Urban Social Vulnerability Assessment under COVID-19 and Natural Disasters

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Sanni Saari[a,f], Ryan Wang[b], John Cairns[c], Claire Wang[a,f], Allen Li[d,f], Edward Yang[e,f], Alexander Brody[g]

[a]Texas A&M Consolidated High School, [b]University Laboratory High School-University of Illinois at Urbana-Champaign(UIUC), [c]Allen Academy, [d]College Station Middle School, [e]Pecan Trail Intermediate School, [f]Texas A&M Chinese School, [g]Emery/Weiner School

Introduction

Natural disasters such as hurricanes and tropical storms are proven to be caused by climate change, a global affliction fueled by unsustainable living[1]. Since 1900, the greater Houston area has endured 45 floods caused by numerous tropical storms and hurricanes[2], the most famous being Hurricane Harvey, which caused an economic loss of $16 billion and the destruction of nearly 135,000 homes[3]. Floods in general also cause chemical leakages which contaminate air, food, and water[4], a dramatic increase in homelessness[5], severe healthcare crises, and the destruction of crucial infrastructure.

The Novel Coronavirus disease has become a new challenge to the greater Houston area. Being within a six-foot distance to an infected patient is enough contact for the virus to spread[6]. As of May 31st, 2020, Harris County contains about 12,220 confirmed COVID-19 cases and 231 deaths related to the virus[7]. National Hurricane Center predicted that a 50% chance exists for a Hurricane to develop near Houston in the start of June[8]. In the case of a natural disaster, people crowding in hospitals and safety shelters is a new concerning level of physical contact which will stimulate exponentially rising COVID-19 cases, adding to Houston's already large potential burden. In summary, Houston is threatened by a double catastrophe. Rising Coronavirus cases and severe flood damage will leave the great Houston area with an economic depression and health crisis.

This poster is developed by a group of K-12 students. We aim to analyze the urban social vulnerability of the greater Houston area, predict the impact of a pandemic and natural disaster, and provide recommendations to protect socially vulnerable communities.

Material and Method

Multiple Criteria Decision Analysis (MCDA) can be used to address problems that involve a finite and discrete set of alternatives that have to be evaluated on the basis of conflicting objectives[9]. The decision maker´s preference is often integrated into value function $V(a)$.

$$V(a) = F\big(V_1(a_1), \dots, V_m(a_m)\big);$$

Where alternative a is presented as a vector of the evaluation criteria, a= $(a_1, \dots, a_m)$; a_j is an estimate of this alternative against a criterion C_j, j= 1, …,m; and $V_j(a_j)$ is the value score of the alternative reflecting its performance on criterion C_j via use of a value function $V_j(x)$ $(0 \le v_j(x) \le 1)$. MCDA allows ranking alternatives based on assessing overall scores for alternatives under consideration. The simplest and most often used aggregation method in MCDA is the additive model:

$$V(a) = w_1 v_1(a_1) + \cdots + w_m v_m(a_m),$$

Where $w_j > 0$, $\sum w_i = 1$, w_j, j=1, …m is the importance weight for each criterion assigned by decision maker. V (α) is the total value of the alternative α; v_i (α_i) is the simple attribute value function reflecting alternative α's performance on each attribute.

Here, the urban social vulnerability for each census block group is evaluated based on the following attributes: percentage of population with no health insurance, number of hospital bed per 1000 people within 25 km, number of people over 60 years old, number of people with health issues such as heart disease, cancer, diabetes, high blood pressure and asthma, and the amount of poverty. We assigned equal weight for each attribute to calculate the weighted sum social vulnerability value for every census block group polygon. After that, we highlighted the census block groups that are within the FEMA flood plain. Figure 1 illustrates the analysis results.

Data

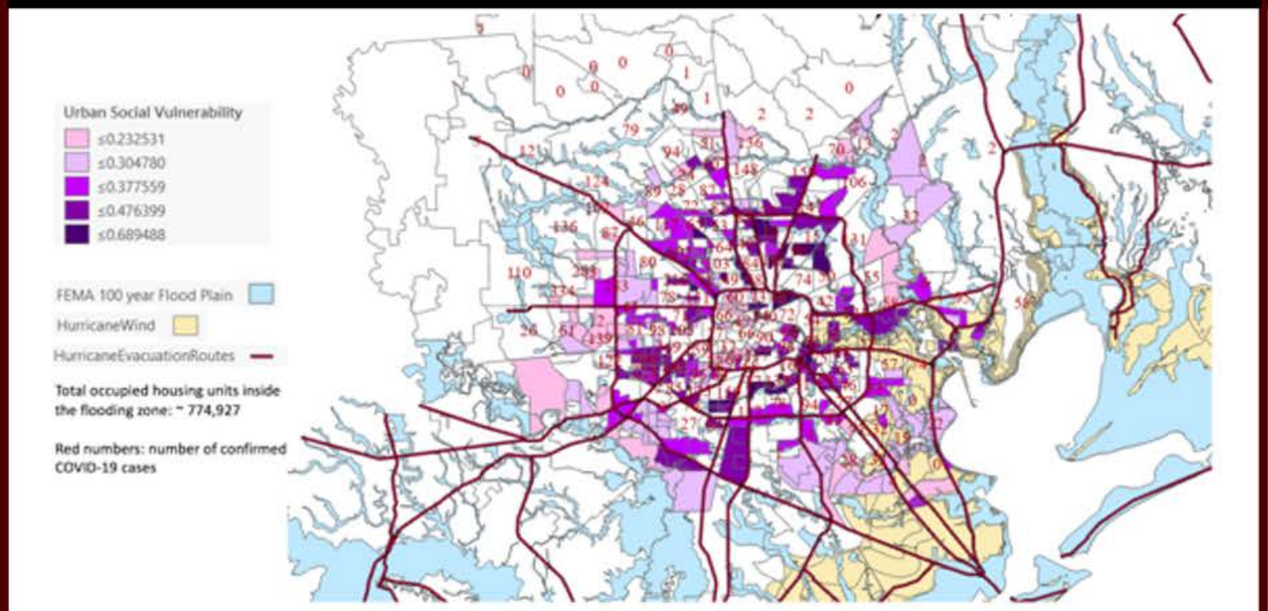
The Center for Texas Beaches and Shores data atlas:
https://www.texascoastalatlas.com/AtlasViewers/bayatlas/viewer.html

Harris County/Houston COVID-19 cases:
https://harriscounty.maps.arcgis.com/apps/opsdashboard/index.html#/c0de71f8ea484b85bb5efcb7c07c6914

COVID-19 vulnerability index score for census tracts in the US' 500 largest cities
https://socialprogress.blog/2020/04/03/covid-19-vulnerability-mapping-for-the-uss-500-largest-cities/

ACS Population and Housing Basic- number of occupied houses:
https://www.census.gov/data/developers/data-sets.html

Figure 1. Illustration of Urban Social Vulnerability for the Greater Houston Area



Results and Discussion

Results:

Figure 1 is a visualization of what the double threats of a flood and pandemic will look like in the greater Houston area; it also examines the most socially vulnerable areas. According to our calculations, a potential flood can damage approximately 774,927 occupied housing units, meaning thousands of people will be forced out of their homes, breaking the rules of social distancing. This new level of contact can accelerate the transmission of the Coronavirus, severely threatening low-income and poor-health communities without insurance. In this map, the red numbers represent the number of confirmed COVID-19 cases as of May 31st, 2020 on a zip code level. As illustrated in the figure, Harris County has the highest amount of cases compared to its surroundings. The tan color represents the track of the hurricane winds if they were to come, and the blue shade represents the flood planes on land. The colored census block groups are the areas that will be in contact with the flood water. The darkness of the purple indicates the severity of the social vulnerability determined by the level of income, health condition, age, and insurance and health care status. The dark red lines represent existing evacuation routes. Results indicate that socially vulnerable areas seem to have a high number of COVID-19 cases. The most socially vulnerable areas are in Northeast and South Houston. Winds hit the eastern shore of Houston, and floods will encompass most of Houston relatively evenly.

Discussion and Recommendation:

- We should work with homeless service providers, public agencies, and philanthropic leaders to develop systems to solve complex problems in reducing homelessness in the greater Houston area.
- Use renewable energy to reduce pollution and climate change; tropical storms are ultimately caused by climate change. Renewable energy does not emit harmful chemicals and is a clean, realistic alternative to burning fossil fuels. The government should set more strict sustainability standards.
- Based on the analysis results, government organizations should invest more effort in the hotspot areas for disaster preparedness and health care mitigation.

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