

A GIS Based Modeling of Landslide Hazards and Potential Impacts on the Local Communities in the Upstate of South Carolina

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I. Introduction

Landslides are the cause of enormous amounts of damage and economic loss in mountainous regions throughout the world. The continuous increase in growth of population and sprawl from urban areas creates a situation where people are more vulnerable to landslide hazards. Landslide is a term which refers to various types of mass movements or downward movements of rock, debris or soil because of gravity. Depending on the type of movement and the material involved, the landslide can vary in shape, rate of movement and how the surface is affected. Generally, mass movements happen when the downward pull, or shear stress of gravity, overcomes resisting forces. Landslide hazard maps provide basic information on the probability of a potentially damaging landslide occurring. Landslide hazard is defined as the probability of occurrence of a potentially damaging landslide within a precise period of time and within a given area (Dahal 2008, Dai 2001, Wachel 2000, Hadmoko 2010).

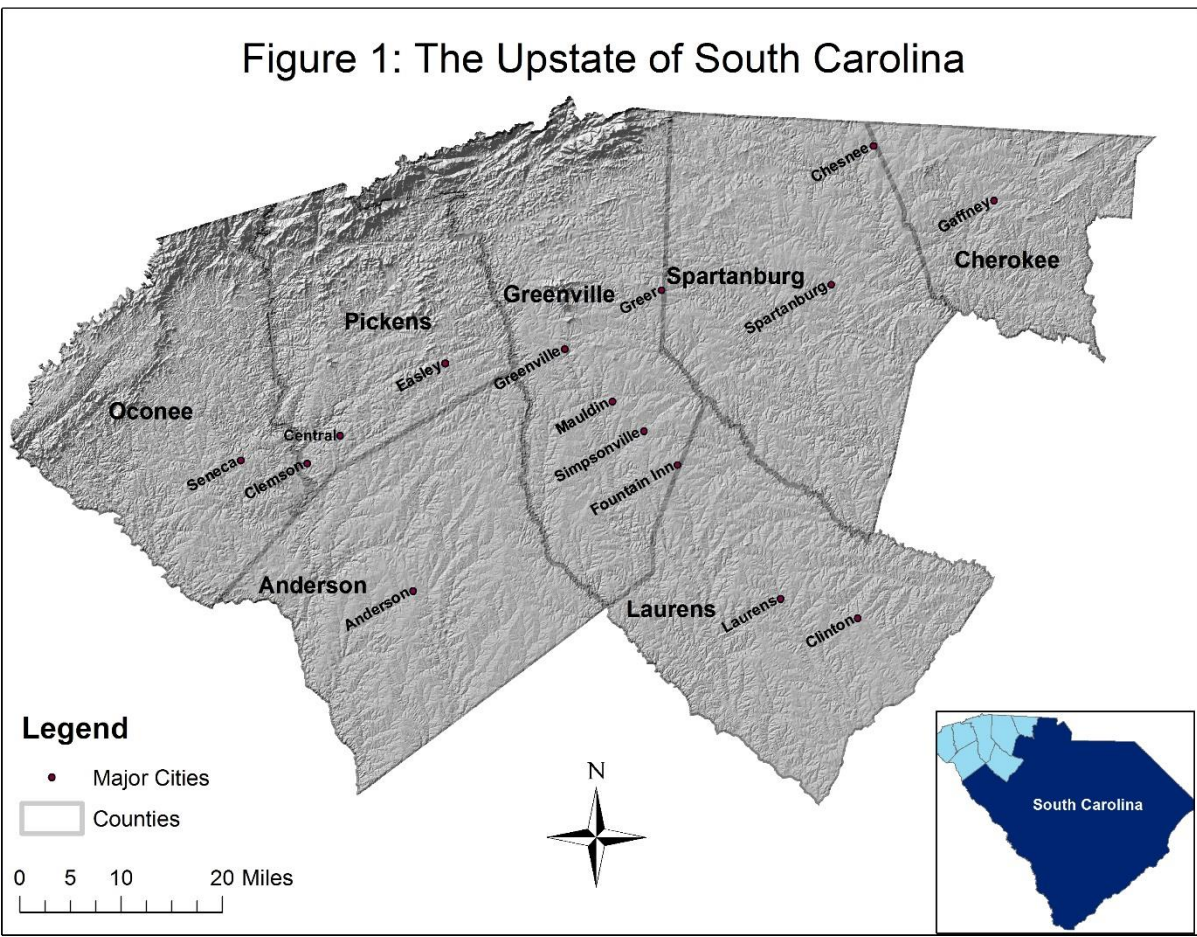
Vulnerability of a population to environmental hazards means the potential for loss. Loss in an event varies geographically, over time, among different social groups, over time and space. There are three main doctrines in vulnerability research: the identification of situations that make people or places vulnerable to extreme natural events or an exposure model; the assumption that vulnerability is a social condition or a measure of societal resilience to hazards; and the incorporation of possible exposures and societal resilience with a specific focus on specific places or regions. Social vulnerability is partly the outcome of social inequalities or the social factors that influence or shape the susceptibility of various groups that are known to harm and govern group's ability to respond, and place inequalities which is the characteristics of communities and the built environment that contribute to the social vulnerability of places (Cutter 2003).

Vulnerability can be defined as the likelihood of being harmed by unforeseen events or as susceptibility to exogenous shocks, which extends the traditional view on poverty. The susceptibility to a shock depends on the ability of avoidance which is another aspect of risk management. The poor and the very poor are especially vulnerable since they are typically more exposed to shocks and have less instruments to manage risk, and even a small drop in welfare can be devastating (Holzmann 2001).

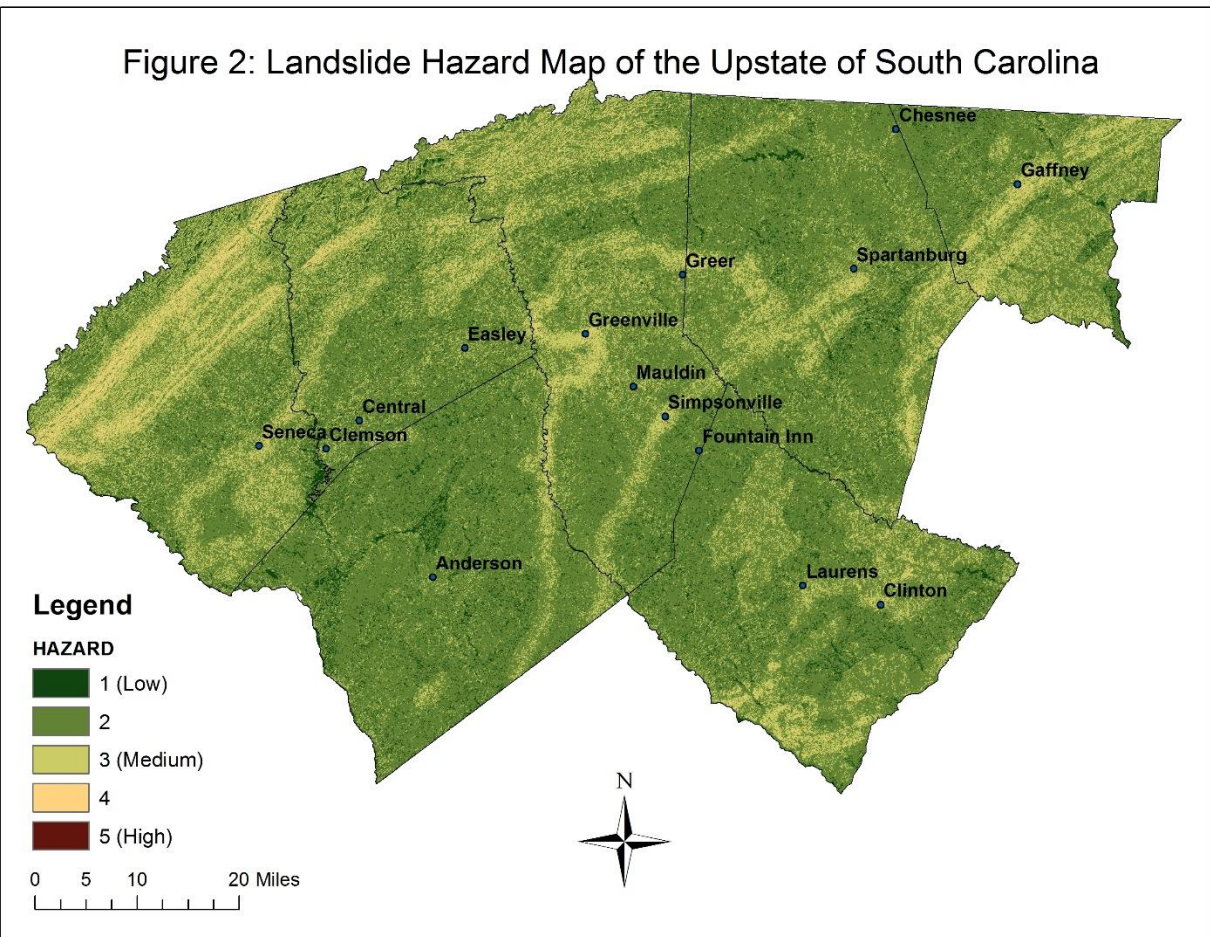
II. Methodology

The study area is located in the Upstate of South Carolina and covers the counties of Oconee, Anderson, Pickens, Greenville, Spartanburg, Laurens and Cherokee (Figure 1). The Socio-Economic map of the Upstate of South Carolina was prepared using Geographic Information Systems (GIS) (Figure 3). The data, divided into census block groups, is calculated by the parameter of majority race in the block group and the parameter of mean income in the block group. Therefore, the mean income of a block group is sorted by race so that the mean income of Whites is 'Above \$45,000' or 'Below \$45,000' and mean income of Blacks or African Americans is 'Above \$25,000' or 'Below \$25,000' (Table 1). Race adds to social vulnerability through the lack of access to resources, cultural differences, and the social, economic, and political marginalization that is regularly related with racial differences. Wealth allows communities to absorb and recuperate from losses more quickly because of insurance, social safety nets, and entitlement programs. Lack of wealth is a primary contributor to social vulnerability as fewer individual and community resources for recovery are available, therefore making the community less resilient to the hazard impacts. Another category of data, the parameter of 'Age', was the percentage of people aged 18-25 or over 85 years of age living in the block group, with 'High' meaning high percentage of those groups compared to 'Low/Medium' (Table 1). Extremes of the age spectrum have less of an ability to move out of harm's way during a hazard event or have the money to recover afterwards. Parents lose time and money caring for children while elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience (Cutter 2003).

The three categories are intersected together to see where they overlap spacially in the study area and the Socio-Economic Groups are each given a group name for ease of understanding (Table 2). This map is viewed in conjunction with previous work done on Landslide Hazards (Figure 2), using the Tabulate Areas tool, to see which residences are living in different hazard areas, with particular focus on the High Hazard areas.



Methodology (Table 1)	
Parameter	Attribute
Race	White
	Black or African American
Income	Income Above (\$25,000, \$45,000)
	Income Below (\$25,000, \$45,000)
Age	High (13%-82%)
	Low (0%-4%)/Medium (5%-12%)



Methodology (Table 2)	
Group Attributes	Group Name
Low/Medium Age and White and Mean Below \$45000	Group 1
Low/Medium Age and White and Mean Above \$45000	Group 2
Low/Medium Age and Black or African American and Mean Below \$25000	Group 3
Low/Medium Age and Black or African American and Mean Above \$25000	Group 4
High Age and White and Mean Below \$45000	Group 5
High Age and White and Mean Above \$45000	Group 6
High Age and Black or African American and Mean Below \$25000	Group 7
High Age and Black or African American and Mean Above \$25000	Group 8

VI. Acknowledgements

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III. Results and Discussion

The Hazard Map shows 0.001% of the study area is in a high hazard area, while 6.415% of the study area is in a low hazard area. The highest percentage is 70.267% of the study area for medium low hazard, and 22.148% of the study area in medium hazard, with finally 1.169% of the study area in high medium hazard. The counties with the highest percentage of high hazard are located in Pickens and Oconee Counties.

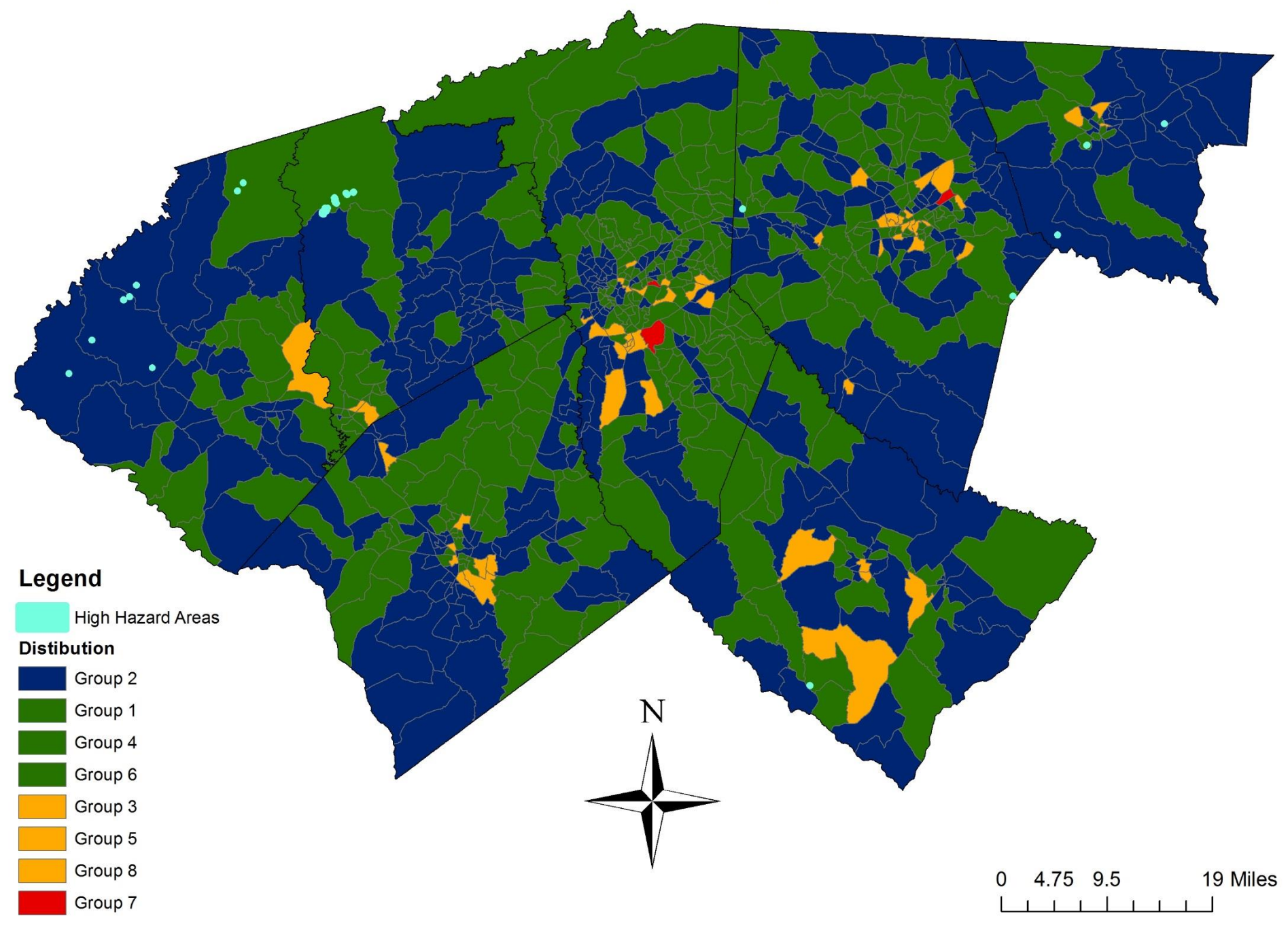
For each population, the hazard most populations live in, percentage-wise, is medium-low hazard (2). The populations that have the highest percentage of living in this hazard area are Group 2, Group 3, and Group 8. The smallest proportion of the population lives in the high hazard area (5), as expected since it is the smallest amount of area. More interestingly, those that live there are only differentiated from the rest of the population categories by the attribute White, and those with the attribute Mean Below \$45,000 are slightly more likely to be living in the high hazard (5) than those living in the category of the attribute Mean Above \$45,000. In the medium-high hazard (4) area, there is a greater distribution of populations but those most likely to be living there are also only differentiated from the population categories by the attribute White. In the low hazard (1) area, Group 6 is the highest population. An interesting trend is that the only time the attribute Age is in the highest population is in the Low Hazard (1) (Table 3).

Only two populations live in the high hazard (5) area: Group 1 and Group 2, with the category of the attribute Mean Below \$45,000 having a much higher percentage of occupation. In every other Hazard rank, Group 2 is the highest percentage. Comparing the High Age categories to one another, Group 2 is the higher percentage in the study area in the lower hazards (1-3) and in medium-high hazard (4) Group 1 becomes the higher percentage in the study area. In comparing the Black categories to one another, Group 3 is the higher percentage in the study area in the lower hazards (1-2) and Group 4 in the medium and medium-high hazards (3-4). Comparing income as a whole looks a little skewed because of the higher numbers under Whites than Blacks or African Americans but if the two races are compared separately before seeing if the trends are the same then it is much easier. Interestingly, Mean Above has a higher percentage of the study area in the lower hazards (1-3 or 4) and Mean Below has a higher percentage of the study area in the higher hazards (3 or 4-4 or 5). This trend seems to hold for both races and across all categories except Low/Medium Age and Black or African American which is reversed (Table 4).

IV. Conclusion

The Socio-Economic Map and High Hazard Landslide Areas (Figure 3) viewed together show the populations that are most affected in the Upstate of South Carolina. Based on the outcome, we conclude that high percentages populations aged between 18-25 or over 85 is not a significant indicator of an individual living in an area of landslide hazard. Low income and race is a much more significant indicator of an individual living in an area of landslide hazard. This is important to understanding which populations are most affected in the Upstate and who is living in landslide hazard areas. This is also important to understanding how different populations can be helped should a landslide occur.

Figure 3: Socio-Economic Map of the Upstate of South Carolina



VII. References/ Data Sources

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Data from South Carolina Department of Natural Resources (SCDNR), United States Geologic Society (USGS), Google Earth, National Historical Geographic Information System (NHGIS), and the American Community Survey (ACS)

V. Future Research

Future work in this area can be done to see if certain a certain race or income level is more vulnerable to be affected by the cost of landslides. Long term, implementing a policy plan that helps supports those who are disproportionately affected is an important step to further the work. Also, I would like to look at what is accessible for shelter and food to those in the area should a landslide occur.