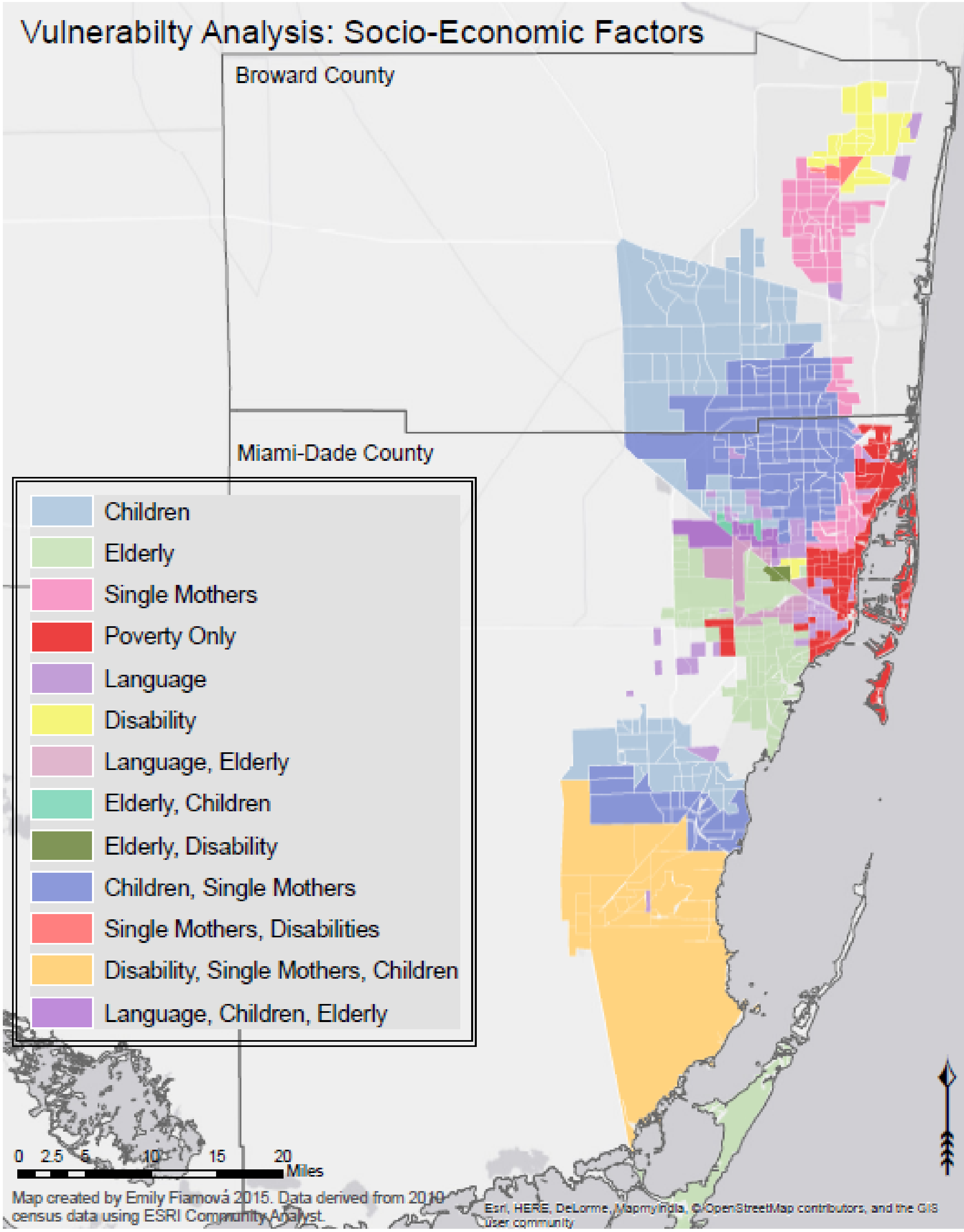

Figure 8. Vulnerability Analysis: Socioeconomic Factors. Each of the variables was added to a map, and analyzed resulting in thirteen different vulnerability areas: Children (light blue), Elderly (light green), Single Mothers (pink), Poverty (red), Language (purple), Disability (yellow), Language and Elderly (teal), Elderly and Disability (dark green), Children and Single Mothers (royal blue), Single Mothers and Disabilities (salmon), Disability and Single Mothers and children (pale orange), Language and Children and Elderly (lavender).

It should be noted poverty was not overlapped with each of the variables; it was separated and mapped as an independent variable. If it was intersected with other variables, results would have been very cluttered and hard to differentiate characteristics of the map. Since poverty encompasses the totality of both Miami and Homestead, poverty was only represented as an independent variable in (Figure 8), the overlaps are not included for poverty as a means of simplifying the data.

Much of the Florida Keys were left out of the analysis because of their low populations, and low vulnerabilities. Leaving the keys in scope left the map looking cluttered and much too small to see patterns of vulnerability. Key Largo was included because it contains the highest population of the keys, and included vulnerabilities. The remaining Keys were excluded due to the lack of populations and patterns for analysis.

Results

There are two main areas of concern regarding socioeconomic vulnerabilities during a hazard event: Homestead and Hialeah. These two areas show the highest levels of vulnerability and include a diverse array of vulnerability categories.

Homestead comprises many different family vulnerabilities. It was a hotspot for single mothers, children, and people living with a disability (Figure 9). Depending on the specific census tract, it displays between nine and 14 types of vulnerabilities.

Homestead is a primarily Hispanic population which is growing rapidly. Since 2000 the population has increased by 30% (City-Data, 2015). The residents of homestead are primarily working class people and agriculture is the main occupation. These details can attribute to the level of vulnerability in the area.

Miami is the second area of peak vulnerability (Figure 10). Miami has a very diverse set of vulnerabilities. Hialeah, one of its suburbs show the greatest number (fourteen) of vulnerability factors. Hialeah is nearly 96% Hispanic, the highest Cuban population in the United States and has a very low average income (City-Data, 2015).

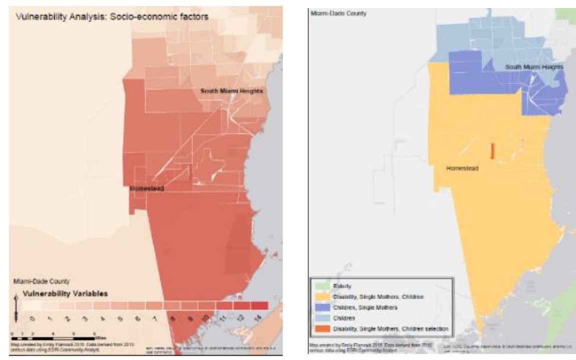

Figure 9. Vulnerability Analysis: Homestead. The left map displays homesteads ranked variables in shades of red. The right map shows each socioeconomic factor that is present in the area: Elderly (green), Children (light blue), Children and Single Mothers (royal blue), Disability, Single Mothers, and Children (yellow), and finally, Language, Disability, Single Mothers, and Children (orange).

There are many factors of vulnerability that could be explored; this study included five. Other variables to analyze might include more demographic data such as housing density, race, and number of high school graduates, unemployment, public health and others. It also may be interesting to analyze demographics using a two variable choropleth map. Demographic data is very usable for studies like this, but can only model so much vulnerability. Point data may include prisons, military bases, and hospitals. The more neighborhood specific data, the more specific the mitigation process can be.

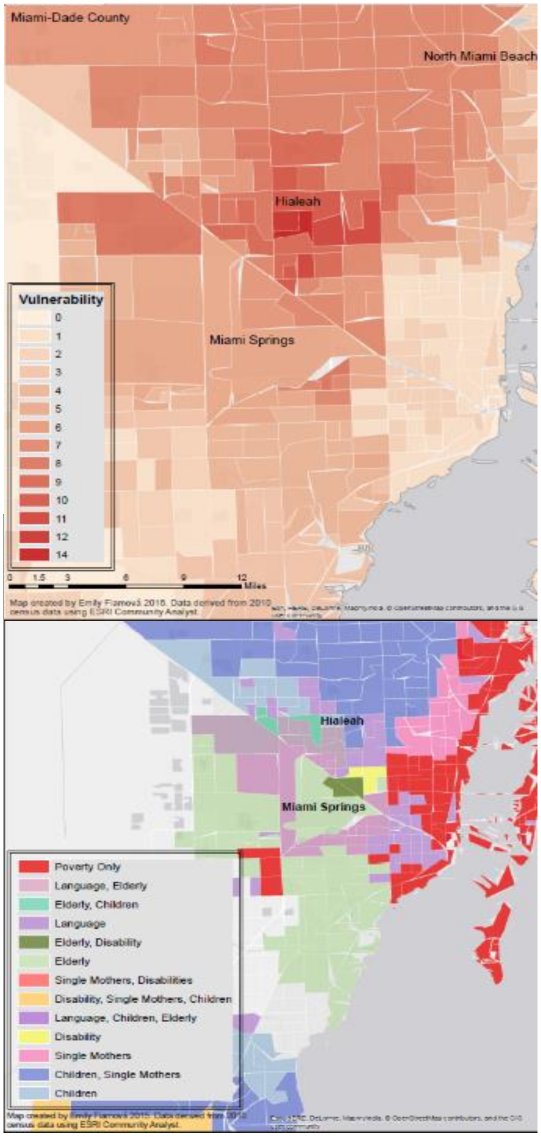

Figure 10. Vulnerability Analysis: Miami Area. The left map shows the Miami Area ranked vulnerabilities in shades of red, and the right map shows vulnerability variables within Miami: Poverty (red), Language, children, and elderly (purple), Single Mothers (pink), Elderly and Disabled (yellow), Elderly and children (emerald green).

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References

Bogard, W.C. 1989. Bringing social theory to hazards research: conditions and consequences of the mitigation of environmental hazards. *Sociological Perspectives* 31,147-68.

Cardona, O.D. 2004. The need for rethinking the concepts of vulnerability and risk from a holistic perspective: a necessary review and criticism for effective risk management. *Mapping vulnerability: Disasters, development and people*, *17*.

City-Data. 2015. "City-Data: Stats about All US Cities" retrieved September 9, 2015. From www.city-data.com.

Chakraborty, J., Tobin, G.A., and Montz, B.E. 2005. Population evacuation: assessing spatial variability in geophysical risk and social vulnerability to natural hazards. *Natural Hazards Review*, *6*(1), 23-33.

Cova, T.J. 1999. GIS in emergency management. *Geographical information systems*, *2*, 845-858.

Cutter, S.L., Mitchell, J.T., and Scott, M.S. 1997. Handbook for conducting a GIS-based hazards assessment at the county level. *University of South Carolina, Columbia, SC*.

Eakin, H., and Luers, A.L. 2006. Assessing the vulnerability of social-environmental systems. *Annual Review of Environment and Resources*, *31*(1), 365.

Enarson, E. 2007. Identifying and addressing social vulnerabilities. *Emergency management: Principles and practice for local government*, *2*, 257-278.

Federal Emergency Management Agency (FEMA). 2015. Retrieved June 2, 2015. From FEMA.gov.

Morrow, B.H. 1999. Identifying and mapping community vulnerability. *Disasters*, *23*(1), 1-18.

National Oceanic and Atmospheric Administration (NOAA). 2015. "Tropical Cyclone Climatology." *Tropical Cyclone Climatology*. Retrieved November 02, 2015 from www.noaa.gov.

US Census Bureau, n.d. “Census.gov.” Census.gov, Retrieved November 9, 2015 from census.gov.