



Assessing the need for evacuation assistance in the 100 year floodplain of South Florida



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ABSTRACT

The main objective of this study is to assess evacuation assistance need in the 100 year floodplain of South Florida (Palm Beach, Broward and Miami-Dade counties) by examining select population characteristics of the floodplain inhabitants. Dasymetric mapping is used to redistribute block group level census data to homogeneous inhabited zones of 30 m × 30 m. Because the 100 year floodplain does not correspond to block group boundaries, this data redistribution increases the resolution and accuracy of the floodplain population and their social characteristics. Data on poverty, age, vehicle ownership and mobile housing units are obtained for each 30 m × 30 m zone in the floodplain and is aggregated to the block group level. It is then used to assess evacuation assistance need (based on volume of need as well as concentration of need) for the floodplain in each block group. Results reveal variations in evacuation need across the floodplain. “Age” is the main driver of evacuation need along the coast. “Poverty” is a factor inland, in both urban and rural areas. “Lack of vehicle ownership” contributes to assistance need in coastal and inland urban areas, but not so much in rural areas. “Mobile housing” is a factor in rural areas. Miami-Dade County has higher volume and concentration of poor households lacking vehicular ownership. Palm Beach and Broward counties, on the other hand, have a more dominant presence of elderly and of mobile housing. These results have important implications for local and regional evacuation planning in the event of a 100 year flood.

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1. Introduction

1.1. Flood hazard and evacuation

Flooding is a major disaster of concern in the United States. According to the EM-DAT International Disaster Database, of all the disaster types in the United States, flooding ranks first in frequency and second in fatalities (EM-DAT, 2015). In order to develop effective flood evacuation plans it is important to delineate high flood risk areas and then to use resident characteristics within these high risk areas to identify pockets of high evacuation assistance need. The 100 year floodplain is an accepted approach to demarcate areas of high flood risk. The designation is a standardized statistical measure and is used to delineate high risk areas (known as Special Flood Hazard Areas), or areas that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in a year. Accurate estimation of population distribution and its

socioeconomic characteristics within the 100 year floodplain can aid emergency planners and responders in reaching out to people most in need.

Researchers from multiple disciplines have made significant contributions to hazards evacuation studies. Most evacuation studies have focused on the temporal aspect of evacuation through route planning and transportation modeling (Cova & Church, 1997; Cova & Johnson, 2003). Some studies have focused on location planning of shelters (Kar & Hodgson, 2008; Kongsomsaksakul, Yang, & Chen, 2005; Sherali, Carter, & Hobeika, 1991). Other studies have focused on population attitudes, behavior and perceptions towards evacuation (Dash & Gladwin, 2007; Kusenbach, Simms, & Tobin, 2010; Lindell & Prater, 2007; Lindell, Kang, & Prater, 2011). Social vulnerability has been recognized as an important theme in hazards research and some evacuation studies have studied the social vulnerability of populations in the hazard zone (Chakraborty, Tobin, & Montz, 2005; Prasad, 2012; Wein, Ratliff, Baez, & Sleeter, 2014). Despite increasing recognition since the late 1990s that effective emergency planning must couple social vulnerability with risk

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exposure (Pielke Jr., 1999; Sarewitz, Pielke Jr., & Keykhah, 2003), it has been recognized that for flooding specifically, the emphasis has been on management and mitigation of flood risk through flood control structures and flood insurance plans, and the social vulnerability of population in the flood zone has not received the same level of attention (Cutter, Emrich, Morath, & Dunning, 2013). This has led to an incomplete understanding of evacuation need in the floodplain and has hindered the development of evacuation plans (U.S. DOT and U.S. DHS, 2006).

Flooding is the most pervasive natural hazard in the three South Florida counties of Palm Beach, Broward and Miami-Dade. The population dwelling in the 100 year floodplain here is extremely heterogeneous in its socioeconomic characteristics. Hence, a 100 year flood event here may result in similar exposure but very different evacuation assistance needs across the floodplain. Evacuation assistance need is described as the need of individuals and families to receive help and support from local emergency management to evacuate to safer locations. Those with low need have the ability to evacuate with little assistance. On the other hand, those with high need are unable to evacuate without assistance. This study contributes to the literature on floodplain evacuation by assessing evacuation assistance need through exploration of the social characteristics of the resident population in the 100 year floodplain of South Florida.

1.2. Flood risk in South Florida

Palm Beach, Broward and Miami-Dade counties, located in the southeastern corner of Florida (Fig. 1), are affected by at least three types of floods: (a) storm surge flooding in coastal areas, (b) flash floods due to heavy downpours during storms and (c) water body (rivers/canals/lakes) overflows and dyke beaches during storms. The 100 year floodplain in South Florida includes both the coastal zone (vulnerable to storm surge impacts) as well as low lying inland areas (susceptible to flash floods and water body overflows during storms). This paper assesses storm induced flood evacuation need in the entire 100 year floodplain, regardless of the nature of flooding (storm surge, flash floods or water body overflows). Although the focus here is on storm induced flooding, the findings are also relevant to evacuation planning for other kinds of flooding.

Approximately 36% of the land area in the study area counties is in the 100 year floodplain. High flood exposure here is due to a combination of natural and man-made factors. Significant natural factors contributing to high flood risk include the relatively flat and low-lying terrain, poor natural drainage, intense precipitation events during summer, and exposure to tropical storms and hurricanes (PBC, 2015a; Miami-Dade, 2015a). Exacerbating the risk is South Florida's long history of heavy urban development and population settlement. According to the 2010 census, roughly 5.5 million people, or 30% of all Floridians, live in these three top ranked counties by population. Settlement is clustered in a high density, heavily built urban environment between the Atlantic Ocean to the east and the Everglades to the west. Urbanization has increased surface imperviousness, thereby causing increased runoff and shortening the lag time between precipitation and flooding peaks. Large parts of the Everglades have been drained to accommodate growing populations, thereby compromising a natural flood control system. Heavy development along its 90 mile long Atlantic coastline, on barrier islands and near waterways has put people and property in harm's way.

South Florida has some of the highest exposure to hurricanes and tropical storms in the country (Pielke Jr. et al., 2008; Zandbergen, 2009). Storm induced flooding is likely to worsen

under a climate change scenario due to potential increase in sea level (Frazier, Wood, Yarnal, & Bauer, 2010; Nicholls, Hoozemans, & Marchand, 1999) as well as the likelihood of more intense hurricanes (Kang & Elsner, 2015; IPCC, 2012; Knutson et al., 2010). Given this scenario, it is possible that a 100 year storm flood could have a much faster return period.

1.3. Study objective

Evacuation planning is a significant aspect of emergency preparedness and response. Evacuation behavior, especially the decision to evacuate, can provide important lessons for evacuation planning. Studies indicate that evacuation behavior is impacted by the proactiveness of local emergency management in communicating risk and in providing support and assistance with evacuation efforts (Baker, 1991; Dow & Cutter, 2002; Whitehead et al., 2000). Indeed, experiences from past hurricanes suggest the inability of certain population groups to evacuate on account of inadequate assistance (Litman, 2006; Morrow, 1997b). The need for assistance depends on specific population characteristics, the distribution of which may vary across the area of risk. While providing evacuation assistance to the needy population has been recognized as an important evacuation strategy, very few studies have actually explored the spatial distribution of evacuation assistance need based on population characteristics. Some hazard vulnerability studies that have done so have used census enumeration boundaries as study area units, using the rather simplistic assumption of equal population distribution within the units. This study, through utilization of a filtered aerial weighting approach to provide a more realistic distribution of population, and through its in-depth analysis and accompanying interpretations of spatial variations in evacuation assistance need, provides an example of how such detailed examination can aid evacuation efforts by providing targeted assistance.

The purpose of this study is twofold. The first is to assess evacuation assistance need in the 100 year floodplain of each block group by examining select population characteristics. Both the **volume** of need (based on the **total number** of people needing assistance) as well as the **concentration** of need (based on the **percentage** of population needing assistance) is assessed. This can help prioritize areas for evacuation assistance and serve as a useful emergency management tool. The second objective is to explore variations in evacuation assistance need between rural and urban areas and between coastal and inland areas. Hazards vulnerability literature has discussed inequities in social vulnerability, exposure and disaster response effectiveness between rural and urban areas (Cross, 2001; Ye, Chaudhari, Booth, & Posadas, 2010). Inequities exist due to differences of scale as well as marginalization of rural areas. Examining variations in evacuation assistance need from the perspective of rural versus urban areas can contribute to the literature on rural–urban divide. In the context of South Florida, differences between coastal and inland areas are also important. Low lying coastal inundation zones have detailed evacuation plans and are under mandatory evacuation orders. Inland areas need not have the benefit of the same level of planning to address evacuation requirements. Compounding this lack of planning for inland areas is the likelihood that inland areas have a higher concentration of the socio-economically disadvantaged, who may be more vulnerable and therefore more in need of evacuation assistance (Wang & Yarnal, 2012). Given that most hurricane related fatalities are caused outside of the storm surge zone and due to inland flooding (Czajkowski, Simmons, & Sutter, 2011), it may be insightful to research evacuation need from a coastal versus inland perspective.

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