**The International Emergency Management Society**
*9th Annual Conference Proceedings*
*University of Waterloo, Canada, May 14-17, 2002*

# A SYSTEM APPROACH TO ENVIRONMENTAL HAZARD ASSESSMENTS

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**Keywords:** Risk Assessment, Systems-approach, GIS, Texas, Hurricanes, and Hazards

## Abstract:

The work of two separate projects are united in this paper, which is a project proposing a systems-based approach to disaster risk analysis. These projects are focused upon the Clearlake region of south Texas, which includes the southern district of Harris county and northern Galveston county. The Clearlake region is composed of growing urban, recreational and industrial developments on the outskirts of the southern Houston metroplex. This area of Texas has historically had the worst natural and technological disasters in the United States of America.

The purpose of this paper is to examine the interplay between industry (especially hazardous material facilities), topography, geography, demographics and politics. The primary data used in this paper is collected from a series of interviews with emergency managers in the area. The information is then juxtaposed with secondary data gathered through GIS analysis and information accessible through the Internet, such as hazardous material sites, and demographics. The GIS analysis shows the extent to which each segment of the study area is likely to be vulnerable to hurricane, flood and chemical hazards.

A unique feature of this paper is the systematic approach to risk analysis which is employed to evaluate the physical dimensions of hazard vulnerability as well as the political and social constraints that exist on preparedness, response, recovery and mitigation. Within this framework, hazard vulnerability is evaluated in light of the Clearlake region's susceptibility to hurricane, flood, and chemical hazards that could severely tax the resources of the area. Ten variables are defined and then applied to the various sub-regions within the study area providing an overall score to represent the risk for each variable. A summary score for each city is then obtained. These scores are averaged together to give an overall risk assessment of the cities in the Clearlake region. The variables examined include: (1) disaster history, (2) special hazard zones, (3) topography, (4) hazardous facility sites, (5) demographics, (6) non-structural mitigation efforts (7) special resources, (8) socio-political dynamics, (9) special administrative districts, and (10) the integration of the planning process.

## Introduction:

This paper introduces a systems-based approach to risk analysis for natural and technological disasters, using the city as the principal level of analysis. Through out the paper the terms "disaster planning" and "emergency management" are used interchangeably. We realize there is a difference in these two activities, but in our case study the disaster planners were also the emergency managers in most instances, and therefore the terms became easily interchangeable. The systems approach to risk analysis is achieved through a multidisciplinary endeavor involving the work of two independent research projects concentrated in the south central region of Texas. The first research project uses secondary data to evaluate spatial land-use patterns to assess relative risk. The Geographic Information System (GIS) is primarily employed to delineate the spatial distribution of hazardous material facilities and their relationship to population centers and surge danger zones. Additionally, secondary data is used to assess risk in relation to population densities, socioeconomic status, hazardous facility sites, and topographical features. The second research project involved an evaluation of the disaster planning process among emergency managers in the region which comprises the southern portion of Harris county and northern parts of Galveston County. In this project many of the sociological and cultural aspects found in this region were considered and their effect on the planning process was assessed. The combination of these two research endeavors has led to a systemic approach to risk analysis which takes into account issues such as planning, geography, industry, urbanization and disaster history.

Previous assessments of risk analysis for natural disasters have tended to focus on a single aspect of risk, such as risk communication (Rogers, 1992, and Lindell, 1997), psychological and social components of risk (Bolin, 1986), or structural and non-structural mitigation efforts. Additionally, most of these research efforts have been focused on securing disaster-related information for the benefit of emergency managers or other researches. Our approach is to use ten variables that can be summarized into a single index; this would give an overall measure of risk for a particular city. In principle these ten variables can then be applied to other cities so a similar risk analysis can be conducted in other areas, and there will thus be a common basis for a comparative risk index. This approach allows a comparison between cities, even when the risk is based on different hazards. For example, one could calculate a relative risk index for Tampa, Florida, and compare it to the risk index for Palo Alto, California; although the potential hazard for the two areas are different. A new home-buyer could then, compare the risk indices of various towns in order to determine the relative risk of living in one town verses another. Obviously, this approach would also have implications for emergency managers, land-use planners, and insurance companies. One of the strengths of using a system's-based approach to measure risk is that it incorporates many societal and cultural factors. Many of the variables identified in the measurement of the risk index can be addressed by local authorities, who may be interested in reducing the region's perceived risk. Emergency managers would gain a certain level of control over how risk is evaluated and perceived for their city, and feel less victimized by the circumstances of their regional geography or a sense of fatalism.

The basic unit of analysis for this is the city, as defined by the political boundaries of those communities in our study area. The variables involved in this study are as follows: (1) disaster history, (2) distribution of special hazard zones, (3) topography, (4) hazardous facility sites, (5) demographics, (6) non-structural mitigation efforts (7) special resources in the area, (8) socio-political dynamics, (9) special administrative districts, and (10) the integration of the planning process. The one element both authors feel is missing in this assessment is a measure of the public's own awareness and knowledge of risk and mitigation behaviors. However, that data was not available at the time of this study. We hope to refine the assessment tool in the future through the development of an interview schedule or survey, and thereby assess the scope of the public's risk awareness, and of their knowledge of appropriate hazardous response behaviors.

## Variables:

Disaster History:

Disaster history accounts for those natural disasters that are particular to a certain area. In our case study, which is concerned with the south Houston metropolitan region and Galveston County, the disaster history is rather significant. Galveston Island was the scene of the worst natural disaster in American history. In September of 1900 a major hurricane hit the island, resulting in the death of over six thousand people (Larson, 1990). This was followed years 47 later by the worst technological disaster in American history, which occurred in the port of Texas City. An explosion of a cargo ship carrying Ammonium Nitrate caused a shockwave, which was registered on a Richter Scale as far away a Denver, Colorado. The explosion had the impact of a force equal to that of the Nagasaki bomb (Thomas, 1987). These two events, in particular, have had a large impact on American disaster history; however, they seem to have had little impact on the development of a functional disaster culture in the area (Davenport: 17-18). Disaster cultures tend to develop when there is a cyclical occurrence of a disaster, such as yearly flooding, and when there is advanced warning of an impending disaster that happens in some predictable fashion, such as a typhoon in the summer months (Schneider, 1957). The history surrounding our study area does not have such a predictable disaster history or all the elements that have been identified as requisite for the development of a disaster culture. There has, therefore, been little development of a disaster culture; instead a sense of bravado has emerged, especially among long-time residents, who feel they can withstand anything nature puts forth (Davenport: 20; Larson, 1999).

New migrants to the area, attracted since the 1950's by the expansion of the oil industry and the technological sector of the economy (Rogge, 1996), have had little exposure to extreme storms and therefore seem to be more sensitive to threats of severe weather. However, as migrants settle into the area and experience severe weather, such as tropical storms and mild flooding, they tend to underestimate the power of truly extreme hurricanes and other disasters. This experience has also been confirmed by researchers as Cutter (1993: 25) who states: “Lack of experience tends to amplify the risks until such time as risks are moderated or people have adapted to them.” Through interviews with emergency managers, and informal conversations with local residents, the researchers conclude that a combination of these two factors, a sense of bravado and a decreasing sensitivity to severe weather warnings, has led to an overall sense among residents of invulnerability to a disasters; this is in spite of numerous attempts by the media and emergency managers to provide hurricane and tornado information and education each year. The risk factor that gets the least attention by the media and others is technological risk. This risk factor is an ever-present and eminent danger in the area due to the many petrochemical plants in the region and the smaller industries that have built symbiotic relationships with them. This brief overview of the area presents some of the historical event relating to disasters which have affected the region, and gives a framework within which one might develop a greater understanding of the culture in the area.

The area under study has a history of four types of disasters which continue to pose risks to the populations, even if that sense of danger diminishes with time. The risk factors identified for this area are as follows: hurricanes, tornadoes, flooding, and toxic releases. Each type of risk is given a weight of one to provide a score for the first variable in the risk index (see table 1). This table is developed a little differently than the rest. Instead of developing categories for each risk type, we have just listed the various risks that have had a historical presence in the area. For the purpose of this analysis, each risk type is valued equally, though we are aware that some hazards have greater frequent and intensity than others.

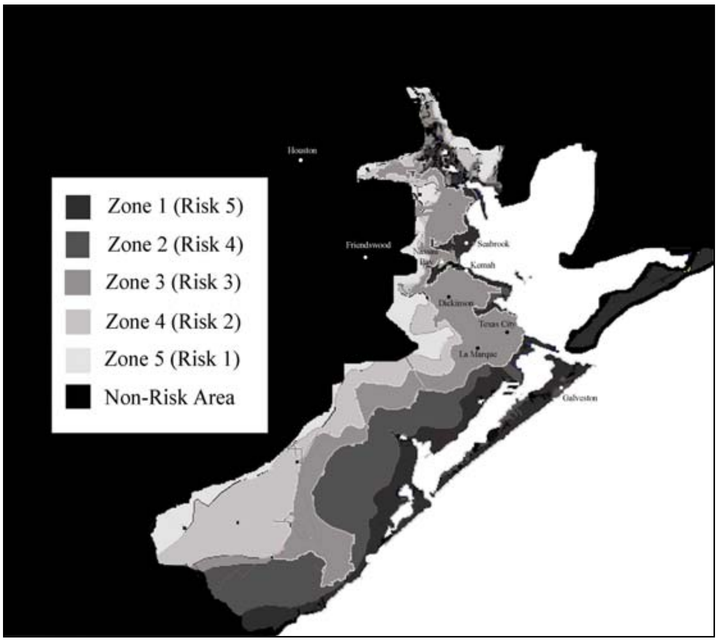
Table 1

| COUNTY | CITY | INDEX | Tornado | Hurricanes | Flooding | Hazmat | POP | Total R POP |
|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | 4 | 1 | 1 | 1 | 1 | 1,205 | 1,205 |
| GALVESTON | Dickinson | 4 | 1 | 1 | 1 | 1 | 17,093 | 17,093 |
| GALVESTON | Friendswood | 4 | 1 | 1 | 1 | 1 | 29,037 | 21,237 |
| GALVESTON | Galveston | 4 | 1 | 1 | 1 | 1 | 57,247 | 55,888 |
| GALVESTON | Kemah | 4 | 1 | 1 | 1 | 1 | 2,330 | 2,330 |
| GALVESTON | La Marque | 4 | 1 | 1 | 1 | 1 | 13,682 | 13,682 |
| GALVESTON | League City | 4 | 1 | 1 | 1 | 1 | 45,444 | 38,901 |
| GALVESTON | Texas City | 4 | 1 | 1 | 1 | 1 | 41,521 | 41,521 |
| HARRIS | El Largo | 4 | 1 | 1 | 1 | 1 | 3,075 | 3,075 |
| HARRIS | Houston | 4 | 1 | 1 | 1 | 1 | 1,953,631 | 1,888,476 |
| HARRIS | Nassau Bay | 4 | 1 | 1 | 1 | 1 | 4,170 | 4,170 |
| HARRIS | Seabrook | 4 | 1 | 1 | 1 | 1 | 9,443 | 9,443 |
| HARRIS | Shoreacres | 4 | 1 | 1 | 1 | 1 | 1,488 | 1,488 |
| HARRIS | South Houston | 4 | 1 | 1 | 1 | 1 | 15,833 | 15,833 |
| HARRIS | Taylor Lake Village | 4 | 1 | 1 | 1 | 1 | 3,694 | 3,694 |
| HARRIS | Webster | 4 | 1 | 1 | 1 | 1 | 9,083 | 9,083 |

Mapping of Special Hazard Zones:

For our second variable, we have employed a GIS mapping system of special hazard zones. The purpose of this variable is to identify different geographical areas that would be associated with a specific natural hazard, such as fault lines, hillsides, or surge zones. In our study area, we are interested primarily in the land areas that are susceptible to surge inundation and ocean winds due to hurricane action. To locate the risk areas in the two counties, we used data developed at the Hazard Reduction and Recovery Center at Texas A&M University. Hurricane risk areas are divided into five categories that correlate to a hurricane's strength. These categories were developed based on topographic characteristics of the area, wind vulnerability and the surge height of a storm. The risk areas delineate the population susceptible to hurricane damage according to the severity of the storm. Areas that are most susceptible would be those that lie along the shoreline or at low elevations and in close proximity to the waterfront. Thus, populations living in area one would be susceptible to surge and wind damage in the event of a category one hurricane, using the Saffir/Simpson scale. As one moves further inland, populations become less vulnerable to wind and surge action from a hurricane. Those areas identified as zone five are the least susceptible to a hurricane and would only be affected by surge inundation and wind damage in the event of a hurricane five (See figure 1).

Figure 1




Since the city is being defined as the basic unit of analysis, we have considered each city and averaged in the hurricane risk for inundation and wind damage. However, in order for the index to have meaning, we must first reverse the level of risk associated with each zone. Thus, zone one would be given a risk rating of five, zone two a risk of four and so forth. Modification was necessary to ensure that all risk indices are on a scale of "1" as the least risk, to "5" as the highest risk. The lower the index number, the lower the risk for any particular category. If a city or part of a city was completely out of the risk zone, it was given a value of "0". We then averaged the risk indices of various zones within each city to achieve an overall risk index for the city. Thus, if a city lies partly within three different risk zones, we multiplied the percentage of the city in each zone and then tallied up the scores to arrive at a special hazard risk value for the city. We did not establish risk zones for tornadoes due to their erratic behavior and movements, and because there is no data to demonstrate any predictable patterns of occurrence, other than what is generally recognized as tornado alley.

Table 2

| COUNTY | City | FR_INDEX | FR_TOTAL |
|---|---|---|---|
| GALVESTON | Galveston | 5 | 4.11 |
| GALVESTON | Clear Lake Shore | 4 | 3.63 |
| GALVESTON | Texas City | 4 | 3.22 |
| HARRIS | Shoreacres | 4 | 3.07 |
| HARRIS | Nassau Bay | 3 | 2.92 |
| GALVESTON | La Marque | 3 | 2.25 |
| GALVESTON | Kemah | 3 | 2.21 |
| HARRIS | Seabrook | 3 | 2.17 |
| HARRIS | Taylor Lake Village | 2 | 2.00 |
| HARRIS | El Largo | 2 | 1.98 |
| GALVESTON | Dickinson | 2 | 1.89 |

| | | | |
|---|---|---|---|
| GALVESTON | League City | 2 | 1.50 |
| GALVESTON | Friendswood | 1 | 0.15 |
| HARRIS | Houston | 1 | 0.01 |
| HARRIS | Webster | 0 | 0.00 |

Topography:

The third variable examined is that of topography. The topography of a region can have many different consequences depending on the types of disasters typical to an area. In our case study, we are particularly concerned with topography in relation to a city's susceptibility to flooding. Using GIS modeling, we have taken The Federal Emergency Management Agency (FEMA) flood insurance Q3 data to identify those areas in our study region which are most susceptible to flooding; these correspond to the 100 and 500 year flood plains. We then compared these readings with actual flood data, and found that they closely resembled the available flood records. Due to the close correlation between topography and available flood data, and since only incomplete flood data was available in this region, topography was used directly to assess flood susceptibility. Once the GIS mapping was complete, we were able to take measurements in increments of one meter to determine where the low-lying areas were within a city. The lowest elevations were given a ranking of "5" since they were the most susceptible to flooding, while the highest elevations where ranked as "1" since they least susceptible to flood damage. The areas with elevation heights of 1 to 5 meters are the most vulnerable to flooding, compared to other areas at an elevation of more than 5 meters. The maximum ranking is five meters, or about fifteen feet, which is approximately the average rise in water level within the 100 year flood plain (FEMA National Flood Insurance Program, 1998). To arrive at a risk index for the city, we have determined the percentage of the population which lies within the various flood-risk zones (1-5) and then averaged these together. For example, if one city had a population center that spanned flood zones "5," "3," and "2," we would determine what proportion of the city's population lived in each risk zone and then multiply the risk zone value by the proportion of the population in the particular zone. These products are then added to give a total flood-risk index for the city (see table 3).

Table 3

| COUNTY | CITY | INDEX | POP | 1 M | 2M | 3M | 4M | 5M | TOTAL R POP |
|---|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | 5.0 | 1,205 | 1,205 | 0 | 0 | 0 | 0 | 1,205 |
| GALVESTON | Dickinson | 3.0 | 17,093 | 0 | 3 | 16,786 | 304 | 0 | 17,093 |
| GALVESTON | Friendswood_G | 0.4 | 21,237 | 0 | 0 | 0 | 680 | 6,379 | 7,059 |
| GALVESTON | Galveston | 4.5 | 57,247 | 29,977 | 27,270 | 0 | 0 | 0 | 57,247 |
| GALVESTON | Kemah | 3.9 | 2,330 | 739 | 551 | 1,040 | 0 | 0 | 2,330 |
| GALVESTON | League City | 2.8 | 45,444 | 4,839 | 2,894 | 23,895 | 4,669 | 9,069 | 45,366 |
| GALVESTON | Texas City | 3.0 | 41,521 | 151 | 344 | 40,917 | 82 | 27 | 41,521 |
| HARRIS | El Largo | 5.0 | 3,075 | 3,075 | 0 | 0 | 0 | 0 | 3,075 |
| HARRIS | Friendswood_H | 0.8 | 7,800 | 0 | 0 | 0 | 251 | 5,876 | 6,127 |
| HARRIS | Houston | 0.0 | 1,953,631 | 14 | 215 | 4,236 | 17,789 | 32,255 | 54,509 |
| HARRIS | Nassau Bay | 4.9 | 4,170 | 3,768 | 369 | 0 | 0 | 0 | 4,137 |
| HARRIS | Seabrook | 5.0 | 9,443 | 9,443 | 0 | 0 | 0 | 0 | 9,443 |
| HARRIS | Shoreacres | 2.7 | 1,488 | 0 | 711 | 373 | 0 | 0 | 1,084 |
| HARRIS | Taylor Lake Village | 4.5 | 3,694 | 3,328 | 0 | 0 | 0 | 0 | 3,328 |
| HARRIS | Webster | 3.2 | 9083 | 2,805 | 2,022 | 1,061 | 1,331 | 1,398 | 8,617 |

Hazardous Facility Sites:

The fourth variable is the potential for hazardous material exposure, which correlated with proximity to hazardous faculties. Here we are interested in identifying various industries that use, store, and produce hazardous chemicals or materials. To arrive at this end, we have used the Toxic Release Inventory (TRI) developed and published on the Internet by the U.S. Environmental Protection Agency (EPA) (http://www.epa.gov/tri/). Using GIS mapping, we established the geographical distribution of hazardous facilities, which we then juxtaposed with population centers and special hazard zones. This helped us to identify both the vulnerability of population groups as they relate to potential toxic release sites, and the vulnerability of hazardous facilities themselves to hurricane damage, which would potentially result in a release to hazardous materials. Population density, which is the attribute we used to identify populations centers, is considered the variable that correlates most closely with toxic releases (Rogge, 1996). In stating this, it should be noted that toxic releases in this instance relates to fugitive releases which are do not pertain to normal emissions released through smokestacks, pumps or other mechanisms which are an integral part of daily operations. (Rogge, 1996). Population densities give a measure of urbanization and general levels of development for any particular city. Density can additionally provide a better understanding of risk; the more dispersed a population, the less risk incurred from any single event. Conversely, the more crowded, a population, the more susceptible that population is to a common threat. Population densities were mapped to show geographic dispersion patterns and the relation of concentration centers in respect to other risk factors.

As with the previous variable, we developed a gradation of risk, based on population density and proximity to hazardous substance facilities. We determined what percentage of a city's population could be exposed to a toxic release for each facility based on a half-mile, one-mile, two-mile, three-mile, and four-mile circumference. These proportions were then treated in the same way as was the variable for topography and special hazard zones (see Table 4). This formula, thus, provides an overall risk index for the city based on proximity to hazardous facility sites. However, it should be noted that the dynamics related to toxic releases would be changed considerably if the toxic release occurred as a secondary disaster, for instance, as a consequence of a tornado or hurricane. The proximity of many hazardous facilities to the coastline has raised concerns among researchers because of the susceptibility of these facilities to surge and wind damage. However, the petrochemical industry, which owns most of these facilities, has a powerful presence in the area, and a culture of passive acceptance has prevailed. People are discouraged from speaking-out about these issues or raising voices of alarm.

Table 4

| COUNTY | CITY | INDEX | 0.5M | 1M | 2M | 3M | 4M | POP | Total R POP |
|---|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | 3.09 | 0 | 109 | 1,096 | 0 | 0 | 1,205 | 1,205 |
| GALVESTON | Dickinson | 1.237 | 0 | 0 | 429 | 3,198 | 13,466 | 17,093 | 17,093 |
| GALVESTON | Friendswood_G | 2.328 | 0 | 754 | 8,004 | 9,927 | 2,552 | 21,237 | 21,237 |
| GALVESTON | Galveston | 2.692 | 637 | 2,532 | 36,484 | 15,126 | 1,109 | 57,247 | 55,888 |
| GALVESTON | Kemah | 2.226 | 0 | 0 | 588 | 1,681 | 61 | 2,330 | 2,330 |
| GALVESTON | La Marque | 3.015 | 453 | 2,954 | 6,617 | 3,658 | 0 | 13,682 | 13,682 |
| GALVESTON | League City | 1.942 | 3,447 | 3,673 | 8,816 | 6,893 | 16,072 | 45,444 | 38,901 |
| GALVESTON | Texas City | 2.917 | 1,206 | 8,072 | 18,492 | 13,591 | 160 | 41,521 | 41,521 |
| HARRIS | El Largo | 3.175 | 0 | 538 | 2,537 | 0 | 0 | 3,075 | 3,075 |
| HARRIS | Friendswood_H | 1.135 | 0 | 0 | 0 | 1,052 | 6,748 | 7,800 | 7,800 |
| HARRIS | Houston | 2.952 | 253,686 | 401,978 | 670,468 | 316,812 | 245,532 | 1,953,631 | 1,888,476 |
| HARRIS | Nassau Bay | 3.749 | 379 | 2,364 | 1,427 | 0 | 0 | 4,170 | 4,170 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| HARRIS | Seabrook | 3.243 | 1,011 | 515 | 7,671 | 246 | 0 | 9,443 | 9,443 |
| HARRIS | Shoreacres | 3.782 | 236 | 691 | 561 | 0 | 0 | 1,488 | 1,488 |
| HARRIS | Taylor Lake Village | 3.171 | 0 | 632 | 3,062 | 0 | 0 | 3,694 | 3,694 |
| HARRIS | Webster | 2.594 | 0 | 0 | 5,413 | 3,656 | 14 | 9,083 | 9,083 |

Demographics:

The next variable incorporates three demographic aspects: household income levels, education, and ethnicity. Since the socioeconomic indicators were not yet released at the time of this report, we used data from the 1990 census (http:// www.census.gov/main/www/cen1990.html), though other demographic data were obtained from the 2000 census (http:// www.census.gov/main/www/cen1990.html). The socioeconomic and ethnic status of the population is an important factor since numerous studies have established an inverse relationship between socioeconomic status and risk (Rogers, 1995). People with a lower-income status stand a higher risk of loss in the event of a natural disaster and they have less ability to recovery after one (Rogers, 1995). Ethnicity is also closely linked with socioeconomic status, but may pose additional complexities not explained solely by education or status differences. The concept of ethnicity refers to "individuals who consider themselves, or are considered by other, to share common characteristics which differentiate them from the other collectivities in a society within which they develop distinct cultural behaviors" (Marshall: 1998, 201). Diversity among ethnic groups can lead to many communication problems based on language differences as well as a lack of shared assumptions and experiences between the ethnic minority and the majority group. Often, these communication differences become critical when dealing with issues of warning and access to institutional aid in the recovery process (Drabek, 1986).

To arrive a measure of risk on these factors, we grouped education into five categories (1) less than high school, (2) high school graduate or equivelant, (3) some college - includes associates degree, (4) a bachelors degree, and (5) a post-graduate degree. In order to do this we combined two of the standard categories used in the US census. The first category of less than High school education or equivelant is two separate categories in the US census data, as is our cagtegory "3". The US census has two different categories for some college (no degree) and associates degree. We combined these categories primarily to stay within the scheme of five that has been set up and provide a sense of consistency to our schema.

Table 5

| COUNTY | City | INDEX_TOTAL | EDUCATION | MEDIAN INCOME_HOUSEHOLD | % OF WHITE |
|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | 4 | 4.53 | 37,241 | 0.96 |
| GALVESTON | Dickinson | 3 | 3.85 | 30,159 | 0.80 |
| HARRIS | El Largo | 4 | 5.08 | 58,884 | 0.99 |
| GALVESTON | Friendswood_G | 1 | 4.49 | 50,492 | 0.94 |
| GALVESTON | Galveston | 4 | 3.59 | 20,825 | 0.61 |
| GALVESTON | Kemah | 3 | 3.25 | 26,797 | 0.91 |
| GALVESTON | La Marque | 3 | 3.37 | 27,914 | 0.64 |
| GALVESTON | League City | 3 | 4.35 | 45,043 | 0.88 |
| HARRIS | Nassau Bay | 4 | 4.98 | 50,574 | 0.94 |
| HARRIS | Seabrook | 4 | 4.41 | 34,658 | 0.91 |
| HARRIS | Shoreacres | 4 | 4.45 | 52,418 | 0.96 |
| HARRIS | Taylor Lake Village | 4 | 5.27 | 74,362 | 0.96 |
| GALVESTON | Texas City | 4 | 3.29 | 26,144 | 0.67 |
| HARRIS | Webster | 2 | 4.08 | 32,377 | 0.82 |

Non-structural Mitigation Efforts:

Nonstructural mitigation efforts refers to political and planning efforts within the area which arise in response to a knowledge of risk, but which do not include the construction of a physical structure. In particular, our study considers five different types of nonstructural mitigation efforts: (1) Community education and outreach, (2) the development and enforcement of building codes, (3) land-use planning which takes into account disaster prone areas, (4) the establishment and publication of evacuation routes or other disaster preventative methods, and (5) governmental compliance with special disaster related ordinances. Community education and outreach can include such actions as having current fliers available on disaster education, making presentations in schools, conducting town hall meetings, and delivering news reports about how to behave in the event of a disaster. Development and enforcement of building codes refers to the implementation and enforcement of construction standards, which are implemented in response to the disaster history of the area. This may mean retrofitting buildings for earthquake resistance, raising buildings above a certain elevation, or conforming to other measures as are appropriate to the circumstances of the area. In our case study, structures had to meet the Southern Building Code standards that require a building be constructed such that it will be able to withstand a hurricane three or less on the Saffir/ Simpson scale (Davenport: p.14). Land-use planning relates to specific measures taken to forbid the construction of new homes or other buildings in areas that are known to be vulnerable to destructive forces. Examples of this type of planning could include setting aside frequently flooded riverine coasts as a wetland preserve or declaring beach fronts as public land so people cannot build directly on shorelines. The establishment and publications of evacuation routes or other disaster-preventative methods would include any measures aimed at keeping the public out of harms way. Since we are not capable of adequately predicting all types of disasters with enough lead time to evacuate populations at risk, this aspect of the variable would include such measures as alleviating extra weight on mountainsides prone to avalanches, or the controlled burning of brush to prevent forest fires, and establishing evacuation routes. The last type of mitigation effort addressed is that of governmental compliance with special disaster-related ordinances such a community involvement in FEMA's flood insurance plan, and the development of a disaster plan as mandated by the federal government. The variable of "non-structural mitigation efforts" is different from the variables previously discussed, in-so-far-as it cannot be assessed empirically. It is for this reason that we have defined five categorical subsections which can be using a binary code which indicates whether a certain type of activity exists or not. However, in keeping with the notion of the "lower the variable index, the lower the risk," we have calibrated these ordinal categories by using a score of "1" and "-1". A score of "1" means that the city or community being discussed does NOT have the sub-category discussed, thus, in effect raising the average risk index. Conversely, if the community does have the mitigation efforts, they score a "-1", which in turn lowers the risk index.

Table 6

| COUNTY | CITY | INDEX | Out-reach | codes | Land-use | Evac. routes | Ordinances | POP |
|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | -1 | 1 | -1 | 1 | -1 | -1 | 1,205 |
| GALVESTON | Dickinson | -1 | -1 | -1 | 1 | -1 | 1 | 17,093 |
| GALVESTON | Friendswood_G | -3 | -1 | -1 | 1 | -1 | -1 | 21,237 |
| GALVESTON | Galveston | -1 | -1 | -1 | 1 | -1 | 1 | 57,247 |
| GALVESTON | Kemah | 1 | 1 | -1 | 1 | -1 | 1 | 2,330 |
| GALVESTON | La Marque | 1 | 1 | -1 | 1 | -1 | 1 | 13,682 |
| GALVESTON | League City | -3 | -1 | -1 | 1 | -1 | -1 | 45,444 |
| GALVESTON | Texas City | -3 | -1 | -1 | 1 | -1 | -1 | 41,521 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| HARRIS | El Largo | 1 | 1 | -1 | 1 | -1 | 1 | 3,075 |
| HARRIS | Friendswood_H | -3 | -1 | -1 | 1 | -1 | -1 | 7,800 |
| HARRIS | Houston | -1 | -1 | -1 | 1 | -1 | 1 | 1,953,631 |
| HARRIS | Nassau Bay | -3 | -1 | -1 | 1 | -1 | -1 | 4,170 |
| HARRIS | Seabrook | -3 | -1 | -1 | 1 | -1 | -1 | 9,443 |
| HARRIS | Shoreacres | -1 | 1 | -1 | 1 | -1 | -1 | 1,488 |
| HARRIS | Taylor Lake Village | -1 | -1 | -1 | 1 | -1 | 1 | 3,694 |
| HARRIS | Webster | 1 | 1 | -1 | 1 | -1 | 1 | 9,083 |

Special Resources:

The seventh variable, special resources, refers to entities that have strong vertical ties, which could supersede or substantially augment the planning and recovery process within the city. "Vertical integration helps to expand the resources potentially available to a community" (Berke, et al., 1993). This variable has been assessed through the examination of five distinct types of special resources: (1) large governmental agencies or operations, (2) large multinational companies, (3) large universities or other academic institutions. (4) national or international non-profit institutions, and (5) distinctive local phenomena. Large governmental offices or operations include special governmental entities (such as the Los Alamos National Research Labs, military bases, or as in our case study, the National Aeronautic and Science Administration [NASA]: Johnson Space Center) that could channel additional resources into the area, which would not normally be present in other communities.

Large multinational companies, such as Amoco, Exxon, or Citibank can be an unusually helpful source of support in all phases of disaster response and recovery. Within our study area, there were a few examples of multinational companies whose presence was strongly felt at the local level. One example is Texas City, which has a state-of-the-art emergency operations center that was made possible through the support and financial contributions of Amoco. Multinational companies like these often have a vested interest in helping their local communities prepare for disasters and recover from them quickly. Because of their expansive international network, they can often tap into resources which may not otherwise be available to such a community. These resources can range from expertise in disaster planning and recovery to financial support for various projects. Two other types of institutions that can provide strong vertical ties are large research universities and large national or international non-profit agencies (often referred to as NGO's). In our study area, we had the presence of Texas A&M University, Galveston Campus, and both the Red Cross and Salvation Army. These institutions could be potential sources of assistance through the provision of expertise, supplies, access to networks, and man-power, which reach beyond the access of the affected region.

The last type of potential resource which could be identified as a source of vertical ties is what we refer to as a "distinctive local phenomena". This category includes any feature, natural or man-made, which is unique to the area and is potentially threatened by a disaster or by the recovery process. An example of this is a city that has a special historical attraction such as Roswell, New Mexico, or Mount Rushmore, South Dakota. These are places that have a distinctive identity and history which makes them easily identifiable to the general public, and therefore there is a general expectation to help preserve these "cultural" places. This expectation makes justifying the allocation of funds for disaster planning easier, which would both help protect them from a disaster and recover from one quicker. This variable follows a similar coding system as the previous one, a bi-modal distribution, except that in this instance “-1” is given for each type of special resource the city possesses, and a "0" is assigned if the resource does not exist. Since the lack of a special resource is not seen as a weakness in the risk assessment, the city is not penalized for its absence. These types of resources help lower the risk index for the cities in question.

Table 7

| COUNTY | CITY | INDEX | Gov't Agency | Multi-national | Univ. | Non-profit | Local Phenom. | POP |
|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | -1 | -1 | 0 | 0 | 0 | 0 | 1,205 |
| GALVESTON | Dickinson | 0 | 0 | 0 | 0 | 0 | 0 | 17,093 |
| GALVESTON | Friendswood | 0 | 0 | 0 | 0 | 0 | 0 | 29,037 |
| GALVESTON | Galveston | -2 | 0 | 0 | -1 | -1 | -1 | 57,247 |
| GALVESTON | Kemah | -1 | 0 | 0 | 0 | 0 | -1 | 2,330 |
| GALVESTON | La Marque | -1 | 0 | -1 | 0 | 0 | 0 | 13,682 |
| GALVESTON | League City | -1 | 0 | 0 | 0 | 0 | -1 | 45,444 |
| GALVESTON | Texas City | -1 | 0 | -1 | 0 | 0 | 0 | 41,521 |
| HARRIS | El Largo | 0 | 0 | 0 | 0 | 0 | 0 | 3,075 |
| HARRIS | Houston | -4 | -1 | -1 | -1 | 0 | -1 | 1,953,631 |
| HARRIS | Nassau Bay | -3 | -1 | -1 | 0 | 0 | -1 | 4,170 |
| HARRIS | Seabrook | -1 | 0 | -1 | 0 | 0 | 0 | 9,443 |
| HARRIS | Shoreacres | 0 | 0 | 0 | 0 | 0 | 0 | 1,488 |
| HARRIS | Taylor Lake Village | -1 | -1 | 0 | 0 | 0 | 0 | 3,694 |
| HARRIS | Webster | -1 | -1 | 0 | 0 | 0 | 0 | 9,083 |

Socio-Political Dynamics:

"Socio-Political Dynamics" and the categories of which it comprised, is the most difficult variable to assess. The political practices and the power struggles endemic to all levels of government are not easily assessed. Albeit, power is essential to achieving one's aim, be it for disaster planning or some other issue. In the field interviews with emergency managers, we were able to ascertain some of the political practices and agendas that both hindered and assisted the advancement of disaster planning. However, because of time constraints and the delicacy with which the subject is treated, some assumptions were made based on the evidence that presented itself to the researcher: such as a lack of time and resources for disaster planning, comments alluding to power struggles, or conversely, the show of support by providing emergency managers freedom and funding. The variable of socio-political dynamics was broken down into five categories: (1) grass-root support, (2) political support, (3) political initiative, (4) funding, and (5) institutionalization of the disaster planning process. These categories were scored on a bi-modal system, where a "-1" is a positive indicator of that category and a "1" a negative indicator, showing that a specific activity has not occurred at the city level (see table 8).

The first category, grass-root support refers to the existence of any group that has taken a political stance to advance disaster planning and actively pursues that agenda, either through lobbying efforts, community education, or other activities. In our case study, the Galveston Branch of the League of Women Voters was seeking an issue it could adopt and promote, and which had immediate significance for the community. They realized that disaster planning was not a well-developed practice in Galveston, and that this lack of a planning process could have a detrimental impact. This was a significant issue for the entire county, not just the island, and it was an indisputable weakness in the administrative system. The support and work of these women helped bring disaster planning to the attention of political power holders who where in a position to fund the activity and elevate its importance in the county administrative agenda. Their work has also assured that the next people in posts of power will be aware of issues relating to disaster planning and emergency management.

The second category, political support, relates closely with grass-root support. Political support refers to the idea of emergency managers having the support (e.g. time, funding, and administrative help) to pursue disaster planning from their political superiors, such as mayors, city councils, or county judges, or others. However, since these offices are positions of public service, the superiors are accountable to the public, and if there is someone or some group in that constituency that has identified disaster planning as a need, the allocation of funds for this activity is made easier, in the face of competing agenda items. In our case study, political will was found to support disaster planning, because, in addition to improving preparedness, the planning process also helped bring cohesion to the county, as pointed out by several emergency managers and the League of Women Voters. Emergency management met a need that the entire county required, therefore cities felt a push for disaster planning coming from the county administrative offices, as well as from the grass-root issue promoters. Political support, however, is not a one-dimensional element. There are occurrences when a political superior may support disaster planning, even though s/he does not have the political clout to follow through on that support. In a situation such as this, grass-root support can be essential to the emergency planning process because it provides additional leverage to initiate a disaster planning process.

The third category relates directly to some early writings by Drabek and his colleagues that found "[that] in order for policies to be adopted a key individual or small number of persons with legitimate authority to take action had to be concerned and actively promote the issue" (Mittler, 1989). This notion of issue champions is very similar to the political activity of lobbying, the difference being that issue champions work from within the system to bring about change. Essentially, this category attempts to measure if there is any person or group with political power who is willing to champion the cause of disaster preparedness in light of the many competing issues on any community's agenda, and how well those issue promoters are integrated into the planning process. By keeping concerned citizens involved, one insures that the planning process is maintained.

The fourth category, funding refers to the availability of funds to support the emergency management process. This may be problematic, especially in small communities, where funds are very limited. There may be political will to be involved in a disaster planning process, but not the available funds to fully support such an activity. This appeared to be the case in several of the communities we visited in the Clearlake area. These communities are primarily bedroom communities, and they have little or no business-tax base with which to support an extended disaster planning process. However, because of a well developed disaster planning program on the county level and among the neighboring communities, disaster planning is generally recognized as a necessary process and one everyone appears to openly support, even though the money is not there. Of course, the opposite may also be true. A community may have money allocated to it for disaster planning, but because of a lack of political support or awareness, the money is left unused or diverted to other area.

The last category refers to the institutionalization of the disaster planning process. This has been accomplished to some extent throughout the United States because of a congressional mandate which states that every locality must have a disaster plan, if they want to be eligible for recovery aid, in the event of a disaster. However, as happens with many unfunded or poorly funded mandates, the disaster plan becomes just an item to check-off a list, and the planning process is circumvented. In this instance we were looking for the establishment of a process; one that is not dependent on any particular leader or event. Examples of this type of work could be seen in the development of full-time offices for emergency management at the county levels, in large cities, and at the NASA space center. The interaction between these entities and their surrounding communities helped establish an expectation for disaster planning and assisted in the development of a comprehensive planning process for the entire region.

Table 8

| COUNTY | CITY | INDEX | Grassroot | support | initiative | funding | establishment | POP |
|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | 1 | 1 | -1 | 1 | -1 | 1 | 1,205 |
| GALVESTON | Dickinson | 3 | 1 | 1 | 1 | -1 | 1 | 17,093 |
| GALVESTON | Friendswood | -1 | 1 | -1 | -1 | -1 | 1 | 29,037 |
| GALVESTON | Galveston | -3 | -1 | -1 | -1 | -1 | 1 | 57,247 |
| GALVESTON | Kemah | 3 | 1 | 1 | 1 | -1 | 1 | 2,330 |
| GALVESTON | La Marque | 3 | 1 | 1 | 1 | -1 | 1 | 13,682 |
| GALVESTON | League City | -1 | 1 | -1 | -1 | -1 | 1 | 45,444 |
| GALVESTON | Texas City | -3 | 1 | -1 | -1 | -1 | -1 | 41,521 |
| HARRIS | El Largo | 5 | 1 | 1 | 1 | 1 | 1 | 3,075 |
| HARRIS | Houston | -1 | 1 | 1 | -1 | -1 | -1 | 1,953,631 |
| HARRIS | Nassau Bay | 1 | 1 | 1 | -1 | 1 | -1 | 4,170 |
| HARRIS | Seabrook | 3 | 1 | 1 | -1 | 1 | 1 | 9,443 |
| HARRIS | Shoreacres | 5 | 1 | 1 | 1 | 1 | 1 | 1,488 |
| HARRIS | Taylor Lake Village | 5 | 1 | 1 | 1 | 1 | 1 | 3,694 |
| HARRIS | Webster | 5 | 1 | 1 | 1 | 1 | 1 | 9,083 |

Special Administrative Districts:

The ninth variable refers to potentially conflicting situations because of an overlap of emergency response jurisdictions in an area. Conflicts can arise in all the various stages of disaster planning (mitigation, planning, response or recovery) because two or more jurisdictions are competing for dominance in a disaster response scenario, or conversely, because there is the assumption that another agency is attending to issues in that jurisdiction. As before, we divided the possible scenarios into five different categories in which jurisdictions could overlap one with the other: (1) governmental authorities, (2) local jurisdictions or authorities, (3) national or regional jurisdictions, (4) volunteer organizations, and (5) private response groups. In our case study we had many examples of these types of overlaps. An overlap of governmental authorities would be found in a situation in which a city may straddle more than one county or state. The city of Friendswood exemplifies this situation in our study area since it lies in three different counties: Harris, Galveston, and Brazoria. This type of overlap has actually led to problems in the past, where one county was declared a disaster area, while the other part of the city was not. This led to frustrations and problems as some residents received federal aid for recovery but others did not, though they had suffered equal losses. This type of situation can happen in places that are administered by different political entities, yet share a common location. Unfortunately the fall out often means that local politicians pay the cost, and the community may lose cohesion, while subsequently delaying the recovery process for the entire community.

The second category in our variable is that of overlapping local jurisdictions. Examples for these types of overlays would probably be most notable in the planning stage of disaster preparedness, as there are many specialized local jurisdictions within a city's reach. Examples of these include municipal utility districts, local emergency planning committees, school districts, and others. To complicate matters further there may be national and regional jurisdictions covering various areas, such as a port authority, Coast Guard, or Ranger Service. In our case-study many of the cities had to interact with various different authorities such as the Coast Guard, that patrolled the ocean front; the Channel Emergency Management Association, which was developed to respond to such incidents as explosions or toxic releases in the ship channel; the Houston Port Authority, which deals with trade and customs issues, and the Marina Patrol that controls the third largest marina area in the USA.

Volunteer organizations and private response groups can also lead to conflicting situations, not only due to overlapping jurisdictions, but also due to overlapping loyalties and role designations. Both volunteer organizations and private corporations often draw on the same sources of man-power within a specific area. Thus, a particular person might work as an engineer Monday through Friday, and as a volunteer firefighter on the weekends. However, if an incident should happen in the plant on a Wednesday, should the person react as an engineer or as a firefighter? These dilemmas can become serious issues when there is a primary employer within a town, and little or no coordination between the employment agency and the volunteer organizations in the area. The problem is also manifested in a calculation of the resources in the area. On our case study, most of the cities had volunteer fire departments, yet the large petro-chemical companies also maintained a professional fire-fighting staff which could assist in any disaster scenario. The problem being that the fire-fighters for the petro-chemical companies where the same men and women who served on the volunteer fire departments. In essence, the human resource for the area was being counted twice, once as part of the private sector, and again as a community fire-fighting force.

This variable is scored very simply, a city gets a score of “1” for each category of jurisdictional overlap that occurs within its immediate area, and a "0" if there are no overlaps (see table 9). In short, we realize that there will always be overlapping jurisdictions of some types that can complicate planning and response efforts in the face of disasters, but many of the potential problems which arise from this situation can be addressed and worked out through our next variable, Planning Integration.

Table 9

| COUNTY | CITY | INDEX | Gov't | Local | National/ regional | volunteer | private | POP |
|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | 2 | 0 | 1 | 0 | 1 | 0 | 1,205 |
| GALVESTON | Dickinson | 1 | 0 | 0 | 0 | 1 | 0 | 17,093 |
| GALVESTON | Friendswood | 3 | 1 | 1 | 0 | 1 | 0 | 21,237 |
| GALVESTON | Galveston | 3 | 0 | 1 | 1 | 1 | 0 | 57,247 |
| GALVESTON | Kemah | 2 | 0 | 0 | 1 | 1 | 0 | 2,330 |
| GALVESTON | La Marque | 2 | 0 | 1 | 0 | 1 | 0 | 13,682 |
| GALVESTON | League City | 2 | 1 | 0 | 0 | 1 | 0 | 45,444 |
| GALVESTON | Texas City | 3 | 0 | 0 | 1 | 1 | 1 | 41,521 |
| HARRIS | El Largo | 1 | 1 | 0 | 0 | 0 | 0 | 3,075 |
| HARRIS | Houston | 3 | 0 | 1 | 1 | 0 | 1 | 1,953,631 |
| HARRIS | Nassau Bay | 3 | 0 | 1 | 1 | 1 | 0 | 4,170 |
| HARRIS | Seabrook | 2 | 0 | 0 | 1 | 1 | 0 | 9,443 |
| HARRIS | Shoreacres | 2 | 1 | 0 | 1 | 0 | 0 | 1,488 |
| HARRIS | Taylor Lake Village | 1 | 1 | 0 | 0 | 0 | 0 | 3,694 |
| HARRIS | Webster | 2 | 1 | 0 | 0 | 1 | 0 | 9,083 |

Integration of the Planning Process:

Planning integration refers to the development and strengthening of horizontal ties which work towards the eventual goal of disaster preparedness. Berke, Kartez and Wenger (1993) refer to Warren's (1963) definition of horizontal integration as "the structural and functional relations among the community's various social units and subsystems." Berke, et al. (1993) emphasis that " the extent to which a strong vertical integration is beneficial is strongly related to the strength of horizontal relationships. When horizontal relationships are weak, communities are basically powerless, subordinate, and depend on outside forces. " This statement emphasizes how crucial the planning process is, since it is through this process that strong horizontal ties are developed and maintained; within the personal contacts made during the disaster planning process. Planning integrity is divided into five categories, the first four address various community players and the last one refers to the quality of the planning process: (1) non-profit organizations, (2) political or grass-root support groups, (3) special care facilities, (4) neighboring communities, and (5) the practice and rehearsal of the emergency response process. We see planning as being one of the essential phases of disaster preparedness, and a variable that is open to human control.

When examining the planning process, we are focusing on the actual production, maintenance and continuous testing of a disaster plan, not on the final development of a manuscript. In this vain, we are looking at the ongoing development of relationships, education and growth of non-emergency mangers into the disaster-planning process. The first category mentioned is the integration of non-profit organizations. This would include regular meetings or involvement in the planning process of disaster-oriented non-profit groups (non-governmental organizations) in the area. Examples of such groups would be RACES, the Red Cross, Salvation Army, and possibly inter-faith organizations. These groups often take the center stage in the sheltering and recovery process, and should be involved with emergency management teams so that recovery can proceed seamlessly, and the correct type of assistance and information is delivered to the appropriate people.

The second category refers to the integration of grass-root support into the planning process. This integration and continuous nurturing of issue backers is essential to the planning process as it may open doors to other resources and also lets citizens invested in the community stay abreast of emergency management issues. By keeping concerned citizens involved, one insures that the planning process is maintained. Additionally, it helps build a support base that is not dependent on just one person or one moment in time. In our study, on-going political pressure to pursue disaster planning was an essential element in helping to elevate disaster planning to a priority item at the county administrative level.

The third category, special care facilities, assess the level of integration between the emergency management plan of facilities and the city disaster management plan. In particular, such facilities as hospitals, schools, elder-care, prisons; and other places that have an immobile population are the topic of this variable. Coordination with these facilities needs to be included in all phases of disaster planning, from the siting of such institutions, to their evacuation (should the need arise), to their potential use in the response and recovery phase of a disaster. Planning integration with such facilities needs to go beyond having a copy of their emergency plan at the emergency operations center; it needs to include their participation in the planning process. In this way key players will be identified, as will any limitations and available resources. The fourth category, planning integration, is crucial when there is heavy reliance on mutual-aid agreements and/or communities in close proximity to one and other. By working with neighboring communities, emergency managers get to know one and other and what can be expected in times of need. Drabek (1987) identifies this need when he states that one of the most important axioms for emergency managers is their formation and maintenance of interagency relationships.

The fifth and last category is probably one of the most important ones, and the one that brings meaning to the previously mentioned categories. Without practicing and continually updating ones emergency plan, there is no feed-back loop to bring in new information or circumstances into the planning process, nor is their an effective way to evaluate the work that has been done to that point. The practice and rehearsal of disaster planning includes regular meetings with concerned groups and individuals to arrive at a standard of quality that will ensure proper orientation and continuous development of disaster planning, not only for one's own agency, but also for all the various players involved in the mitigation, planning, rescue and recovery phases of a disaster.

Our last variable is scored similarly to the previous ones, though here there are three possible scores. A "-1" is a positive sign, showing that the community has integrated their planning efforts with the various agents in that category. A "0" means that there are no agents in that category, for a particular city. Many of the communities studied in the Clearlake area were bedroom communities and did not have the full array of facilities often found in other places. A score of "1" means that a particular facility exists within that community, but there is not adequate integration of the facility's emergency plans with the city in which it is situated. By using this scoring method, communities without some of the amenities mentioned in the variable will not be penalized for not having an integrated plan, while simultaneously accounting for these amenities in the communities where they do exist (See Table 10).

Table 10

| COUNTY | CITY | INDEX | Non-profits | political | Special care | Neighbor | practice | POP |
|---|---|---|---|---|---|---|---|---|
| GALVESTON | Clear Lake Shore | 1 | 0 | 1 | 0 | -1 | 1 | 1,205 |
| GALVESTON | Dickinson | -1 | 0 | 1 | 0 | -1 | -1 | 17,093 |
| GALVESTON | Friendswood | -3 | 1 | -1 | -1 | -1 | -1 | 21,237 |
| GALVESTON | Galveston | -5 | -1 | -1 | -1 | -1 | -1 | 57,247 |
| GALVESTON | Kemah | 1 | 0 | 1 | 0 | -1 | 1 | 2,330 |
| GALVESTON | La Marque | -3 | 0 | -1 | 0 | -1 | -1 | 13,682 |
| GALVESTON | League City | -4 | 0 | -1 | -1 | -1 | -1 | 45,444 |
| GALVESTON | Texas City | -4 | -1 | -1 | 0 | -1 | -1 | 41,521 |
| HARRIS | El Largo | 1 | 0 | 1 | 0 | -1 | 1 | 3,075 |
| HARRIS | Houston | -1 | 1 | -1 | 1 | -1 | -1 | 1,953,631 |
| HARRIS | Nassau Bay | -4 | 0 | -1 | -1 | -1 | -1 | 4,170 |
| HARRIS | Seabrook | -3 | 0 | -1 | 0 | -1 | -1 | 9,443 |
| HARRIS | Shoreacres | 1 | 0 | 1 | 0 | -1 | 1 | 1,488 |
| HARRIS | Taylor Lake Village | -3 | 0 | -1 | 0 | -1 | -1 | 3,694 |
| HARRIS | Webster | -3 | 0 | -1 | 0 | -1 | -1 | 9,083 |

## Conclusion:

The approach to risk analysis set forth in this paper is an attempt to provide an inclusive assessment of risk for a city which incorporates many aspects of disaster planning. In doing so it sets a framework that incorporates geographical, industrial, social, cultural, and demographic features into the planning process. However, many nuances and details are glossed over while arriving at the risk index. The aim of this index is not to provide a detailed assessment of risk for any individual, but instead to allow those individuals who are concerned about disaster risk to quickly compare the relative risk in their area, with others. If further information is required, one can then ask for greater details on how the risk index was obtained. Additionally, an aspect that is appealing about this method of analysis is that scores on many of the variable can be addressed through a comprehensive planning process. This risk analysis index can then be used by many different groups to advance disaster planning and increase awareness of emergency management issues. Among the different potential uses of this risk assessment are its use by emergency mangers in their attempts to lobby for greater support of the disaster planning process; city councils can attempt to promote their cities with it (if they have a good rating), and insurance companies can give additional credits to cites that rate well on the index.

In conclusion, we are providing a risk comparison of the various cities within the Clearlake region (see table 11). To arrive at the final risk index, we calculated the sum of the indices for all variables and then divided by ten, to reach a mean index for each city studied. As we stated earlier, this is not a comprehensive detailed analysis of risk for each city, but is instead an attempt to take into account the relationship between human organizations and environmental factors as they relate to disaster risk.

Table 11

| CITY | MEAN INDEX | VAR.1 | VAR.2 | VAR.3 | VAR.4 | VAR.5 | VAR.6 | VAR.7 | VAR.8 | VAR.9 | VAR.10 | POP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clear Lake Shore | 2.21 | 4 | 4 | 5.0 | 3.09 | 4 | -1 | -1 | 1 | 2 | 1 | 1,205 |
| Dickinson | 1.52 | 4 | 2 | 3.0 | 1.237 | 3 | -1 | 0 | 3 | 1 | -1 | 17,093 |
| Friendswood | .43 | 4 | 1 | 0.6 | 1.732 | 1 | -3 | 0 | -1 | 3 | -3 | 21,237 |
| Galveston | 1.22 | 4 | 5 | 4.5 | 2.692 | 4 | -1 | -2 | -3 | 3 | -5 | 57,247 |
| Kemah | 2.21 | 4 | 3 | 3.9 | 2.226 | 3 | 1 | -1 | 3 | 2 | 1 | 2,330 |
| La Marque | 1.78 | 4 | 3 | 2.8 | 3.015 | 3 | 1 | -1 | 3 | 2 | -3 | 13,682 |
| League City | .69 | 4 | 2 | 3.0 | 1.942 | 3 | -3 | -1 | -1 | 2 | -4 | 45,444 |
| Texas City | .99 | 4 | 4 | 3.0 | 2.917 | 4 | -3 | -1 | -3 | 3 | -4 | 41,521 |
| El Largo | 2.62 | 4 | 2 | 5.0 | 3.175 | 4 | 1 | 0 | 5 | 1 | 1 | 3,075 |
| Houston | .79 | 4 | 1 | 0.0 | 2.952 | 4 | -1 | -4 | -1 | 3 | -1 | 1,953,631 |
| Nassau Bay | 1.37 | 4 | 3 | 4.9 | 3.749 | 4 | -3 | -3 | 1 | 3 | -4 | 4,170 |
| Seabrook | 1.72 | 4 | 3 | 5.0 | 3.243 | 4 | -3 | -1 | 3 | 2 | -3 | 9,443 |
| Shoreacres | 2.55 | 4 | 4 | 2.7 | 3.782 | 4 | -1 | 0 | 5 | 2 | 1 | 1,488 |
| Taylor Lake Village | 1.87 | 4 | 2 | 4.5 | 3.171 | 4 | -1 | -1 | 5 | 1 | -3 | 3,694 |
| Webster | 1.58 | 4 | 0 | 3.2 | 2.594 | 2 | 1 | -1 | 5 | 2 | -3 | 9,083 |

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## Author Biography

Kim Galindo was born in Houston, Texas in July of 1965, but raised in Bolivia, South America. She moved back to Texas with her parents in the mid seventies. Kim has extensive experience in international travel and development issues since she spent much of her life visiting family and friends in Europe and South America. She has lived briefly in France, and Denmark and for extended periods in the United States and Bolivia. She received her B.S. in Sociology and a B.A. in Modern Languages from the University of Texas A&M in College Station. Her masters degree was conferred to her from the University of Texas in Austin in 1993, from the department of Social Work, with an emphasis on administration and planning. She is presently working on her Ph.D. in Urban and Regional Sciences, at the University of Texas A&M, College Station,. During the summer of 2000, she interned at NASA, Johnson Space Center in Houston, Texas to help them assess the planning process of the communities in the area. Currently, she is working on her dissertation which examines the recovery process and organizational development of local non-profits in a rural, Texas community following a flood. Her interests are in disaster recovery issues and how culture impacts the disaster recovery and planning process.