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Exploring the use of Geographic Information Systems as an Environmental and Social Justice Advocacy Tool for Community-Based Organizations: A Case Study of Galena Park, Texas

Demetrice R. Jordan
Georgia State University

EXPLORING THE USE OF GEOGRAPHIC INFORMATION SYSTEMS AS AN ENVIRONMENTAL AND SOCIAL JUSTICE ADVOCACY TOOL FOR COMMUNITY-BASED ORGANIZATIONS:

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by

DEMETRICE RACHELE JORDAN

Under the Direction of Katherine B. Hankins

ABSTRACT

Environmental factors within communities play a significant role on the health and well-being of residents. These social and physical determinants have a substantial effect on health. This interaction can result in environmental injustices, inequality, and ultimately poor health for residents. The community of Galena Park, Texas, is a predominantly minority community of Hispanic and African-American residents with previously undocumented concerns related to air quality, the built environment, access to healthcare and the food environment. Through participatory engagement with Galena Park residents using Geographic Information Systems (GIS), this research examines the degree to which GIS is an effective tool in illustrating and visualizing environmental and social injustices. Findings from this research suggest that GIS only relays part of the story and is most powerful when the lived experiences of residents are integrated into the analytical process.

INDEX WORDS: Environmental justice, Social justice, Health disparities, Residential segregation, Geographic Information Systems, Participatory GIS, Cancer, Built environment, Environmental health

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by

DEMETRICE RACHELE JORDAN

Committee Chair: Katherine B. Hankins

Committee: John M. Allensworth

Timothy L. Hawthorne

John A. Steward

Daniel M. Deocampo

Electronic Version Approved:

Office of Graduate Studies

College of Arts and Sciences

Georgia State University

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DEDICATION

I dedicate the writing of this thesis to my Lord and Savior, Jesus Christ, the loving memory of Louis Jordan, Sr. (grandfather), Sadie Harris (great-grandmother), Alberta Jackson (aunt), Willie Campbell (cousin), Robert Louis Jordan (uncle), John Edward Jordan (uncle), beloved grandmother Lula B. Jordan, the ENTIRE Jordan Family, especially my son, Ashton C. Jordan, Dr. John M. Allensworth, and the community of Galena Park, Texas. Truly I stand on the shoulder of giants.

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1 INTRODUCTION

Environmental factors within communities play a significant role on the health and well-being of residents. These social and physical determinants have a substantial effect on health via the interplay of humans and the built environment. This interaction can result in environmental injustices, inequality, and disparities that create negative health outcomes for residents. Likewise, racial/ ethnic characteristics, income, social networks, social cohesion, and a person's physical environment all work together to either promote or negatively impact health. The community of Galena Park, Texas, located eight miles outside the City of Houston along the Houston Ship Channel in the Port of Houston Petro Refining Complex, is a predominantly minority community of Hispanics and African-American residents with previously undocumented concerns related to air quality, the built environment, access to healthcare, the quality of the neighborhood food environment, and cancer risk. For example, Galena Park is a medically underserved area due to the lack of primary care providers for persons over the age of 18. It is an economically challenged community; and according to the U.S. Census Bureau, 25 percent of the residents live below the federal poverty level, 80 percent of the population in Galena Park is Hispanic, and there is a high rate of linguistic isolation. Many residents do not own vehicles, and public transportation in the area is virtually non-existent. The community also shares its landscape with a dredge dump site, and preliminary reports show high levels of DDT, PBT's, Lead, Cadmium, and other heavy metals (E-CAP 2010). Given this difficult social and environmental setting, Galena Park residents have been agitating to bring to light the multiple layers of injustices that their community faces. In this thesis, I evaluate the role of Geographic Information Systems (GIS) in facilitating these claims of injustice.

The research presented here was conducted as a companion to the larger Environmental Community Assessment Project (E-CAP), which is a collaborative community-based participatory research initiative between Harris County Public Health and Environmental Services (HCPHES), UT MD Anderson Cancer Center (for which I was a summer research fellow), and the Environmental Community Advocates of Galena Park (ECAGP), a community-based organization (CBO). The larger study seeks to determine the social and physical factors within the Galena Park community that may have adverse effects on the residents. My role in the project brought to light the challenges and possibilities associated with truly collaborative partnerships among these kinds of organizations.

Ultimately, through the research protocols of the E-CAP, aspects of community health will be investigated and strategies for the development of a community action plan, detailing resources and strategies that, if implemented, would support healthier environmental conditions in the Galena Park community will be established. To date, however, through on-going dialogue sessions with the residents of Galena Park and the members of their CBO, three main priority areas have been established: air quality, access to care and nutrition, and the quality of the built environment. While identification of the three priority environmental health concerns has been a significant accomplishment, community residents and members of the E-CAP team were interested in quantitative data to reconcile community *perceived* concerns with actual, measurable phenomena. Therefore, after much discussion it was determined by the residents and the E-CAP team that the use of GIS and spatial analysis would be employed to visualize the community's concerns, given the power of GIS to display spatial relationships (see discussion in section 2.5).

This companion project to the larger study became the basis of this thesis. The community's concerns were entered into a GIS for 1) expression of their *perceived* environmental hazards and 2) comparative spatial analysis and the production of maps that can be used by the group in policy and planning meetings with decision-makers, city planners, and elected officials. What we discovered was that using GIS to map official datasets was inadequate without the constant engagement with local knowledge to accurately reflect the lived experience. In what follows, I offer the context for the social and environmental conditions in Galena Park, which I believe stems from structural inequalities around class and race. Then, I review the literature on participatory GIS, highlighting previous studies that have demonstrated the importance of community participation in mapping. I then explore my experience with residents of the Galena Park, Texas, community and demonstrate the robustness of *community-based participatory GIS*.

2 REVIEW OF LITERATURE

As the sociopolitical climate becomes increasingly turbulent and evidence of the gap between the rich and the poor widens, marginalized minority groups in cities and towns across the United States are uniting to form grassroots coalitions to take back their neighborhoods and communities (e.g., King and Jordan, forthcoming). Bullard (1993:8) notes “In many instances, grassroots leaders emerged from groups of concerned citizens (many of them women) who see their families, homes, and communities threatened by some type of polluting industry or government policy.” Often emerging from frustrations with local governments, community-based organizations are taking steps to have their voices heard, rallying for environmental and social equality policies that are inclusive and promote the participation of all residents in decisions that impact their communities.

Communities across the ethnic spectrum are battling a host of environmental threats from toxic contamination and locally unwanted land uses (LuLu’s) to unsafe and substandard housing and natural resource extraction (Brulle and Pellow 2006). CBOs often have the most intimate knowledge of community needs and assets and can better organize community members to address their concerns (Kellogg 1999). In partnership with environmental advocacy organizations, CBOs have the opportunity to be involved in community-based knowledge production about environmental quality issues, a key strategy for gaining the social power needed to effect change (Gaventa 1993; Kellogg 1999). A key aspect of knowledge production might include utilization of computer-based technologies, including Geographic Information Systems (GIS) (Kellogg 1999; Elwood 2006; Elwood and Leitner 1998). Researchers and government officials alike have argued that in order to fulfill this role, community groups need spatial information and information technologies such as GIS, which can provide powerful tools to visualize geographic patterns (Elwood and Leitner 1998; Treuhaft 2009). In order to understand why the use of GIS would be beneficial to residents in community-based organizations one first has to understand the production of the social and environmental injustices that plague many communities of color.

2.1 The Social Production of Inequality and Environmental Degradation

Research in public health, epidemiology, and medical geography strongly suggests that place affects health (Macintyre et al. 2002; Yen and Syme 1999; Jackson 2002; Morello-Frosch and Lopez 2005) and that there are links between environmental conditions and human welfare (Cutter et al. 2003). However, the precise extent to which exposure to industrial pollutants contributes to health problems is unclear (Brulle and Pellow 2006; Morello-Frosch and Lopez 2005). Environmental health researchers, sociologists, policy-makers, and activists concerned about environmental justice argue that communities of color that are segregated in neighborhoods with high levels of poverty and material deprivations are also disproportionately exposed to physical environments that adversely affect their health and well-being (Morello-Frosch and Lopez 2005). Brulle and Pellow (2006) argue that the social production of environmental inequality means that the creation and maintenance of environmental inequalities are fundamentally outcomes of the social dynamics of society. This echoes Pellow's previous sentiment (2000; 2001; and 2002) that suggests an analysis of the underlying social structural dynamics that systematically create and maintain environmental inequality can reveal connections between social hierarchies and exposure to environmental risk. These assertions validate Brulle and Pellow's argument that the first step toward understanding the origins of environmental inequality is to situate this phenomenon within the larger social dynamic of the social production of inequality and environmental degradation (Brulle and Pellow 2006).

2.2 Conceptualizing Environmental Injustice in the United States

Environmental justice is a fundamental concept that encourages the fair treatment and meaningful involvement of peoples regardless of race/ethnicity, sex, or income. Environmental justice, or EJ, as some scholars and advocates refer to it, has been defined by researchers many times (e.g., Massey 2004; Bullard 1996; EPA 1992); however the most important aspect of any definition of environmental justice is the perception that environmental inequality is unjust (Massey 2004). Historically, many groups that organized around environmental justice concerns emerged from within communities of color and poor working class white communities throughout the United States (Brulle and Pellow 2006; Brulle 2000; Bullard 1990; 2000; Gottlieb 1993). The neighborhoods where these populations live, work, and play have been disproportionately burdened with a range of toxic and hazardous pollution and other environmental harms (Freudenberg and Steinsapir 1992). The earliest work in this field found that minority neighborhoods hosted a disproportionate share of the environmental hazards and toxins produced by an industrialized society (Bullard 1990).

Beginning in the early 1970s a substantial body of literature was developed that documents the existence of environmental inequalities in the United States (Burch, 1976; Freeman 1972; Lave and Seskin 1970; Pulido 2000; Morello-Frosch 1999, Morello-Frosch et al. 2001, Pastor et al. 2005; Brulle and Pellow 2006; Pastor et al. 2001). By the late 1970s and early 1980s a national movement for environmental justice took shape (People of Color Environmental Summit II). This was followed by the 1983 regional study conducted by the US General Accounting Office (US GAO), which documented that African American communities in the southern United States were playing host to a disproportionately high number of waste sites. The results of the official report sent shockwaves through Washington, D.C. and many disputed the findings (US GAO 1983).

Following US GAO's regional study, a landmark national study was conducted by the United Church of Christ Commission on Racial Justices in 1987, titled *Toxic Waste and Race in the United States*. This study tackled the subject of environmental racism (Pulido 2000) while both concurring and validating the results of the US GAO's study and further demonstrating that it was not just a regional issue but also a national one. The UCC's study documented the unequal and discriminatory siting of toxic waste facilities across the United States. The study also concluded that race was the most important factor in predicting where toxic waste sites would be located; however, this portion of the study would later be disputed (Brulle and Pellow 2006; Pastor et al. 2001; Pulido 2000).

While the literature on environmental justice continued to grow, the movement would not see a significant victory until 1992. The report titled "Environmental Equity: Reducing Risk for All Communities" submitted by the US Environmental Protection Agency was the first official acknowledgement by a federal agency (of the environmental justice problems) in a position to effect change (US EPA 1992; Brulle and Pellow 2006; Pulido 2000; Morello-Frosch 1999; 2001; 2002; Pastor et al. 2001). This report led to the subsequent creation of the Office of Environmental Justice within the EPA as well as the National Environmental Justice Advocacy Council to the EPA (US EPA 1992; Pastor et al. 2001; Brulle and Pellow 2006).

In 1994 on the heels of the UCC (1987) study and the EPA (1992) report, a Presidential Executive Order signed by President Clinton directed all federal agencies to take into account the potentially disproportionate burdens of pollution or hazards in US minority communities (Pastor et al. 2001; Pulido 2000; Brulle and Pellow 2006; Massey 2004). This order titled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" spelled out to all federal agencies the need to take environmental justice consequences into account in their decision making and to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, activities on minority and low income populations (Pastor et al. 2001; Pulido 2000; Brulle and Pellow 2006; Massey 2004).

In March 2004 as noted by the EPA's own report (2004), the Inspector General of the EPA declared the agency was not doing an effective job enforcing environmental justice. Among other problems the inspector General notes that the EPA has no strategic plans, goals, or performance measurements designed to advance the intent of the 1994 Executive Order (US EPA 2004). The failure of the EPA to execute the Federal order gives rise to questions of race and the politics of the environment. Furthermore, it underscores that the current moment is one where environmental disparities are increasingly left to local communities to address—an issue that cannot be divorced from environmental racism, which is defined as a socially and spatially constructed form of institutionalized discrimination through which environmental hazards disproportionately impact people of color (Pulido 2000).

2.3 Environmental Racism: A Social Construct

The study of racial inequality is not new to geographers (Anderson 1987; Gilmore 1998; Jackson and Penrose 1994; Kobayashi and Peaker 1994; S. Smith 1993; Pulido 1996 and 2000; Harvey 1992); however given the social, ecological, and health implications of environmental hazards, geographers have explored environmental racism with the goal of contributing to better policymaking (Pulido 2000). According to Runfola and Hankins (2010) the identification of environmental justice has frequently focused on unveiling racial bias in the spatial arrangement of negative environmental factors, such as polluters (e.g., Pastor Jr. et al. 2005; Chakraborty 2001). This idea suggests that environmental injustices are social constructs created spatially and therefore the outcome of sociospatial processes. Pulido (2000) submits that thoughtful consideration of how racism, environmental quality, and urban processes intersect will lead to an understanding of the geography of urban environmental racism and the politics of environmental justice.

Racism is a socialspatial relation both constitutive of the city and produced by it. “If we wish to create a more just society, we must acknowledge the breadth and depth of racism” (Pulido 2000: 533). Pollution concentrations are inevitably the product of relationships between distinct places, including industrial zones, affluent suburbs, working-class suburbs, and downtown areas, all of which are racialized (Pulido 2000). Beck (1986) argues that environmental problems are fundamentally based in how human society is organized (Mohai and Kershner 2002). In the Environment and Society: The Enduring Conflict, Schnaiberg (1994) contends:

> The capitalist economy forms a “treadmill of production” that continues to create ecological problems through a self-reinforcing mechanism of ever more production and consumption. This process breaks down the ability of society to ensure the safety of its citizens from the production of industrial hazards (Beck, 1995). This function of the market invites injustice, since the caretakers of society are more prone to ignoring the hazards imposed upon minority populations for the sake of economic growth and expansion.

Brulle and Pellow (2006) agree with Schnaiberg, and conclude that there are two key social dynamics that systematically create environmental inequality 1) the functioning of the market economy 2) and environmental racism, adding that a specific form of environmental inequality is the phenomenon of environmental racism. Race is so pervasive in our society: race exists in various realms, and racial meanings are embedded in our language, psyche, and social structures. Racial meanings are both constitutive of racial hierarchies and informed by them. According to Pulido (2000) all places are racialized and racism informs all places, therefore it would be impossible for our social practices and structures not to reflect racial understandings (Pulido 2000). Landscapes are artifacts of past and present racisms, they embody generations of sociospatial relations, what might be called the “sedimentation of racial inequality” (Oliver and Shapiro 1995). The dynamic of racism has created a substantial differentiation in both occupation characteristics and community of residence between white and nonwhite populations. The examination of these issues through the lens of race-based residential segregation offers insights into the junctures of the political economy of social inequality with discrimination, environmental degradation, and health (Morello-Frosch, 2002).

2.4 Race-Based Residential Segregation and Environmental Inequality

Myriad forms of past and present discrimination in the US are imprinted onto our urban landscape, as evidenced by the persistent spatial separation of diverse communities along racial/ethnic and to a lesser extent class lines (Farley 1995; Jargowsky 1997; Logan and Molotch 1987; Massey and Denton 1993; Massey and Gross 1994; Walker 1981; Morello-Frosch 2002). Race-based residential segregation is a major contributor to the creation and maintenance of environmental inequality because governments and corporations often seek out the path of least resistance when locating polluting facilities in urban and rural settings. Polluters can site locally unwanted land uses in such neighborhoods, because they are more isolated socially and relatively powerless politically (Bullard 2000; Massey et al. 1993). In 1990 Bullard published his now classic book, *Dumping in Dixie*, which was the first major study of environmental racism that linked hazardous facility siting with historical patterns of spatial segregation in the southern US. It showed that communities of color were being deliberately targeted for the location of society's unwanted waste (Brulle and Pellow 2006) and directly repudiated the minority move-in hypothesis (Pastor Jr., et al. 2001).

The minority move-in hypothesis (Pastor Jr., et al. 2001) suggests that minority residents moved in to communities where industrial plants had been sited due to the low land values. This hypothesis counters the "disproportionate siting or racial disproportionality hypothesis" which suggests industrial facilities sought out lands near minority communities due to their low land values and poor political power (Been 1995). More alarming is the fact that researchers have found little evidence of so-called "minority move-in" into areas where potentially hazardous facilities had been previously located suggesting in fact that industrial and often hazardous facilities are sited in previously established poor minority communities (Been and Gupta 1997; Pastor Jr. et al., 2001; Saha and Mohai 2005; Pulido 2000). Some might argue that this is just the way the market works, since richer communities can afford better environmental protection; however others contend that the issue involves broader questions of human rights and fundamental justice (Massey 2004).

In *The Just City*, Fainstein (2010) argues that structural inequality and hierarchies of power are key social forces shaping our cities and that the inequitable impacts of urban programs resulted from blocking the voices of affected publics. Therefore, the demands for transparency, inclusion, and negotiation in public decisions are a reaction to the top down technocratic approach underlying government programs such as urban renewal, exclusionary zoning and placement of toxic producing facilities (Fainstein 2010). According to Runfola and Hankins (2010), procedural injustices exist in the inability of certain groups (minorities and the poor) to enact positive change (or prevent negative change) in their neighborhood environment. Community-based organizations have a long history of mobilizing resources and residents to improve the quality of life in urban neighborhoods in the United States (Silver 1985; Kellogg 1999). Many of these organizations are challenging such procedural injustices as residential segregation, disproportionate siting, and environmental inequality.

2.5 Visualizing Equality: Community Responses to Environmental Injustice

Communities across the ethnic spectrum are battling a host of environmental threats from toxic contamination and locally unwanted land uses (LuLu’s) to unsafe and substandard housing and natural resource extraction (Brulle and Pellow 2006). The advent of new technologies such as GIS has the potential to aid community organizations in documenting and visualizing such concerns (Treuhaft 2009). Maps are a robust medium (Monmonier 1993:3), and GIS-generated maps have added benefits provided by visual, rather than simply textual or numerical (Dennis et al. 2009) accounts of the experience of social and environmental injustice. Spatially-referenced GIS produced maps are often preferred by policy makers over other forms of data (Elwood 2006), which can make it imperative for communities to produce their maps for consideration in policy and planning meetings. GIS can also aid communities, especially those who have been underrepresented in public policy making (Obermeyer 2004), like Galena Park, by giving them a voice. Through the use of geospatial technologies and spatial data many community organizations, non-profit groups, and social service agencies are expected to play an increasing role in planning and administering American cities, as governmental control and responsibility are devolved to the local level (Elwood and Leitner 1998).

However traditional GIS is largely void of the input of those who can benefit the most from its use, such as communities like Galena Park. Historically, GIS was an agency-driven technocratic tool that favored top-down “expert” knowledge development within hierarchical institutional frameworks (Harris and Weiner 1998, emphasis added). To that avail, traditional GIS has no regard for qualitative forms of knowledge, such as sketch maps, mental maps, narratives and oral histories (Harris and Weiner 1998; Elwood 2005; Sheppard, 1995; Knigge and Cope 2004). Although demands for a democratic or community integrated issue-driven GIS were abundant, to date the literature and activity in this area still remains sparse (although see Jakariya 2009; Elwood 2005; Horley 2008; Hawthorne et al. 2006). One such form of a community integrated GIS approach is public participation geographic information systems (PGIS). Within a GIS and Society conceptual framework, PGIS has demonstrated the potential for GIS to engage the public in collaborative efforts to address community problems (Thompson 2011; Hawthorne 2005).

2.6 A Just GIS?

PGIS is the result of a merger between Participatory Learning and Action (PLA) methods with Geographic Information Technology (GIT) (Corbett et al. 2005). The main ways in which PGIS research differs from traditional GIS is that qualitative information and “expert” quantitative data are both given prominence. Craig et al. (2002) contends that PGIS is becoming an effective methodology for incorporating community local knowledge into complex spatial decision-making processes. This suggests that PGIS has the ability to produce uniquely significant data opportunities, since GIS can substitute the descriptive literature with a visualized narrative by facilitating the representation of local people's situated spatial knowledge using two- or three-dimensional maps. These map products can be used to facilitate decision making processes, as well as support communication and community advocacy (Corbett et al. 2005).

> PGIS practice is geared towards community empowerment through tailored, demand-driven and user-friendly applications of these geospatial technologies. Good PGIS practice is flexible and adapts to different socio-cultural and biophysical environments and it often relies on the combination of 'expert' skills with local knowledge. Unlike traditional GIS applications, PGIS places control on access and use of culturally sensitive spatial data in the hands of those communities who generated it (Rambaldi et al. 2005).

PGIS could provide a useful tool to improve residents' understanding of conditions and problems, through participatory processes of mapping what is important to the community and increasing the effectiveness of community-based organizations working on the frontlines of environmental problem-solving (Kellogg 1999; Elwood 2006; Hawthorne 2005). This is particularly true for those organizations that seek information about environmental hazards and assets that affect health and quality of life conditions in their service areas (Bullard and Wright 1993; Heiman 1997; Kellogg 1999). Of the vast opportunities yet to be realized from a PGIS research approach, issues of access cannot be ignored. Participatory GIS research has required geographers and planners to re-evaluate the meaning of access to GIS technology, GIS databases, and decision-making processes using GIS from a community's perspective (Elwood and Leitner 1998). Access refers both to the availability of GIS and to the appropriateness of the available GIS for addressing the problem in a way that is consistent with the position and perspective of the group seeking to use it (Sheppard 1995).

Many researchers argue that traditional GIS is potentially the most appropriate technology to tailor spatial representation to neighborhood perceptions because of its flexibility in manipulating diverse geographic units to analyze and present information (Kellogg 1999; Gallagher 2006; Gatrell and Dunn 1995; Apelberg et al. 2005; Morello-Frosch and Jesdale 2006). GIS has also been used to analyze spatial relationships among socioeconomic and environmental concerns across multiple scales (Kellogg 1999). These investigations included monitoring air quality (Kellogg 1999; Morello-Frosch 2001; Treuhaft 2009), identifying spatial relationships between cancer risk boundaries and air pollution (Moore 1995; Morello-Frosch 2001; Treuhaft 2009), assessing relationships between air pollution and birth and mortality rates (Williams et al. 1992), and routing hazardous waste transport (Lovett et al 1997; Brainard et al 1996; Kellogg 1999). GIS is also useful because it is integrated with databases that can be modified as neighborhood conditions change, generating new maps with relative ease (Kellogg 1999; Elwood 1998). However, Harris and Weiner (1998) and critics of GIS argue that GIS traditionally contributes to the social and spatial marginalization of communities and cite three ways in which this occurs:

1) Data access and political economy of information. This refers to the fact that spatial data is not always universally, freely, or publicly available, which suggests that, community groups may have access to data for an initial project but may face challenges accessing additional data when the initial project has concluded.

2) Geodemographics and the surveillant capabilities of GIS. Maps produced in GIS can potentially lead to profiling people based on where they live and associating people in the area with the specific phenomena being analyzed (e.g., poverty, affluence, education, health conditions, etc.).

3) Digital representation, epistemologies, and the multiple realities of landscape. This implies that knowledge is situated and shaped on personal and lived experiences of the individual, suggesting that GIS data, applications, and products have to be objective representations of space.

This translates to further marginalizing those in communities who are already marginalized, and thereby supports the need for a more democratic participatory GIS.

Although PGIS seeks to expand the use of GIS to the general public and non-governmental organizations that are not usually represented in traditional top-down GIS projects (Hawthorne 2005; Craglia and Onsrud 2003; Ghose 2001), critics caution that it does not entirely empower communities and should not be the uncontested successor of traditional GIS (Harris 1998). In part, they argue that the term “public participation” is used without qualification and that “public” is too loosely defined (Harris 1998). Critics of PGIS further assert that while this approach is laced with the proper buzzwords (participation and empowerment), which often serve to legitimize policies and projects, it may in fact have the opposite effect (Harris and Weiner 1998). Still proponents of PGIS (Thompson et al. 2011; Hawthorne et al. 2007; and others) contend that it goes further with public inclusion. They cite its alternative epistemologies to contemporary GIS research as evidenced in the five main tenets of PGIS research, which include

1) Integration of qualitative data in GIS, suggesting that PGIS is inclusive of local knowledge
2) Differential access to technology and data, implying that PGIS brings technology to poor communities
3) Place-based GIS methodologies that allow residents’ perceptions to be combined and analyzed along with data about the built environment for a community such as Galena Park
4) Integration of multiple realities in GIS, asserting that PGIS does not assume homogeneity of community members or shared space, and embraces difference in perspective
5) Relationship of GIS to the local political and community contexts - Spatial knowledge and cartographic representations produced using GIS and other digital technologies are often given greater weight in planning and policymaking than knowledge presented in other forms (Aitken and Michel 1995; Elwood and Leitner 2003; Elwood 2006).

These tenets underscore that PGIS does go further with community involvement than its predecessor and provides more profound insights as a result. To date there is little research to support claims of a truly “community-participatory” GIS, even with that stated intention. In fact, most PGIS approaches emphasize taking the GIS out of the community, because it “involves GIS software long after the exercise is completed and far from the community” (Thompson et al. 2011). This continues to perpetuate the hierarchical differences between expert and local and contradicts the purpose of PGIS.

The critics of PGIS offer an alternative, a “community-integrated” GIS (CiGIS). Proponents argue that community-integrated GIS seeks to broaden the use of digital-spatial-data-handling technologies with the objective of increasing the number and diversity of people who are capable of participating in spatial decision-making (Harris and Weiner 1998; Vajjhala 2006; Harris and Weiner 2002). Of course this is all contingent upon GIS being made more inclusive as well. According to Harris and Weiner (2002), Supporters of the CiGIS approach offer that CiGIS is

1) Likely to be agency-driven, but not top down or privileged towards the expert
2) Assumes that local knowledge is valuable as is experts
3) Broadens the access base to digital spatial information technology and data
4) Incorporates socially differentiated multiple realities of landscape
5) Integrates GIS and multimedia
6) Explores the potential for more democratic spatial decision making through greater community participation
7) Assumes that spatial decision making is conflict ridden and embedded in local politics

Supporters of CiGIS acknowledging that GIS is a socially constructed expert system, but they ascertain that this approach will test the technologies capacity in the context of people, through linking robust amounts of local data in to the formal datasets to produced combined knowledge of local and expert (Harris and Weiner 1998). The tenets of CiGIS suggest that the difference between Ci GIS, PGIS, and traditional GIS is that community-integrated GIS would be issues-driven (Harris and Weiner 2002), as opposed to the demand-driven practices of PGIS (Rambaldi 2006), and the expert-driven nature of traditional GIS (Jakariya 2007). Proponents assert that CiGIS would be a system where local knowledge (concerns, desires, and wishes) are actually incorporated and embedded as layers or objects in the GIS. However, based in my experience, many of the primary GIS functions of CiGIS like those of PGIS still occur outside of the community. In this thesis, I demonstrate the importance of step-by-step integrated community-researcher engagement.

In the days when "if you are not mapped you do not exist" I argue that it is not just the mapping of sophisticated data sets and the use of eloquent cartographic representations to visualize spatial coincidences, many of which occur at institutional places with long corridors and well lit GIS labs. Nor, single-handedly is it the interviews, surveys, community meetings, and focus group responses that are critical for revealing sites, processes, and moments of injustice. Rather, it is the collective efforts of mapping inclusive of local knowledge in an active community engagement that shape the visual narratives of social and environmental injustices using GIS. An active involvement allows the community members to determine their own level of engagement with the project, either through actively contributing to the data collection process, the initial choice of cartographic design and layout, or reacting to and even objecting to the subsequent results of the map analysis, the layout, and/or the design.

The approaches CiGIS and PGIS utilize, outlined above, while innovative ways to expand the use of the GIS technology and to encourage community inclusion and integration, do not go far enough in truly involving the community in the post-knowledge-production application of GIS or in involving the community in the way their local knowledge is cartographically represented. This thesis will demonstrate that the principle application of traditional GIS alone does not adequately represent the complete picture of injustice in the Galena Park community, and it fails to capture the lived experience of residents (a vital part of any claim of injustice). I will also show that while PGIS and CiGIS approaches surpass the traditional use of GIS, as they are more democratic and public centered, they, too, miss an important opportunity as advocacy tools to actively involve the community with GIS. This is primarily because most of the GIS functions of PGIS and CiGIS occur in agencies and institutions far from the community (Thompson 2011), which essentially reduces the role of participation in the GIS component of these approaches to that of expert-driven traditional GIS.

I assert that a community-based participatory GIS (CBPGIS) approach would be a more appropriate advocacy tool that combines the best practices of both PGIS and CiGIS with an issues-driven, community controlled, bottom-up democratic focus, and truly "community-based" GIS participation. This includes

1) Highlighting local knowledge production pre and post map production
2) Facilitating active community involvement using GIS software
3) Providing on-site cartographic modifications to the layout and design using ground truthing techniques

This thesis contributes to the field of participatory GIS as it incorporates use of GIS software with qualitative (local knowledge) and quantitative data (expert skills) and expands the community's participation with GIS, in an active participation role in map design and production. I affirm that this type of engagement seeks to counter the possible marginalization that often occurs with other participatory GIS projects approaches, promotes stronger representation of non-elite groups by allowing non-experts to engage the GIS, develops a model for GIS where disadvantaged groups with conflicting ideologies can come together to pursue democratic outcomes to their environmental and social justice concerns and truly empowers communities thereby creating a *just* GIS. This method also allowed the residents of Galena Park to let their voices be heard in the project and subsequently represented in the maps produced. This research approach is tested with the community organization in Galena Park, Texas.

2.7 Purpose of the Study

This thesis research initially set out to explore the use of Geographic Information Systems (GIS) as an advocacy tool and to determine the degree to which GIS is the most appropriate method to aid the Galena Park community-based organization in visualizing their social and environmental health concerns. Following the discussions among residents groups in Galena Park, this includes

1) Mapping the extent of poverty
2) Determining access to healthcare and supermarkets
3) Identifying cancer risk related to the community's proximity to industrial sources of benzene pollution

Ultimately, as maps were produced that revealed these dynamics in Galena Park, it became clear that the true findings of this thesis research lay in offering an approach to truly community-based, participatory GIS practice. As I detail below, preliminary findings indicate that commonly mapped GIS datasets (ie.US census and EPA) are inadequate as they are unable to capture the situated knowledge of the residents' lived experience.

3 METHODOLOGY

The methodology for this research is to use a case study approach (Yin 2009), in which a single example reveals broader processes that can be applied to other social phenomenon. In this research, I developed my experience in Galena Park, Texas, to examine the degree to which community groups in many different contexts might use GIS to best represent their interests.

3.1 Case Study

Through the use of GIS and spatial analysis the case study of this thesis explores the social and physical determinants of cancer risk in Harris County, Texas, with emphasis on Galena Park. Galena Park is a small city situated on the north bank of the Houston Ship Channel in eastern Harris County at geographic coordinates 29°44′20″N 95°14′14″. Within the Greater Houston-Sugar Land-Baytown metropolitan area, Galena Park sits on five square miles of land eight miles east of the City of Houston, although never officially annexed (see Figure 1).

Galena Park encompasses one census tract in the highly industrious Port of Houston Petroleum Refining Complex and is home to many Petrochemical plants and refineries (see Figure 2). All the streets in Galena Park are terminal (one way in and out) and the community is completely encased by railroad tracks posing an evacuation hazard. The smell in Galena Park changes from place to place with the most prominent odors near the Panther Creek (raw sewage) and Clinton Drive near the Middleton supermarket.

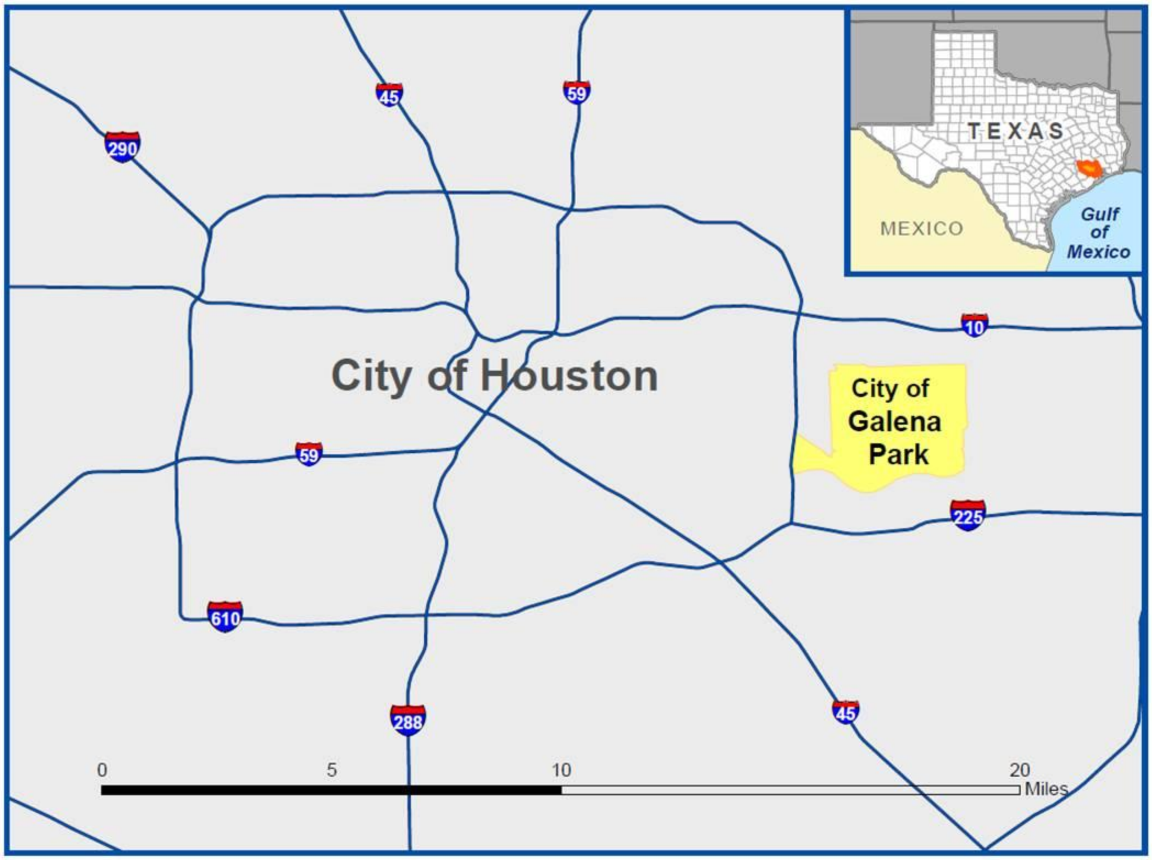

Figure 1. City of Houston and Galena Park Study Area

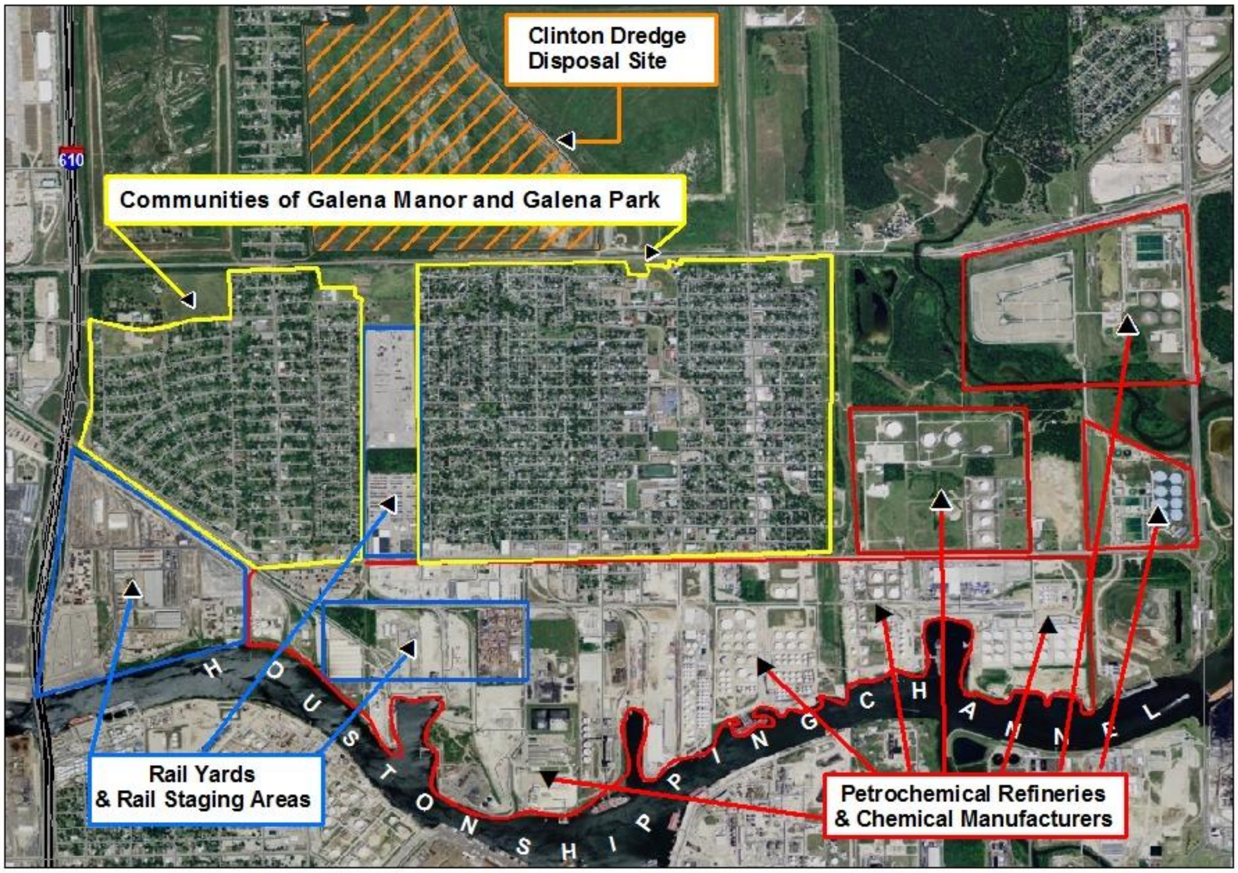

Figure 2. City of Galena Park (Aerial)[1]

Originally named Clinton in the 1800's, the name was changed to Galena Park when the city was incorporated in 1935. According to the written records and word of mouth accounts from long-term residents, Galena Park began as an agriculture and ranching community and later evolved into a railroad center (ECAGP 2010). After the first oil company (Galena Signal Oil Company of Texas which was later brought out by Texaco) was built in the town, Galena Park began to grow rapidly and was transformed into the petro refinery center of today. Originally a white-only town, with the growth and expansion, the city became more diverse, and Galena Park began allowing African American residents to settle along the western section in what is historically known as Galena Manor sometime around 1940

[2]Harris County- includes the City of Houston and the Greater Houston Metropolitan Area, which includes Galena Park.

[3]Port of Houston Petro Refining Complex- 25 mile long port is the largest and the busiest in the US.

[4]Houston Shipping Channel- is a conduit for ocean going vessels, the Houston ship-yards and, many petrochemical companies.

(ECAGP 2010). The black and white races were completely residentially segregated by a train depot and train staging area, which still separates the community today. The effects of segregation would have lasting impacts on the social landscape of Galena Park for many years to come.

In the late 1960's the city of Galena Park saw its first Hispanic residential migration; subsequently around the same time it experienced a mass exodus of white residents in the white flight phenomenon of the same decade. This, too, would have a lasting effect and reshape the social and demographic characteristics of Galena Park. A seawall that barricaded Clinton Park a "black section" in Houston from the white areas of Galena Park still exists today, according to Rafael Longoria and Susan Rogers of the Rice Design Alliance: "This barricade still exists today, a stark example of the segregationist sentiment that plaque much of the south."

As of the 2010 census there were 10,901 residents in Galena Park. As table 1 indicates, Galena Park is a predominantly minority community of Hispanic (80 percent) and African American (6 percent) residents. As Table 1 reflects, there was a significant demographic shift between white and Hispanic residents from 2000 to 2010. The population declined in White Americans from 22 to 11 percent, and increased for Hispanic/Latino residents from 69 to 81 percent, shifting exactly 11 percentage points for both racial groups. The table also reflects population declines for all other races, with the white population having the greatest decline.

Table 1. Galena Park SES and Demographic Landscape

Population	Census 2000	% Pop	Census 2010	% Pop
White American	2,347	22.15	1,240	11.37
African American	803	7.58	721	6.61
American Indian / Alaskan Native	22	.20	13	.11
Asian	29	.27	10	.09
Native Hawaiian (Other Pacific Islander)	1	.0	1	.0
Hispanic / Latino	7,344	69.32	8,872	81.39
Children <6yr	989	9.33	1,054	9.67
Women of Childbearing Years (Age 15 to 44)	2,535	23.93	2,343	21.49
Adults Age 65yr>	1,053	9.94	1,785	16.37
Total Pop	**10,593 (yr 2000)**		**10,901 (yr 2010)**	

According to resident testimony from members of the ECAGP, residents in Galena Park have faced historically undocumented perceived environmental justice and community health concerns. The rapid growth and expansion of Galena Park has led to many occupational and environmental health concerns. The number one health concern according to the members of the Environmental Community Advocates of Galena Park (ECAGP) is cancer. Residents have long suspected they were being exposed to environmental contaminants from routine industrial discharges, accidental spills, and the dredge disposal site in close proximity to their homes and schools. According to news articles dating back to the late 1980's from Houston Chronicle archives (circa 1987), Toxic Waste Coordinators like Rick Abraham of the Texas Center for Rural Studies, an advocacy group, have complained that the dredge dump site although diked, is leaky and spreads materials in floodwaters to surrounding neighborhoods and communities. Long-term residents such as W.F. Biggs was reported as saying, “The runoff from the dredge site enters Panther Creek which winds throughout the entire city and its often tainted with an oily substance with an odor that burns the nostrils” (Houston Chronicle circa 1986). In 1973, US Representative Bob Eckhardt called for an investigation of dead fish and “chemicals so strong they took the paint off people’s homes” (Houston Chronicle circa 1988). In 1987, the community residents faced a significant blow to their environmental health complaints after the Texas Water Commission announced the locations that would receive environmental remediation as a result of the state’s Superfund program. The Water Commissioner advised that the dredge facility was not within its jurisdiction (but lies under the Houston Port Authority and the Army Corp of Engineers), was not an imminent hazard, and chemical testing of the dredge facility did not indicate contamination high enough for Superfund status.

The Clinton Dredge Disposal site is a 1,100 acre site bounded by Galena Park’s Holland Drive to the east and Fidelity Street to the west, the Port Terminal railroad in Galena Park to the south, and Jacinto City’s Lane Street to the north (see Figure 2 above). According to a Houston Chronicle article dated in March 1988, Carol Gentry, longtime resident of Galena Park, described her feelings about the Clinton Disposal site that she blames for her family’s health problems. “My son and I have allergies, we have sneezing, coughing, and headaches, and now we take medications to breathe”. Audrey Germany, local resident recounted a levee breach in the 1980’s from the dredge site and remembered area homes “turning plumb black” after the waste escaped the site due to heavy rain. In stark contrast to his constituents longtime Galena Park Mayor, Alvin Baggett, whose home overlooks the dredge site stated, “the dredge site is an important to us as the Ship Channel itself, we have to have someplace to dump the material”.

Current residents and members of the Galena Park Environmental Community Advocates Group advise that the dredge dump site is still a mystery to them; they have the same fears as other longtime residents and even greater health concerns since most of those past residents have died of causes that they feel are related to Galena Park's poor environmental conditions (E-CAP 2010). Due at least in part to lack of deed restrictions, many residents along the Houston Ship Channel live precariously close to large industrial facilities (Engelman 2010), also allowing the dredge dumping facility to site 200 yards from Galena Park's MacArthur Elementary School. As a precaution the school has warning signs asking students to stay away. Unfortunately for the residents of Galena Park, this type of Industrial/residential spatial arrangement plays out throughout the city's landscape, is the subject of much debate, and, according to many residents, it is the cause of many healthcare concerns.

In December 2007 the Houston Shipping Channel was featured on CNN's Planet in Peril as a potential polluter of nearby neighborhoods, including Galena Park (CNN 2007). That same year the University of Texas released a bombshell study suggesting that children living within two miles of the Houston Ship Channel were 56% more likely to become stricken with leukemia than the national average (Whitworth 2008). Additionally, the Houston Ship Channel and Harris County are historically at the top of the EPA's National Priority List, a list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants, throughout the US and its territories (US EPA 2012). The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation (US EPA 2012). Harris County and companies in the Houston Ship Channel complex are considered the number one offenders of environmental accidents for the past decade, according to the Agency for Toxic Substance and Disease Registry's Hazardous Substance Emergency Events Surveillance[2] (HSEES) report of 2012. Due to the potential harmful human impacts these types of environmental issues produce, they are cause for immediate concern for the Environmental Community Advocates of Galena Park.

[2] The HSEES system was established by the ATSDR to collect and analyze information about acute releases of hazardous substances and threatened releases that result in public health action such as evacuation.

3.2 Formal Datasets

As mentioned previously, community residents, in conjunction with E-CAP desired to see visual representation of many of their social and environmental concerns. As such, the first step in my role as a research collaborator with the group was to gather "official" datasets to map a variety of phenomena, which I describe in more detail below. These include data from the U.S. Census that characterize the socioeconomic and demographic landscapes of poverty and race-based residential segregation. One of the primary concerns for residents of Galena Park is air quality and benzene exposure; the EPA provides model air quality data through the National Scale Air-Toxics Assessment, which were obtained to visualize benzene concentrations through the study area.

3.2.1 **Census Data**

Area level demographic and socioeconomic information from the 2000 Census (summary file 3) was obtained for Harris County, Texas at the tract level (U.S. Census Bureau 2010). The 2000 census data was chosen for analysis because it is the most current comprehensive (long form) decennial census available. The 2010 census, having undergone major changes, no longer captures socioeconomic data, customary of the long form. The new census format is strictly a population count (short form only). The socioeconomic data are captured in the American Community Survey (ACS). While the ACS does capture those significant socioeconomic indicators, the measurements have significantly high margins of error (MOE). The MOE reflects a potential sampling problem associated with the smaller sample size from which the ACS estimates are based. The ACS also only releases data in 1, 3, and 5 year counts and currently no decennial counts exist. There are also table suppression concerns; the ACS deems areas with less than 100,000 insufficient for sampling (US Census 2010). This would be of particular concern for smaller geographic areas such as Galena Park, which has a population of approximately 10,000 residents and encompasses one census tract.

3.2.1.1 Poverty

Researchers suggest that economically disadvantaged neighborhoods are often disproportionately located in close proximity to industrial sources of environmental pollutants (Apelberg 2005; Massey and Denton 1988; Pastor Jr. 2000; Morello-Frosch 2000). Poverty and deprivation patterns were analyzed at the census tract level within the study area to determine whether disparities exist in benzene concentrations related to socioeconomic status throughout Harris County, Texas, with special emphasis on the Galena Park community. Estimates were determined by normalizing the population for whom poverty status was determined over 15 years (in accordance to the US Census Bureau's Poverty Universe definition) with the total population in each census tract. The result of this technique provided the poverty ratios per census tract for Harris County. Poverty status was then determined by the U.S. Census Bureau's poverty thresholds, and the methods used to generate the poverty threshold are described by the U.S. Census Bureau (U.S. Census Bureau 2010).

For this analysis, I assigned poverty status using the methods described by the U.S. Census Bureau to generate the poverty threshold, which is the benchmark for determining the poverty level (i.e., the degree to which the family income is below the poverty threshold). The U.S. Census classifies poverty into three main categories: low/moderate (characterized by twenty percent of the tract population living below the federal poverty level; high (characterized by twenty - thirty nine percent) of the tract population living below the federal poverty level; and concentrated (characterized by over forty percent) of the tract population living below the federal poverty level (Census Bureau 2010). Studies suggest that there is a correlation between residential segregation and poverty levels evidenced by a persistent overlap in areas of high minority residential concentrations and area level poverty (Massey and Denton 1988).

3.2.1.2 Race-Based Residential Segregation

According to Massey and Denton's landmark 1988 conceptual analysis of residential segregation, there are five key dimensions of segregation which include evenness (dissimilarity), exposure (isolation and correlation), concentration, centralization, and clustering (Massey and Denton 1988). The dissimilarity index is the most commonly used of all the segregation measures for the expressed purpose of determining how dissimilar a community is. The outcome of the dissimilarity index would yield the amount of residents in the community that would need to move to achieve "evenness". Having spent time in Harris County, Texas, and more importantly the Galena Park community I have firsthand knowledge of how "dissimilar" the community is. The residents are socially or geographically isolated from one another. They have clearly defined territories, and each racial/ethnic group stays in their space, most often with others of their same race/ethnic group. Galena Park is also a very stable community of generational residents, most of whom are retirees and highly unlikely to move. Therefore the dissimilarity index would not be the best choice for this study.

To address this limitation, the Isolation Index of Segregation was employed for the purposes of this study to determine the social interactions of the racial groups in order to reveal the probability that a Hispanic/Latino or African-American resident would encounter a resident of the same race in any random meeting in his/her own neighborhood (Libersons 1978) versus a White resident. This measure will also reveal the presence or scarcity of social capital within the community. The Isolation Index of Segregation was calculated using the following formula:

$$\sum\left(\frac{b_i}{B}\right)\times\left(\frac{b_i}{t_i}\right)$$

where: b_i is the African-American population of the block group, t_i is the total population of the block group, and B is the total African-American population of the census tract. Research implies that residentially segregated, economically challenged minority community's often lack the social and material supports necessary for a community to thrive. For example, the absence of material supports such as grocery retailers can have a significant impact of the overall health of the residents (Gallagher 2006), which I describe in more detail below.

3.2.2 **U.S. EPA's NATA Census Tract-level Estimation**

Given the Galena Park residents' desire to map cancer risk, I include National Scale Air Toxics data (NATA) to determine benzene exposure risk. NATA is a modeled air toxins dataset available at many geographic scales; it was most recently updated in 2005 using the 2000 geographic boundary files. Therefore, the 2000 census tract data would not properly align with the newly redistricted tracts of the 2010 census. The NATA benzene estimate data was combined to the census in order to analyze the relationship between demographic and socio-economic variables and exposure to environmental pollution from benzene, a group 1 A known human carcinogen. Air toxics are pollutants known or suspected of causing cancer or other serious health problems (U.S. EPA 2010). As stated in section 3.3.1 the most current National-Scale Air Toxics Assessment (NATA) was released in 2005 and assessed 181 toxicants. NATA estimates risk from exposure to emissions from industrial, as well as, on and off road sources. The cancer non-cancer risk estimates are based on 81 toxicants including benzene. Cancer risks presented in the On-road and Non-road Mobile Risk files identify cancer risks that are not due to the diesel PM component of diesel engine emissions. These cancer risks are due to the other air toxics, such as benzene, which are found in the gaseous component. The U.S. EPA describes in detail the calculations used to compute census tract-level estimates (U.S. EPA 2010).

The census tract level is the smallest spatial resolution for the NATA. The NATA US Cancer Risks Tract level data was downloaded, and the data for Harris County were extracted using the census state county Federal Information Processing Standards (FIPS) code as the identifier ('48201'). The ambient level concentrations for each source are multiplied by a ratio (or tract-level exposure factor) of the estimated hazardous air pollutant (HAP)-specific exposure concentrations to HAP-specific ambient concentrations (HAPEM output/ASPEN output for the same HAP, source, and census tract) that were developed from the 1999 HAPEM5 modeling (U.S. EPA 2010). The census block level ambient concentrations (stationary sources were initially modeled at the census block level) were then converted to tract-level exposure concentrations using the tract-level exposure factors, and the exposure factors were applied to each census block equally (U.S. EPA 2010). For the purposes of this analysis only the benzene concentrations at the tract level for Harris County Texas were investigated.

3.2.2.1 Benzene exposure and Cancer Risk

National and international agencies are responsible for determining the cancer-causing potential of different substances. For the residents of Galena Park, having official acknowledgement of the cancer causing properties of benzene, supports their claims that the cancer-related deaths within the community are associated with benzene exposure. The International Agency for Research on Cancer (IARC) defines cancer risk in the following categories: Group 1: Carcinogenic to humans, Group 2A: Probably carcinogenic to humans, Group 2B: Possibly carcinogenic to humans, Group 3: Unclassified as to carcinogenicity to humans, and Group 4: Probably not carcinogenic to humans. The U.S. Environmental Protection Agency (EPA) categorizes cancer risk as follows: Group A: Carcinogenic to humans, Group B: Likely to be a carcinogenic to humans, Group C: Suggestive evidence of carcinogenic potential to humans, Group D: Inadequate information to assess carcinogenic potential, and Group E: Not likely to be carcinogenic to humans. For this study hybrid of the two (2) classification systems was used and benzene is referred to as a Group 1A known human carcinogen.

The benzene concentrations from all sources (industrial area, background, on and off road) were extracted from the NATA data using the state county FIPS for Harris County ('48201') and combined with the census tract boundary shapefile of Harris County for the year 2000 in order to visualize the spatial distribution of Benzene concentrations. Inhalation unit risk is defined as the upper-bound (7.8×10^{-6}) excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 microgram per cubic gram ($\mu g/m^3$) in air (U.S. EPA 2010). Estimated Cancer risk for Benzene was determined using the upper-bound inhalation unit risk in micrograms per cubic meter using the following equation:

$$\textbf{Lifetime CR = EC x IUR}$$

where *CR* is the cancer risk in the year 2000 census tract, *EC* is estimated cancer risk, and *IUR* is the inhalation unit risk estimate for benzene in micrograms per cubic meter. The upper bound limit is the excess lifetime cancer risk estimated resulting from continuous exposure to an agent at a concentration of $1\mu g/m^3$ in air. According to the EPA (2012) the inhalation unit risk range for benzene absorption is: 2.2×10^{-6} (lower bound) to 7.8×10^{-6} (upper bound) per $\mu g/m^3$. The upper bound limit was included in the analysis to determine the excess cancer cases expected to develop per 1, 000,000 people if exposed daily for a lifetime to 1 µg of benzene in 1 cubic meter of air. The lifetime cancer risk was normalized by the population of each census tract to determine the number of potential new cases that could develop based on the current tract population.

3.2.3 **Anciliary Data**

Through various qualitative processes, Galena Park residents identified and prioritized the social and physical environmental factors of greatest interest. The determinants selected for investigation in this thesis were at the request of the Galena Park residents and included access to supermarkets and healthcare. Community members perceived they had a longer than average drive to the supermarket and health care services. They wanted to determine if the disproportionality in access was specific to their neighborhood or a generalized occurrence through the Harris County region.

3.2.3.1 Supermarket Access

The neighborhood food environment refers to both the availability of healthy foods within a community and how easily residents can access those foods (Mikkelsen and Chehimi 2007). According to the USDA, the absence or presence of a supermarket in a community determines the quality of the food environment (USDA 1999). Research suggests that minority and economically disadvantaged populations are disproportionately restricted access to low cost high quality foods, evidenced by the lack of supermarkets or super centers (i.e. Wal-Mart and Target) in their communities. This dearth can reveal the impacts of structural racism and the on-going effects of residential segregation (Williams and Collins 2001; Brulle and Pellow 2006; Massey and Denton 1988; D. Smith 2010). Impoverished areas with poor access to retail food outlets are considered "food deserts." Food deserts by definition are large and isolated geographic areas where mainstream grocery stores are absent or distant (Blanchard 2006; Mikkelsen 2007).

Food deserts are characterized by area poverty, long commute times, and travel distances. According to the USDA's Healthy Food Financing Initiative (HFFI) in order to qualify a place as a "food desert" or "low access community", two disparities must exist: 1) the census tract must qualify as a low income community, meaning that it has a poverty rate of greater than or equal to 20 percent (high poverty) and 2) at least 500 people or 33 percent of the census tract population must reside more than one mile from a supermarket or large grocery retailer (USDA 2012). To assess the quality of the food environment in Harris County, all food stores were categorized using the Occupational Safety Health Administration's (OSHA) Standard Industrial Classification (SIC) code. Grocery stores were identified using the SIC code of 5411 and supermarkets identified as grocery stores with 50 or more employees using the Reference USA database for the businesses demographics.

A network dataset of the Harris County road network was built in order to run a network analysis to measure accessibility from the population weighted block group centroid to the nearest supermarket in the study area. This measure calculates the network distances which simulate near actual drive times. Network distances are more accurate for measuring travel distance and spatial accessibility than Euclidean/Cartesian and Manhattan distances because people travel along a road network. The roads file for Harris County, Texas was obtained from the Navteq 2010 GIS database. Distance/proximity was measured using the following equation:

$$Z_i^a = \frac{\sum_{b \in i} w_b (\min|d_{bs}|)}{\sum_{b \in i} w_b}$$

where: Z_i^a = mean distance between census tract i and the closest supermarket, w_b is the total population of block group *b* completely within census tract i, and d_{bs} is the distance between block group *b* and supermarket *s*.

3.2.3.2 Healthcare Access

The residents of Galena Park, and many African-Americans, Hispanic/Latinos, American Indians, and low socioeconomic status whites in the U.S. often have less access to healthcare and receive a lower quality of care than do middle and upper class whites, especially for more complicated procedures (Alliance for Health Reform 2006; Williams and Collins 2001). Disparities in health care include lack of health care coverage, too few minority providers, inadequate provider qualifications, communication barriers, and spatial access (Alliance for Health Reform 2006; Williams and Collins 2001). For residents in the Galena Park community, the absence of healthcare providers for residents over 18 years-of-age raises concerns, especially for those seeking major or ambulatory care for chronic illnesses or following human-made and natural disasters. Hospitals were identified using the SIC code of 8062 (Major and Ambulatory Care). Using the Navteq 2010 file a network dataset was created to analyze the distance from Galena Park to the nearest hospital along the road network. Distance was measured using the following equations:

$$Z_i^a = \frac{\sum_{b \in i} w_b (\min|d_{bh}|)}{\sum_{b \in i} w_b}$$

where: Z_i^a = mean distance between census tract i and the closest hospital, w_b is the total population of block group *b* completely within census tract i, and d_{bh} is the distance between block group *b* and hospital *h*.

3.3 Techniques

Participatory actions and the use of GIS were employed in this thesis in order to visualize and examine the environmental factors of most concern to the residents. Spatial exploration using the GIS was conducted in order to reveal inconsistencies among resource distribution for the purpose, ultimately, of improving the lives of Galena Park residents.

3.3.1 **Community Participatory Actions**

Through a series of bi-monthly meetings, the Environmental Community Assessment Project (E-CAP) Team and I reviewed and analyzed environmental health concerns using existing traditional health and environmental data sources, which I have just explored in detail. Five focus groups and a larger community-wide environmental health forum were held, which allowed the community members of Galena Park, along with members of the E-CAP, and I to identify priority health issues and strategies to address them. The E-CAP Assessment Team was made up of representatives from the Galena Park community, City of Galena Park City Council, Harris County Commissioners Sylvia Garcia (Precinct 2) El Franco Lee's (Precinct 1) offices, Harris County Community Services Department, Harris County Hospital District, various divisions from Harris County Public Health and Environmental Services (HCPHES), and researchers from UT MD Anderson Cancer Center's Center for Research on Minority Health, for whom I was a summer research fellow. The E-CAP Assessment Team members discussed health equity and social justice concepts and identified root causes of the City's challenges. Through this collaboration, the group identified three priority issues: air quality, access to health care, and the built environment. These ongoing dialogue sessions also provided the opportunity to integrate local and professional knowledge about the identified environmental priority areas (King and Jordan, forthcoming).

While identification of the three priority environmental health concerns was a significant accomplishment, quantitative data needed to reconcile community "perceived" concerns remained elusive (King and Jordan, forthcoming). Meetings with the research team and community members resulted in the decision that I would utilize GIS and spatial analysis in order to provide the much needed quantitative component of the study as well as visual representation of the community's concerns which could be used at future planning and policy meetings (King and Jordan, forthcoming). For comparison purposes the spatial analysis in this thesis includes the portion of Harris County, Texas, inside the Beltway 8 (an intermediate Beltway in the Houston area) and encompasses 402 census tracts including Galena Park. Census tracts were selected as the scale of analysis for the case study because a census tract is the lowest level in which cancer risk estimates are available.

Following the Racial and Spatial Relations conceptual framework adapted from Schultz (2002), I conducted spatial analysis to assess the physical environment by measuring the concentration and proximity to industrial sources of the hazardous air pollutant, benzene. Additionally, race-based residential segregation and poverty, as well as, lifetime cancer risk disparities attributed to prolonged benzene exposure, was evaluated for the Galena Park, Texas, community. The social environment was investigated by visualizing spatial accessibility to healthy food options and adequate health care providers (King and Jordan, forthcoming).

3.3.2 **Community Geographic Information Systems (GIS) with Galena Park Residents**

As recounted above, GIS is a computer based technology that merges cartography, statistical analysis, database technology and geographical features (i.e. cities, counties, states) to visualize data through its spatial relationship with other phenomena. GIS utilizes geographic properties to analyze relationships between spatial units (ESRI 2010) in order to assess real world problems. Census tracts and block groups are spatial units that represent permanent statistical subdivisions completely within a county (U.S. Census Bureau 2010). In the case of Galena Park, it was mutually decided by the residents and the E-CAP team, that GIS was the technology of choice to visualize the community's concerns. This decision was reached primarily because the residents had tried many content choices (ie. posters, flyers, power points) to relay their concerns to the local government without much success. As they expressed to me, they understood the growing interest in map products and the partiality of policy makers to GIS created map products. A key part of this process involved ground-truthing the maps that were produced.

3.4 Ground Truthing

In order to encourage opportunities for continuous participation with GIS, post map production; I decided to use a method of evaluating known as ground truthing. Ground truthing is a term used widely in remote-sensing and cartography which describes the process of verifying maps and images with the on-ground phenomena, in this case with the resident's knowledge of the social and physical environmental. I feel that using the ground truthing technique post map production is especially critical in participatory GIS research, in order to accurately represent the community's perspective and details that they deem necessary and important, as well as to relate the image to real features on the ground, given strength to the community's argument. In this thesis ground truthing was a post map production process that included a series of meetings with residents and multiple iterations of the maps, which I describe in more detail below.

4 RESULTS AND DISCUSSION

Working with the community of Galena Park revealed many things about the expert and non-expert didactic. Local residents are keenly aware of their environments, often more than so-called experts. They are sharp, witty, and willing to share many of the nuanced details about their local environment, often left out of official datasets and scholarly works. The residents and many of the E-CAP assessment team members, had never heard of, nor used Geographical Information Systems prior to the summer of 2010. Therefore I deemed it necessary to provide an overview of the technology, in order to determine if it was feasible to use for the group's purpose, as well as to introduce the groups to the functions and capabilities of GIS and to shape realistic expectations of the project. The residents of Galena Park are serious about their concerns and ready to take action. They did not shy away from the use of technology; in fact they encouraged it. They were actively engaged and had the drive and willingness to help make the final GIS-produced maps successful, at least to the extent that the maps incorporated their view of those social and environmental factors that contribute to the environmental injustice they face.

The use of traditional GIS, as stated in the introduction, provided the community with an opportunity to visualize the social and environmental conditions discussed in the weekly community meetings. This also afforded me the opportunity to critically examine the perceived concerns and draw much needed connections from the data display. The series of before and after maps produced in this thesis will evidence that the traditional GIS was useful in providing a bird's eye view of social and environmental phenomena; however it was not sufficient at revealing the lived experience of the residents, which is just as important as quantitative data when substantiating claims of injustice. As a result the maps went through several iterations during the ground truthing phase, resulting in products that accurately captured the lived experience of residents, inclusive of the local knowledge of topics and nuanced details that were originally neglected. The meetings were very interactive as residents used the laser pointer to bring attention to areas they were concerned about. Many times residents walked up to the screen to take a closer look and make requests for changes. Since the maps produced were going to be the official ones used in planning efforts, local government meetings, lectures, and conferences, all cartographic modifications were on the majority rule system, meaning that if the majority of the people present at the meeting wanted a change that the change would be made.

4.1 Mapping Perceptions

Figure 3 is an image of the blank aerial I distributed to residents at a regularly scheduled community meeting, in order to determine their perceptions of the environment in Galena Park.

Figure 3. Blank Aerial Map of Galena Park

Residents were first asked to identify areas in the community from the aerial. Almost immediately they began naming the companies in the petro complex. I was surprised by just how many of the companies in the ship channel complex the residents could name and the details they could provide about many of them, such as: who just received a fine for an "accidental" release, the company that refused to make their monitoring reports public, which companies sponsored the football team, and the companies suspected as being very politically connected. Narrative forms of knowledge unable to be capture by mapping conventional datasets. I labeled the aerial using ArcMap GIS software as the residents identified the different places. I asked the community members to verify the locations I was labeling for accuracy as we went. Some community members came up to the laptop and looked over my shoulder to "make sure I was getting it right" advised the Vice President of the ECAGP. Figure 4 captures the resident's identification of their surroundings. I asked the residents, if any of them worked in the ship channel there was a resounding no. More than the word no, it was the way *no* was stated, arguably; a manifestation of embodied experiences between the residents and entities representing the ship channel.

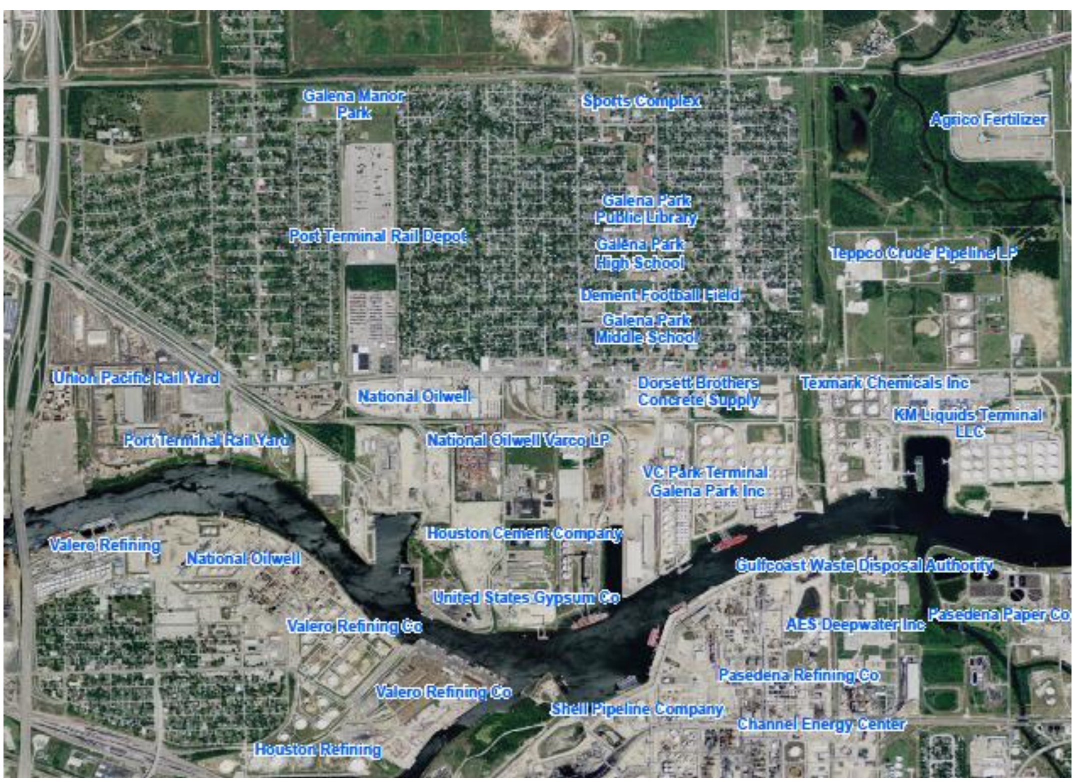

Figure 4. Community Identified Surrounding

To further investigate underlying sentiment in their response to the ship channel question, I attempted to capture the community's perception of their space. In order to do that, residents were also given one red, blue, and yellow marker each, along with an index card and pencil. Residents were asked to outline areas they perceive to be a negative in red, areas they perceive to be a nuisance in blue, and areas they perceive as positive in yellow. I outlined the areas in the aerial in accordance with the resident's responses. Figure 5 displays the color coded image of community perceptions.

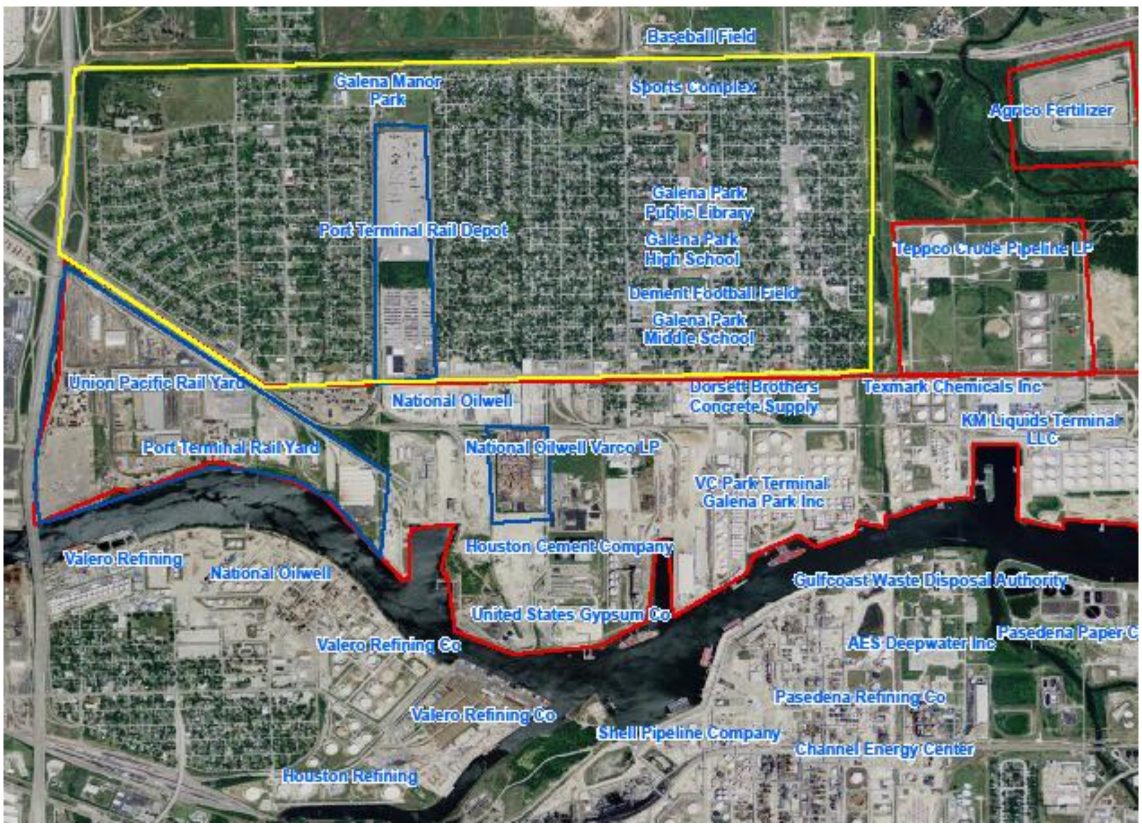

Figure 5. Color Coded Image of Community Perceptions

Overwhelmingly, the community members labeled many of the same areas in the petro complex in red, suggesting that they perceive many of those companies as negative entities. Areas that were considered noisy such as I-610, the rail yards, and parts of Clinton Drive were labeled in blue. With the amount of red and blue on most of the maps I assumed there would be very little yellow. I could not have been more wrong; residents unanimously labeled their residential spaces in yellow. This suggests that, in spite of all the negative entities in their community, they still are largely satisfied with their personal residential space. Moreover, there were places where both positive and negative areas met; and even still some places where all three perceptions converged. This suggested that at least for Galena Park, space is often contested.

Residents were completely engaged in this meeting, as their perceptions were starting to be illustrated. Many of the longtime residents objected to the single yellow box around the communities. They advised that Galena Park is made up of not one, but two communities: Galena Park, the white and Hispanic side, and Galena Manor, the black side, and they wanted the image to reflect this historical segregation that they have come to accept, and in cases embrace, over the years. The photograph in figure 6 is of the historic Galena Manor as one enters the black section of the community. This photo was taken during a driving tour hosted by members of the ECAGP. According to the residents the sign is fenced in because it has been vandalized many times over the years.

Figure 6. Galena Manor Welcome Sign

Residents also advised that I was missing a key part of their reality: the Clinton Disposal facility in the back of the community. ECAGP members directed me to the area of town where the facility is cited. Even more curious was the fact that the residents did not want the dredge facility labeled in red (negative). They suggested the dredge facility was far more than a negative entity it was an extreme biohazard and imminent threat to the children of the community; therefore it was decided that the color would be orange (the color of many caution signs in the community surrounding the dump site). Some community members wanted an orange X on the site and some wanted a skull and X. For the purpose of presenting the image to policy makers and elected officials, we settled on orange hatch marks. Figure 7 shows the final results of the community's perception of their environment. The residents were also asked to write their initial reactions to some of the places in Galena Park on the index card provided to them. This would be used in the future multimedia aspects of the project in which I link their perceptions to photos of the spaces.

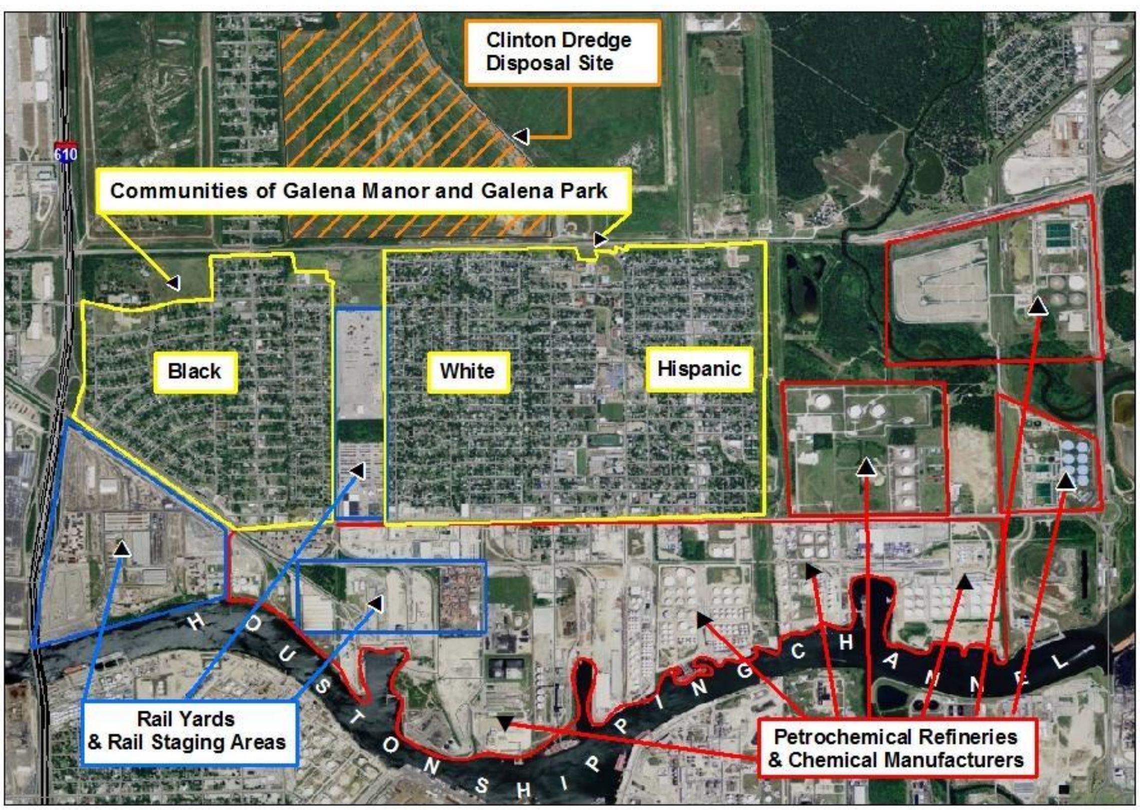

Figure 7. Final Map of Community Environmental Perceptions

The results of these maps confirm how important local knowledges are and how useful they can be in presenting a complete picture of a community. The details provided in these maps are not the type of information a researcher or policymaker can find by only mapping formal datasets. However, these are the types of insights that could be integrated into GIS in order to shape a comprehensive understanding of shared knowledges. Without local situated knowledge vital pieces of information may be overlooked. Places like the Clinton Dredge Disposal facility are not marked on the mapping services such as Google Earth, Google, and Bing Maps; because such places are unmarked they are often "unmapped". Participatory engagement with the community yielded details of their lived experience that are essential to who they are and where they live. This suggests that there is added value in continued community engagement when conducting GIS-related mapping exercises.

The active involvement of community members with the cartographic functions of GIS is imperative to the success of community-academic partnerships, provides an additional buy-in factor, provides community members the opportunity to aid in the production of maps, and gives members of the CBOs the opportunity to better understand the layout and design, which could result in better talking points with emphasis on those items that are of relative importance. The cartographic portion of the community meeting became very popular. According to the E-CAP team officers more residents attended the cartography and GIS meetings than the regular business of the day meeting. At one meeting it got pretty crowded around my laptop as many in the community wanted to see what I was looking and how I was modifying the maps using GIS. I started bringing a portable projector to the meetings so everyone could see the image on my laptop and offer their suggested edits.

4.2 Mapping Access

The ECAGP members wanted to work on the food desert maps next, as they had an upcoming meeting with H-E-B, a chain grocery store, and wanted to have a map to present. Figure 8 shows the distribution of food stores throughout Harris County using traditional GIS applications and mapping an informal dataset, before meeting with community members to determine the accuracy of the information presented. This crude map was not intended to be cartographically sophisticated, but more a way of reviewing the spatial arrangement of the data in order to inform decisions on how best to represent the data.

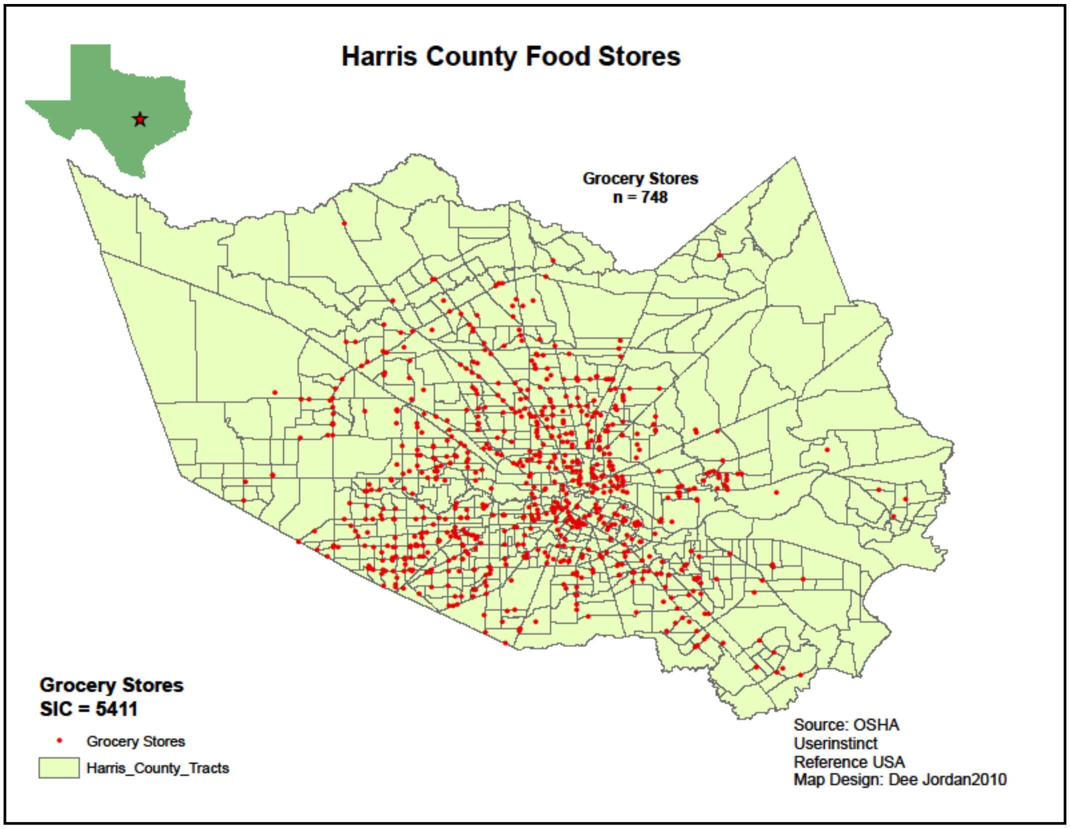

Figure 8. Distribution of Food Stores (Before)

This was the first time many had seen the GIS County and census tracts layers and many residents were unfamiliar with these boundaries. The following critiques were offered: many residents did not recognize the county outline or the census tract boundaries. Most had not heard of census tracts. One Galena Park resident remarked, “Everyone may not know that this is Harris County but everyone in Harris County knows the Beltway 8 or I-610.” Residents encouraged me to bring the focus area in more and highlight Galena Park because they could not determine where it was on the map. Most residents objected to the number of supermarkets that appeared to be in Galena Park. The residents were adamant that they live in a food desert. In community meetings residents and members of the Galena Park CBO shared that the sole “grocery store” in the community, Middleton Supermarket was more like a convenience store than a grocery store. As one member put it, “there is certainly nothing *SUPER* about it.” Figure 9 is a photo of Middleton Supermarket.

Figure 9. Middleton Supermarket

Visiting the Middleton Supermarket on a community tour revealed the residents’ revelations. Middleton’s had very little fresh produce and those items that were visible were in various states of spoilage. The store had mostly canned items, and only one worker was present on several site visits. The store also doubles as a take-out restaurant, certainly not meeting the HHS criteria for supermarket classifications. The residents have petitioned the owners of Middleton to provide healthy options beyond canned and processed foods. The community is very concerned about the health effects associated with processed foods, since processed foods have been link to many chronic diseases, all-cause mortality, and cancer. Negotiating with Middleton has been unsuccessful; residents have sought alternative means to accessing fresh fruits and vegetables such enrolling in a fruit and vegetable co-op, and contacting local farmers' markets to establish a site within the community, and contacting H-E-B (chain grocery store), to establish a small grocery store within the community. The following image (figure 10) is the result of the supermarket distribution analysis that has undergone participatory ground truthing to correct the map.

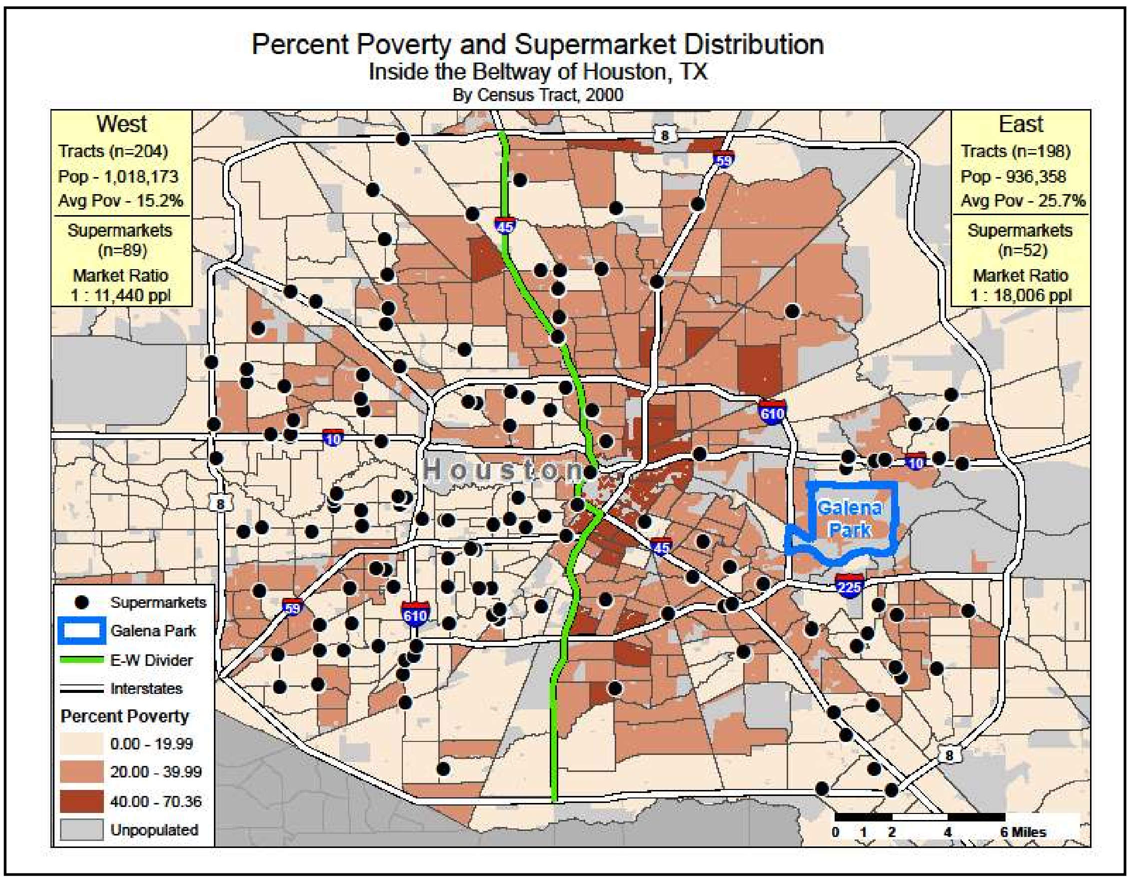

Figure 10. Supermarket Distribution (After)

The results of the supermarket analysis reveal that there are 141 supermarkets inside the beltway area, 52 on the east and 89 on the west, and none in Galena Park. According to the results the market ratio for the east side there is one supermarket for every 18,006 residents. The west side, while better with a ratio of one supermarket for every 11, 440 residents, is still not as equitable as the standard set in the United Kingdom of 1:10,000 (Baker et. al, 2004). Although there is no standard for “inadequate” or “adequate” access to foods in the United States, the simple market analysis suggests disparities in the distribution of supermarkets within the Beltway. The trend of supermarket distribution appears to follow prosperity lines, as many tracts in low poverty areas have clusters of supermarkets within a single tract, while some impoverished tracts (like Galena Park), do not have a single super market within their areas. Not only do the residents of Galena Park lack supermarkets, they also lack personal healthcare services and hospitals. Access to health care should be a fundamental right of life, but often for the urban poor this is not the case (Ahmed et al. 2001).

Figure 11 shows the hospital distribution in the study area using traditional off site GIS application and the Houston Galveston Area Council (HGAC) hospital dataset. Residents advised that the

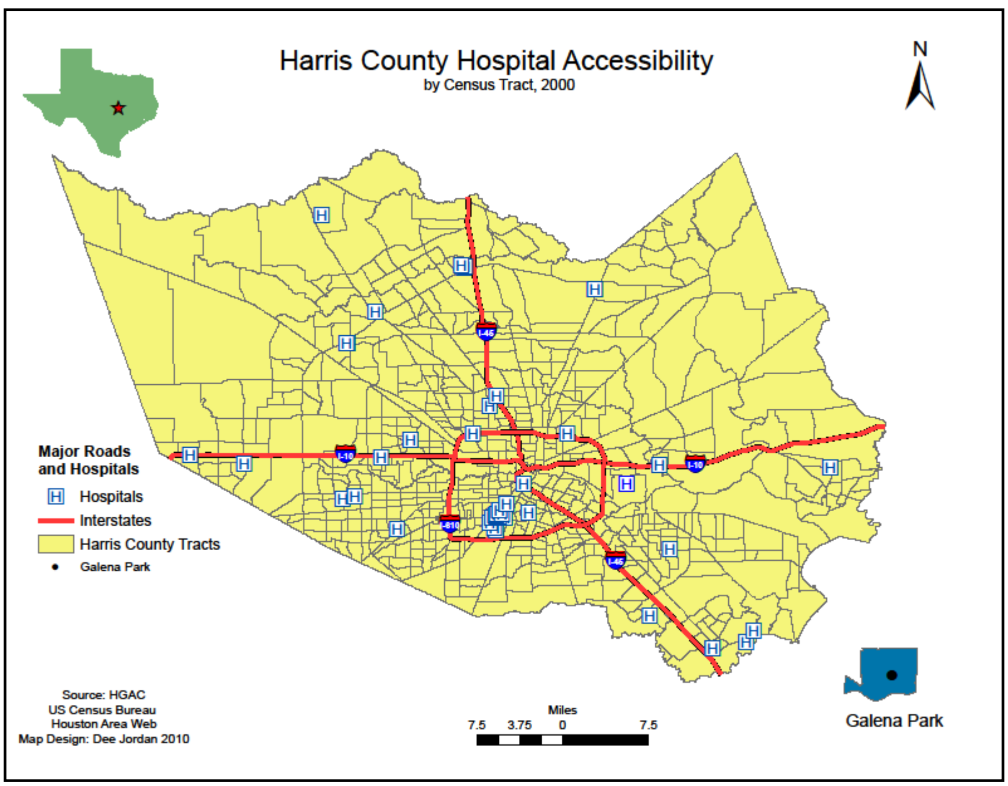

Figure 11. Distribution of Hospitals (Before)

hospital marker in Galena Park was incorrect. They explained that there had not been a hospital in Galena Park in over 20 years. Later I discovered that the dataset I used from the HGAC was outdated. Residents also thought the map with the Beltway focused would be a little easier for someone to situate themselves in relation to the highway. They also suggested spreading out the TMC hospitals some way because they were on top of one another and one could not see them all. Figure 12 displays the access to care map after undergoing participatory engagement by the residents.

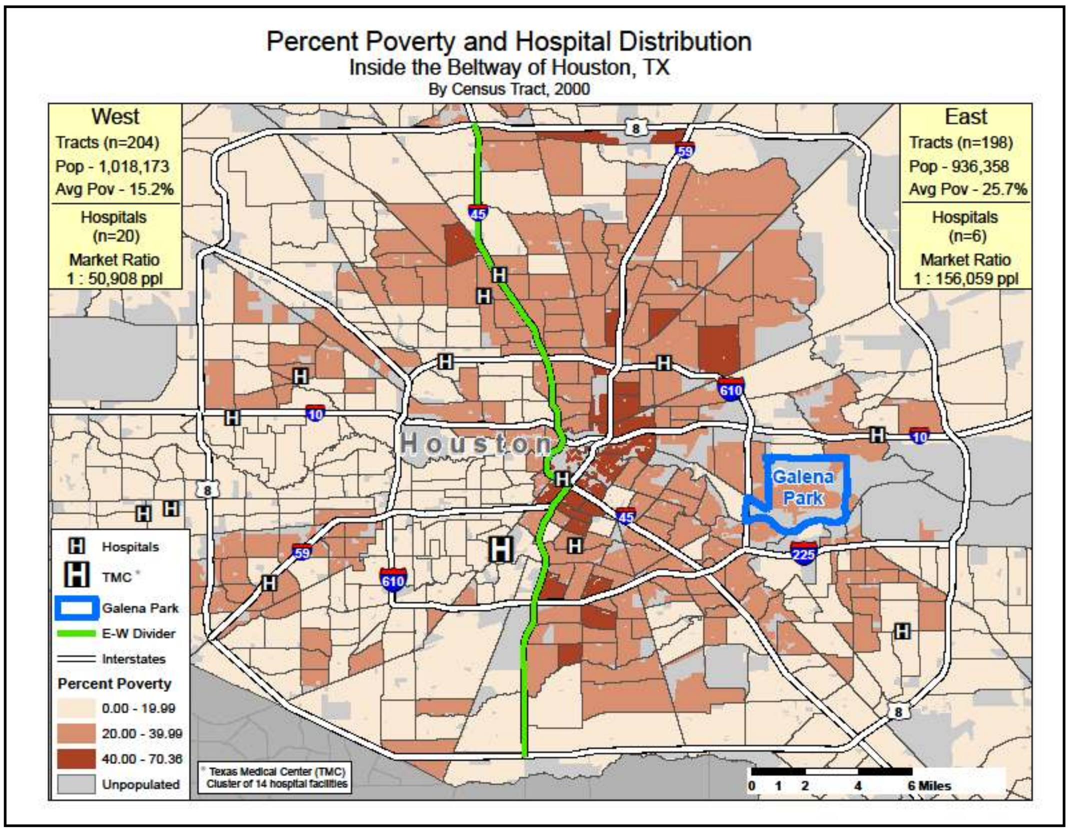

Figure 12. Distribution of Hospitals (After)

The results show great disparities in people-to-hospital ratios, especially in the east were the area is more impoverished. Access to care was determined an area of priority by the residents during E-CAP sessions. The resident s' primary chronic illness concern is cancer; however the community's proximity to industrial entities prone to accidental spills, leaks, and discharges puts them as potential risk for ambulatory care. According to figure 12 there are 26 hospitals inside the Beltway area, six on the impoverished east side, and 20 on the more affluent west side. There are no hospital in Galena Park and immediate surrounding areas. The west side is also the home of the Texas Medical Center, a cluster of 14 trauma center, level-one research institutions, teaching hospitals, and the MD Anderson Cancer Center. The market ratio analysis shows for the east side there is one hospital to every 156, 059 residents (1:156,059), whereas the west side has one hospital to 50,908 residents (1:50,908) ratio, indicating a gross disparity in where the hospitals were sited (along the more affluent sector). Only seven of the twenty-six hospitals (27 percent) are in impoverished tracts. This is an interesting point when one considers the disproportionate siting hypothesis (section 2.4), which suggests that industrial entities site in minority communities, due to low land value. For residents in Galena Park, being located in close proximity to a large petroleum refining complex increases the likelihood of negative health concerns; the primary risk is cancer, resulting from exposure to ambient air sources of benzene. However, in spite of the potential need for health care providers, the area subject to greatest health threat is the most under-served.

4.3 Mapping Benzene Exposure and Cancer Risk

The longtime residents of Galena Park, having seen many incidents and deaths from cancer within their community, are very concerned about the long term health effects of benzene exposure. The following photo (figure 13) shows an average industrial release from one of the refining companies. Residents advise these releases happen every day with the largest plumes appearing on rainy days.

Figure 13. Photo of Industrial Release in Galena Park

The following map (figure 14) illustrates the benzene concentrations across the Harris County study area. This is a very important topic for the residents of Galena Park, as benzene exposure is one of their chief concerns. The residents expressed concerns about the distribution of benzene throughout the study area suggesting that it was too wide spread; they maintained that the highest concentrations of benzene are in areas closest to the ship channel, which includes Galena Park and neighboring communities. They challenged that the map below shows the highest concentrations in the ship channel as well downtown Houston. The residents are well versed on the topic benzene, having done extensive research on the subject; however, the official dataset obtained from the EPA's NATA program displayed results that contradicted their perceptions.

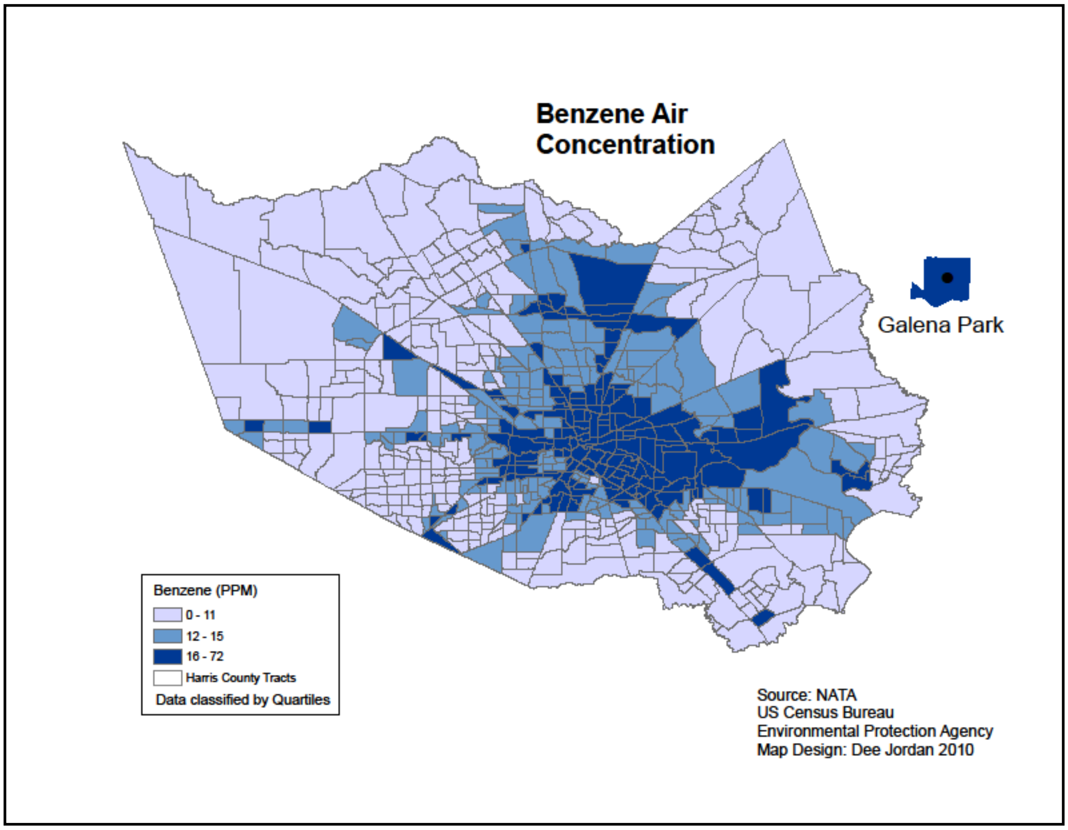

Figure 14. Benzene Concentration (Before)

After checking the metadata for the NATA 2002 database, there were noted inconsistencies and modeling errors that would be corrected in the 2005 release. According to the metadata, users were encouraged to download the 2005 dataset which corrected most of the errors. The corrected data was obtained and joined to the shapefiles, and modifications of the map occurred on site at the following community meeting. This crucial flaw in the data would have gone unnoticed without the community members' familiarity with the area and the subject matter, proving how important post-production ground truthing maps can be, especially with those who know the area explicitly well. Figure 15 reflects the cartographic representation of benzene concentrations in parts per million throughout the study area. The TCEQ's long term effects screening level is 1.4 ppb or .0014 ppm.

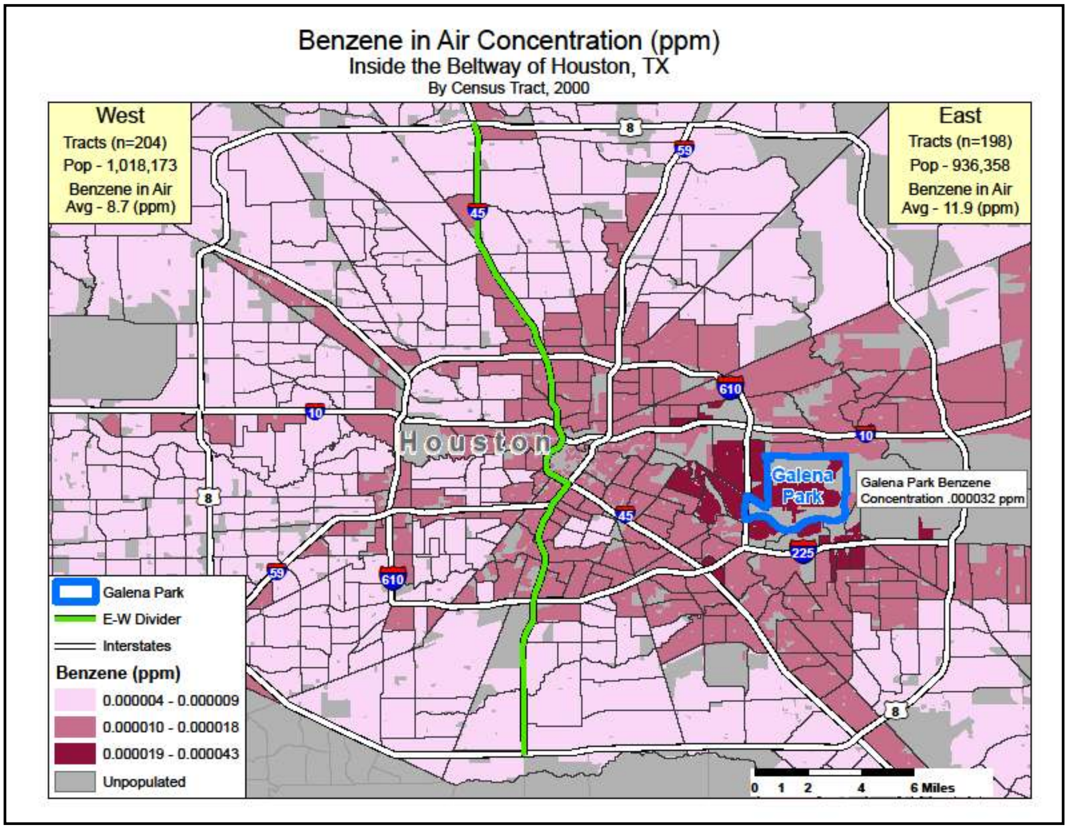

Figure 15. Ambient Benzene Concentrations (After)

On average areas on the east, most of which are highly segregated and/or impoverished, which include Galena Park and other areas closest to the Houston Ship Channel have benzene concentrations of .0012 higher than areas on the west with average concentrations of .0008 which are further away from the Houston Ship Channel. The benzene concentration in Galena Park is .0032 ppm, more than double the TCEQ's long term effects screening limit. The higher benzene concentrations persist in areas immediately surrounding Galena Park near the shipping channel with one tract's concentration of .0043 at triple the screening limit. This suggests that residents in close proximity to the shipping channel receive substantially greater benzene exposure, placing them at greater risk of negative health outcomes.

Throughout this section this work has evidenced that constant engagement by community members is a crucial part of participatory GIS. Formal datasets alone do not provide the level of detail that a resident's situated knowledge can offer; for example the dredge dump site was unmarked and unnamed on the official data used to map the community. However, community members, while not happy about the presence of the dump facility, also did not want it excluded from the community map, because it is in fact, a part of their community. Residents objected to the singular lens in which their residential community was understood (as Galena Park), when in fact there are two distinct places (Galena Manor and Galena Park) which occupy the residential section. There was nothing available in the official data that supported that there was a Galena Manor, however residents took me on a tour of the community and pointed out the Galena Manor welcome sign, and even showed me the now abandoned field, where the all-black Fidelity High School was sited in Galena Manor. Furthermore, the data from HGAC included a hospital in Galena Park, which had been closed for more than 20 years. Without the residents' input this dataset would have been accepted as accurate and incorrectly labeling Galena Park a "medically served" community.

The examples that I have pointed out and the other examples in this section suggests that the inclusion of place-specific photos, narratives, and oral histories are a necessary layer in shaping the view of social and environmental injustices from the community's perspectives. Official GIS datasets largely void of residential accounts and embodied experiences are insufficient for demonstrating the environmental and social injustices in communities. GIS datasets are sometimes out of date, corrupt, riddled with errors, subjective, and above all may not relay the comprehensive details of on-the-ground phenomena as local knowledge can. To that avail, local knowledge void of quantifiable data also only tells part of the story, as it is often easily dismissed as conjecture by policy makers and locally elected officials, especially to substantiate claims of injustices. I also assert that community engagement with the GIS software through on-site map modification sessions, and similar cartographic activities yields better digital representation of the observed phenomena, and prevent the marginalization that can occur with PGIS and CiGIS approaches, which generally perform GIS applications far away from the community. Local residents are also undoubtedly more familiar with the surrounding areas and nuanced local norms that may not be apparent to outsiders, such as the self-imposed residential segregation within the Galena Park community (see figure 7). Details about the study area that should come across on the map may be missed by an outsider. I feel this type of engagement empowers the residents beyond the data collection in the early stages of many research projects and allows them to participate throughout the entirety of the study, control how their knowledge it presented, and it effectively shifts their role from contributor to collaborator. The bringing together of the local and the expert to create shared knowledge is the primary contribution of this work.

4.4 Evaluating the effectiveness of GIS as an advocacy tool for Galena Park

When determining the effectiveness of GIS as a social and environmental justice advocacy tool, it became apparent that GIS alone is not enough to give a clear depiction of the community's concerns. Yes, maps were produced. However quantitative data only captures part of the story (Rambaldi, et al. ND; Bujang 2004; McLafferty 2002) and does not accurately represent the lived experience as only local knowledge can. The everyday knowledge of social places is only captured qualitatively, through ongoing dialogue during the focus groups and community meetings with residents and the environmental community advocates. Mapping-perception activities revealed the feelings of the residents--that in spite of the community's immense social and environmental challenges, they feel good about where they live. I affirm this is not the type of data that would be found in a formal dataset. I also assert that qualitative data, derived from non-experts cannot capture all the on the ground phenomena in a singular lens. Therefore it is imperative that a mixed-methods approach, such as grounded visualization (Knigge and Cope 2000) provides the optimal opportunity to blend both the qualitative and quantitative approaches, while simultaneously increasing the richness of the outcomes.

Post-map-production fieldwork included making presentations to community members, conferences, local government, Congressional Representatives, planning firms, and medical institutions in the Houston Medical Center in order to shed light on the community concerns in a new way. The post map production exercises aided in gathering a steering committee to help remediate some of the environmental concerns, gaining official 501C3 status for the ECAGP, two new independently owned air quality monitors within the city, adding Metro public transportation routes, repaving Clinton Drive, and the planning of a benzene abatement program for Galena Park. I feel that the effects of this collaboration and the progress already achieved are due in part to the active engagement of the community in the production of knowledge throughout the project. Community members who participated in the cartographic representations of the maps became keenly aware of the findings and implications thereof, which I feel strengthened their ability to press their claims of environmental injustice.

5 CONCLUSIONS

The original premise of this study was to explore the use of GIS as a social and environmental justice advocacy tool and to understand the degree to which it is a suitable approach to best illustrate those concerns that have plagued the Galena Park community for decades. The desire to conduct this study was sparked by the growing mobilization of communities who are standing up against the distributional unevenness of resources and demanding procedural power in order to effect change in their local communities (Runfola and Hankins 2010). Residents across the country have begun seeking the best solutions for their social and environmental justice concerns. These grassroots movements have ignited interest in community-based participatory research and the use of GIS in a participatory fashion (effectively participatory GIS).

Thus the objective of this thesis was to understand the degree to which GIS is a productive method to aid the community-based organization of Galena Park in visualizing its social and environmental health concerns. This included mapping the extent of poverty, determining the proximity of Galena Park to industrial sources of benzene pollution, potential cancer risk from benzene exposure, and analyzing access to supermarkets and hospitals. This thesis accomplishes the goal at least to the extent of 1) capturing the lived experience in some of the maps produced 2) determining the maps were accurate representations of the residents' reality through post-map-production ground truthing and 3) addressing the need for more community-based participatory GIS practice by a) conducting the GIS functions of the project on-site with the community and during community meetings and b) encouraging resident involvement in the cartographic modifications to the maps. There is significant evidence that this type of participatory process using GIS allows the community residents to be more involved in the shaping of the research project and therefore more invested in the outcomes (Hawthorne 2005; Elwood 2006; Elwood and Leitner 2003; Rambaldi 2006; Thompson 2011). Exposure to the GIS technology has given the community members, most of whom were unfamiliar with it, the chance to give input from their own experiences, which was immediately entered into the GIS, thereby enhancing the project and bridging the technological divide between local and expert.

5.1 Future study directions

While this research incorporated the opinions and feedback of many residents of Galena Park and revealed the importance of community-based participatory GIS, it also brought to light other possibilities for representing and incorporating a variety of media in documenting and advocating for social and environmental justice. In the course of the research for this project more than 200 photos of the Galena Park community were taken and analyzed. While many of these photos have been viewed for documentary purposes, it is my hope to use them in a photovoice as a follow-up to this work. I feel this would be an important follow-up project because it allows the linking of photographic representations of the lived experience to multimedia in GIS and can be used at community meetings to further gauge perceptions, especially as the environment changes. I would also like to conduct another perception analysis, potentially determining what residents would like to see in their community and in what locations. However, my immediate plans to build an atlas with all the maps I have created over the past two years for the ECAGP's website and return the maps to the people whose knowledge helped create them, the community of Galena Park.

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