

Develop A GIS Based Risk Model to Evaluate the Economic Resilience of Houston Neighborhoods for the Next Oil Bust

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1 Introduction

Houston is the center of energy in the world and hosts more than 5,000 energy related companies. Oil and gas business has been the major industry in Houston since the early twentieth century. By the end of 1970, Houston had attracted thousands of oil workers because of the oil boom in West Texas. Many young professionals rushed to Houston for high earning jobs in oil and gas companies. However, due to the oil exploration and production in North Sea and the following declined demands, the price of crude oil dropped from 20 dollars to 1 dollar in the early 1980s, which caused serious unemployment problem in Houston. Many people lost jobs and many apartment complexes became empty. The drop of crude oil price caused significant impact on Houston's economical and urban development. With the rising energy demand from developing countries such as China and India from the 1990s, oil prices rose up dramatically in the past decade. Many new technologies have been developed to increase oil production such as Deep Sea and Shale Gas technologies. This change has stimulated the oil and gas industry in Houston and the oil and gas business has been booming again. Many young professionals are rushing to Houston again for oil and gas.

According to some statistics, the population in Houston is increasing at a rate of 2.0 % per year. A very large percentage of jobs are related to oil and gas industry. According to the survey data, 3.4 % of the total jobs in Houston are related to oil

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and gas business. The percentage of oil and gas jobs in Houston is much higher than the average 0.3 % national level. At the same time, many services jobs are also serving the oil and gas workers. The oil and gas industry brings tons of money into the city and the whole city depends on the energy business. However, a possible breakthrough in the research of clean energy technology can cause another bust of oil and gas industry in Houston in the near future.

Many other cities have similar economic structures. For example, Detroit is the capital of auto manufacturing industry and many of the jobs belong to vehicle manufacturing and its related business. San Jose, California heavily relies on the information technology (IT) industry. This kind of single mode of economy has potential risks on future development. With the decline of auto manufacturing, the whole city of Detroit got into economic depression since the late 1970s. Detroit was selling some one-dollar houses in the recent housing market crisis. Many communities became ghost neighborhoods. Relying on a single industry can put cities into high risk if the major industry collapses. A city with multiple industries can be more resilient to this kind of industry collapse.

With the development of green energy, it is possible that oil and gas industry can collapse in one day. How will we respond to such an event? Is Houston ready for changing its traditional oil and gas industry or switching into other industries? In the future several decades, it is possible that a green energy technology can replace the traditional fossil fuel. It is necessary to evaluate the potential risk associated with this event and make us be prepared for future challenges.

2 Urban Resilience

In the literature, urban resilience refers to the capacity of a city to prepare for, respond to, and recover from destruction. Campanella [1] stated that urban resilience is a function of resilient and resourceful of citizens. The recovery of social network with strong citizen participation would be as important as the rebuilding physical infrastructure to ensure the successful revival of a city after major disasters, such as New Orleans after the strike of Hurricane Katrina. Some scholars also made conceptual and empirical discussions on the relevant issues from the aspect of economic vulnerability, such as Cordina [2], Liu et al. [3], and Weir et al. [4].

Urban or regional resilience has been addressed in the literature from different aspects. Lin [5] examines the long term population change across metropolitan areas in the US using regional resilience index that were measured using population data from Census. It is possible to develop an urban resilient index for cities responding to unfavorable events.

High fuel price may have positive effects for the economic sectors related to energy industry but negative effects on many other sectors. It may impose a large gap of social and economic impacts among cities with different combination of industries. Dodson and Sipe [6] developed oil vulnerability index to demonstrate the spatial variability of social and economic impacts of higher fuel prices in Australian cities.

Oil bust has also been addressed in literature. Leigh and Vukovic [7] analyzed the recent change in the supply and demand of oil and investigated the socio-economic and geopolitical consequence of dwindling supply of crude oils. Newman [8] points out most of the U.S. Cities are automobile dependent and thus oil dependent. The progress made by electrical car manufacturers these years can potentially reduce the oil demand significantly. It would be interesting for this study to focus on Houston, the world's energy capital and to develop a resilience index for the city.

3 1980 Oil Bust

In the early 1980s, oil price was about \$33 a barrel. The oil and gas industry was booming in Houston. Major oil companies' exploration and production in the US soared and many new oil fields were under development to meet the economic development needs. Houston attracted much attention from job-seekers across America. At the same period, the unemployment rate stood at 17.2 % in December, 1982 because of the huge import of Japanese cars. Many people moved to Houston from Detroit and other parts of the country. Many apartment complexes were built in the Southwest and other parts of Houston to accommodate these migrant workers for oil and gas industry.

However, the oil bubble didn't last for too long. The oil industry bust began in the early 1980s as a result of slowed economic activity in developed countries due to the energy crisis of the 1970s. The energy conservation caused by high fuel prices slowed down the economic development. In the U.S., domestic exploration declined dramatically in the 1980s. Major oil companies put holds on the search for new oilfields. Houston went into recession due to the slowdown of exploration. During these recessions in the early 1980s, Houston's economy collapsed. Many apartments were abandoned and a large percentage of workers were unemployed. Many workers moved out of Houston to seek other opportunities in other cities.

Southwest Houston has a high population density close to approximately 9,000 people per square mile. This area is composed of residential, commercial, and industrial development. There are both single-family residential neighborhoods and numerous low-rise and mid-rise multi-family residential complexes. Southwest Houston has multiple light-industrial parks, as well as a heavy-industrial plant.

Many subdivisions in Southwest Houston were once the victims of the oil-bust recession of the early 1980s. Neighborhoods such as Westwood, and Forum Park, etc. were created over night as large apartment complexes were built to accommodate the oil workers in the 1970s. Oil price dropped to \$10 a barrel in January 1986. With 70 % of jobs in the Houston area depending directly or indirectly on the oil industry, the bust caused devastating effects on local economy. Construction stopped overnight and many people lost jobs. In January 1983, unemployment rate in the Houston metropolitan area rose to 9.1 %, the highest among the state's largest metropolitan areas. Many people moved out of Houston and most of these people were renters and many apartments became empty.

Unfortunately, this area went down dramatically with the oil bust in the early 1980s. Almost as fast as these apartment complexes had been built, they were

nearly abandoned after the oil bust. A high crime rate was caused by these abandoned apartments. Drug deals and prostitution were made in these abandoned apartments in Southwest Houston. It was similar to what is going on in Detroit today. Many crimes were generated in abandoned homes. The high crime also caused more people to move out of those neighborhoods. The oil bust in the early 1980s put this area into a bad cycle. With the new booming of oil and gas business these days, this area is becoming better than that in 1980s, but there is still some risk related to this area. This area was never fully recovered from this oil bust and remains one of the poor areas in the city.

4 Risk Factors for City and Community Resilience

The risk model assessing city resilience to major economy meltdown needs to cover multiple factors. In this paper we mainly focus on the following factors:

Education attainment

Median income

Homeownership

Availability of public transportation

Percentage of oil and gas employment

Population stability

Employment needs

Education attainment plays an important role in the risk modeling for economic resilience because it determines whether the residents in the neighborhood can switch to other types of jobs if another oil bust happens in Houston. The median income level also plays an important role because higher incomes can allow residents to stay with unemployment benefits. Homeownership is another important factor because people tend to stay longer if they own a house or apartment. Renters tend to move soon after they become unemployed. Availability of public transportation factor is based on the number of bus stops because public transportation can help find jobs during recession especially for the poor people. The percentage of oil and gas employment is the most important factor in this model. The ACS 5 Year estimate provides the percentage of direct oil and gas employment in each census tract. Population stability is measured by the percentage of population that stayed in Harris County for more than 1 year. People who moved from other counties or states tend to move back easily. Employment needs is measured by the percentage of population between ages 18 and 64. All these seven factors have five different rankings based on the corresponding classification criteria. The American Community Survey along with the US Census data provides the best estimation of all these factors at census tract level (Tables 1, 2, 3, 4, 5, 6, 7, and 8) (Figs. 1, 2, 3, 4, 5, 6, 7, and 8).

The overall resilience is a sum of all the ranking scores. It is a good indicator for the future economic resilience in case of another oil bust in the future. It provides an

Table 1 Resilience ranking for education factor

Range (percentage of people with high school diploma or higher)	Resilience score (1–5)
0–13.2	1
13.2–28.1	2
28.1–46.2	3
46.2–65.2	4
65.2 or higher	5

Table 2 Resilience ranking for median income factor

Range (median income in USD)	Resilience score (1–5)
13,257–29,082	1
29,082–43,014	2
43,014–59,539	3
59,539–83,167	4
83,169–133,096	5

Table 3 Resilience ranking for home ownership factor

Range (percentage of homes owned by residents)	Resilience score (1–5)
0–24.99	1
24.99–47.85	2
47.85–64.93	3
64.93–80.09	4
80.09–96.1	5

Table 4 Resilience ranking for public transportation factor

Range (number of bus stops)	Resilience score (1–5)
0–7	1
8–21	2
22–39	3
40–75	4
76–215	5

Table 5 Resilience ranking for oil and gas employment factor

Range (percentage of oil and gas employment)	Resilience score (1–5)
0.084769–0.190149	1
0.051502–0.084768	2
0.028640–0.051501	3
0.011612–0.028639	4
0–0.011611	5

overview of the distribution of resilience indexes in Harris County. In Fig. 8, we can tell that some areas are going to have better resilience to future oil bust than other areas. The risk index gives planners a big picture for the future planning activities.

Table 6 Resilience ranking for population stability factor

Range (percentage of population with more than 1 year residence in Harris County)	Resilience score (1–5)
0.612871–0.798963	1
0.798964–0.884758	2
0.884759–0.936300	3
0.936301–0.970098	4
0.970099–1	5

Table 7 Resilience ranking for employment needs factor

Range (percentage of oil and gas employment)	Resilience score (1–5)
78.3–98.7	1
69.1–78.3	2
63.5–69.1	3
58.5–63.5	4
47.9–58.5	5

Table 8 Resilience ranking for all the factors

Range (summed factor scores)	Category
12–17	1
18–20	2
21–23	3
24–26	4
27–31	5

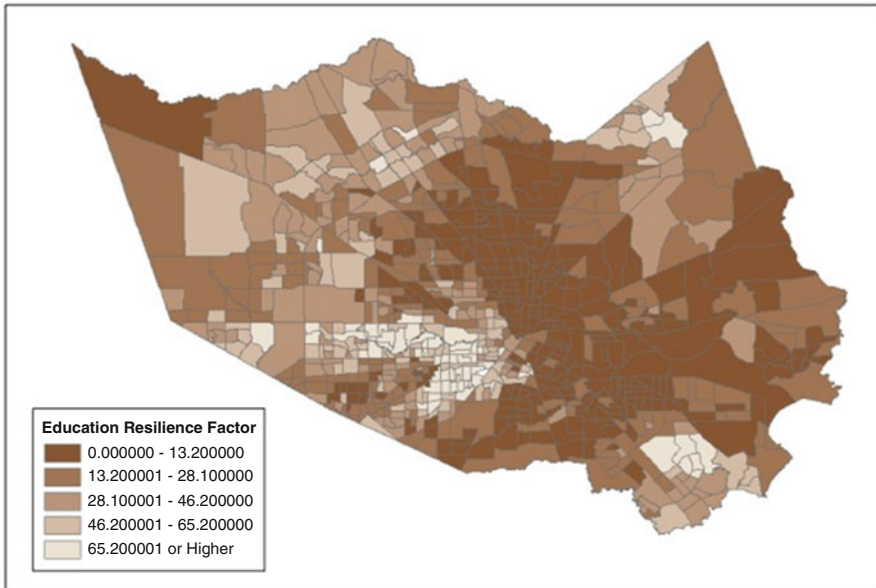


Fig. 1 Education attainment factor in Harris County

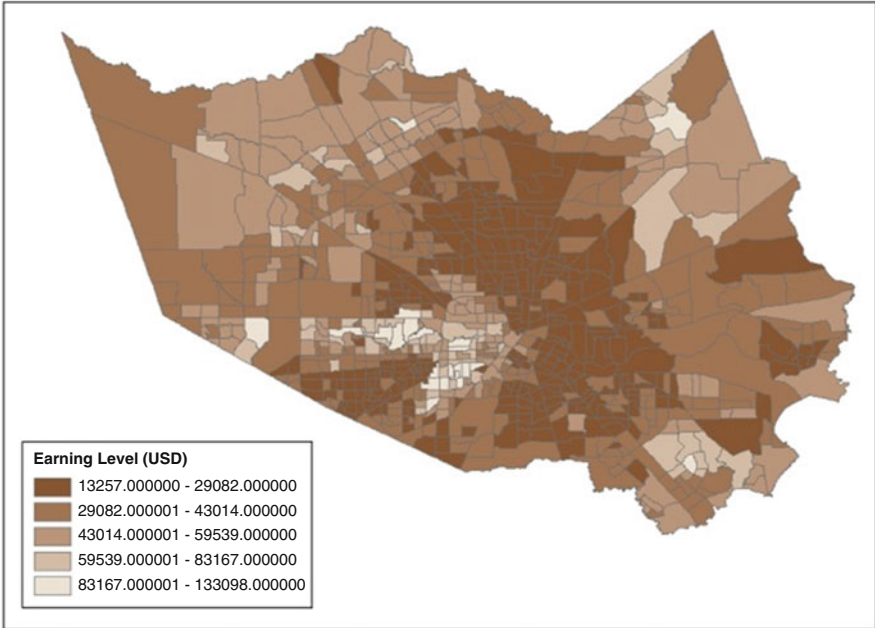


Fig. 2 Earning level risk factor in Harris County

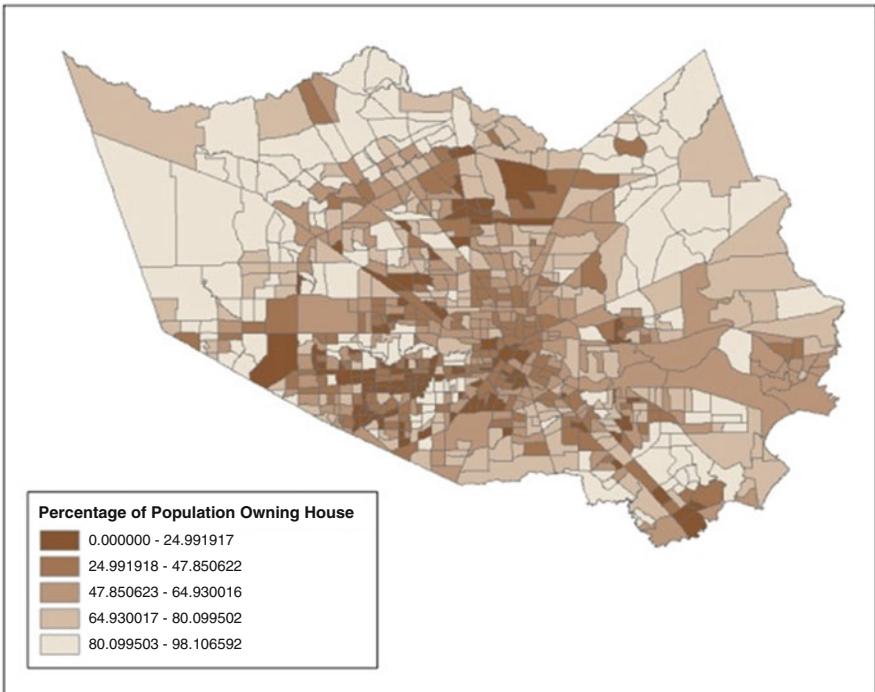


Fig. 3 Home ownership risk factor in Harris County

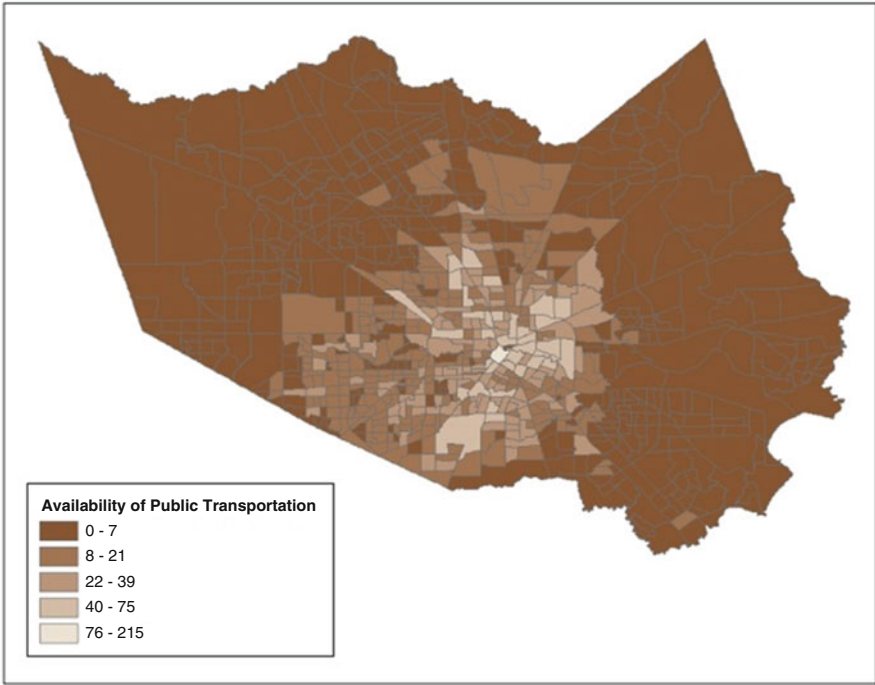


Fig. 4 Public transportation risk factor in Harris County

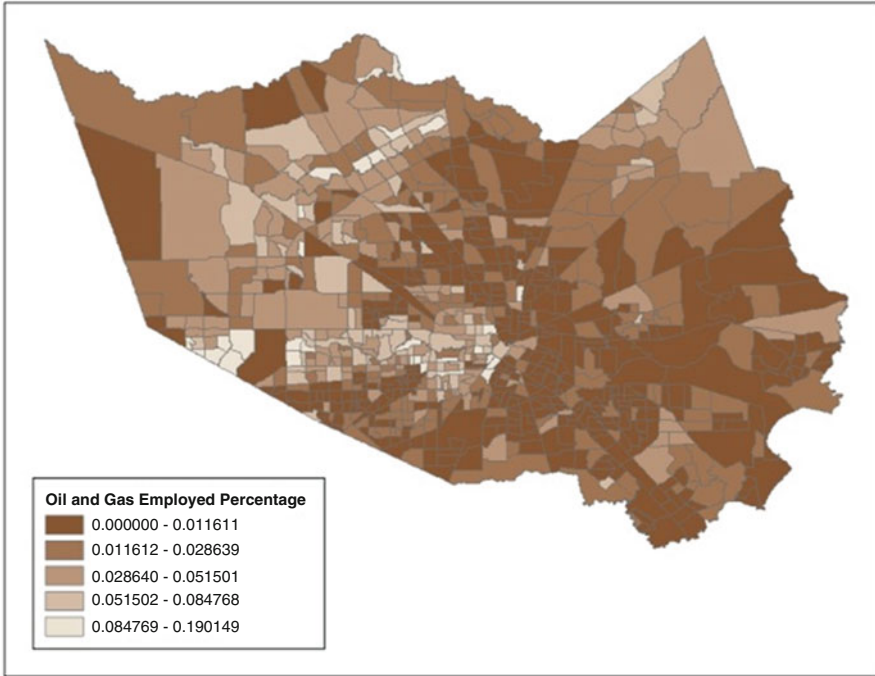


Fig. 5 Oil and gas employment risk factor in Harris County

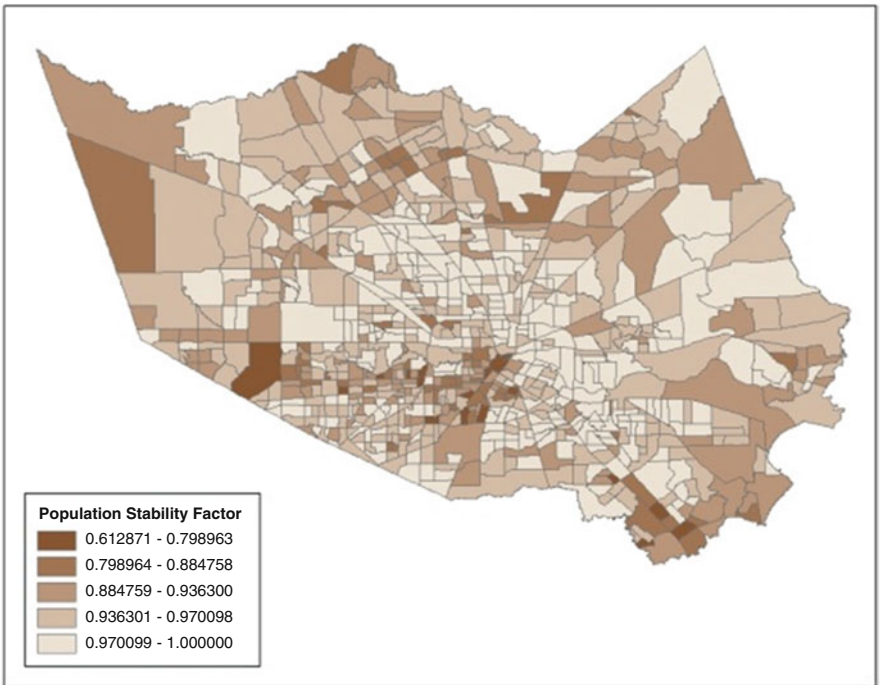


Fig. 6 Population stability risk factor in Harris County

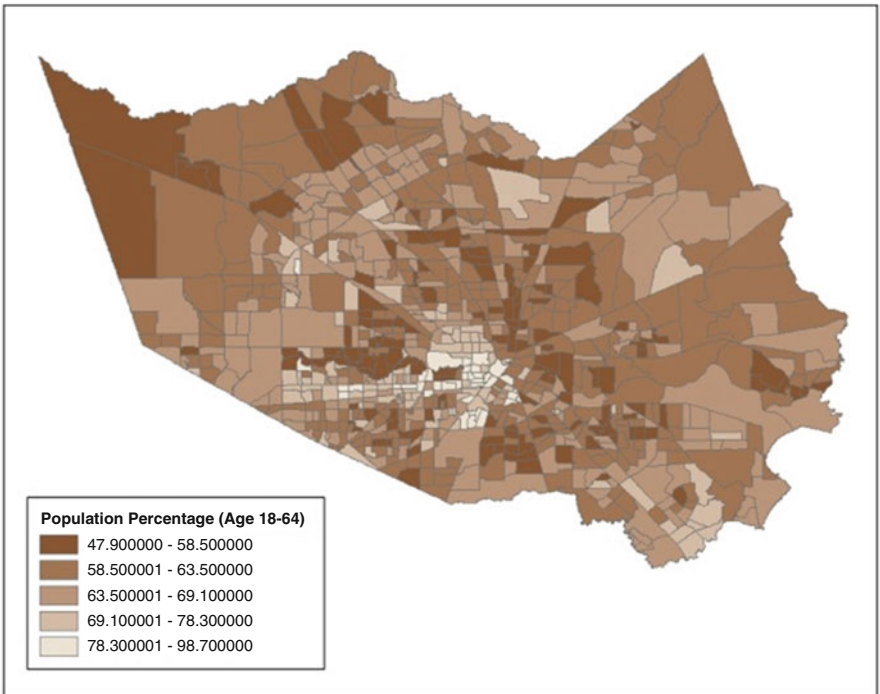


Fig. 7 Employment needs risk factor in Harris County

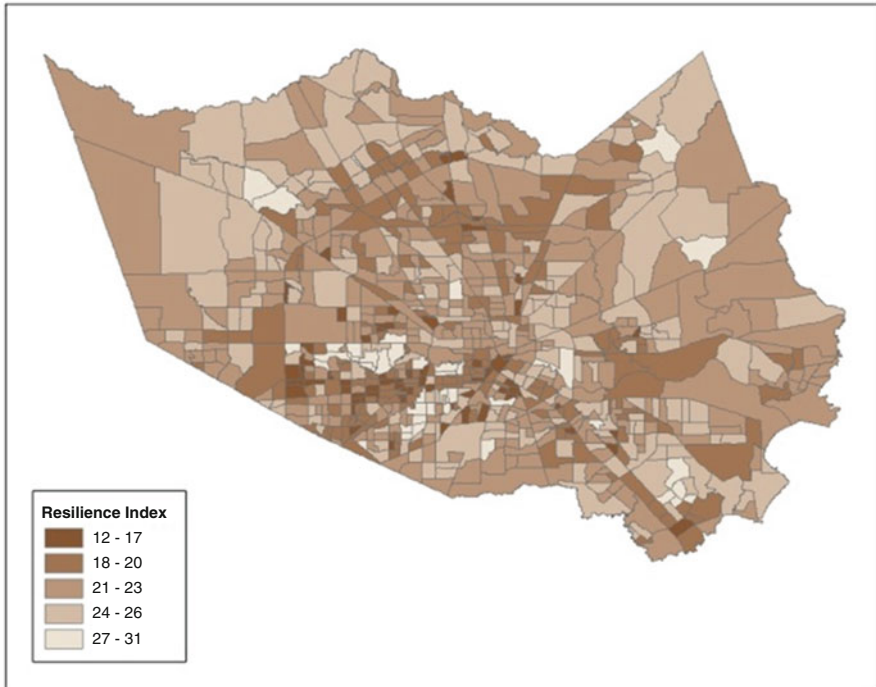


Fig. 8 Overall resilience index in Harris County

5 Conclusion

The American Community Survey (ACS) data sets give us much useful information to model the economic resilience of communities. The model proposed in this paper is a prototype and this model can be expanded to incorporate more risk factors. This prototype gives us a big picture of the economic resilience in Harris County. In order to improve the economic resilience in Houston, we need to improve the education system and prepare more educated work force for the future economic meltdown. At the same time, we also should promote the public transportation and make the jobs more accessible. It is very important for the poor people to get jobs in an economic recession. This model can be very helpful for planners to understand regional economic resilience to the next oil bust.

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