HHS Public Access
Author manuscript
Int J Disaster Resil Built Environ. Author manuscript; available in PMC 2018 December 03.

Published in final edited form as:
Int J Disaster Resil Built Environ. 2018 ; 9(4-5): 402–419. doi:10.1108/IJDRBE-02-2017-0015.

Participatory Action Research: Tools for Disaster Resilience Education

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Abstract

Purpose—Participatory action research can improve scientific knowledge and community capacity to address disaster resilience and environmental justice. Evidence from the literature suggests that resident participation enhances assessment of environmental risks, raises awareness, and empowers residents to fight for equitable distribution of hazard and climate risk adaptations. Yet, risk assessment and urban planning processes still frequently operate within expertise-driven groups without significant community engagement. Such fragmentation results in part from a lack of appreciation for community expertise in built environment adaptations and educational tools to support resident involvement in the often technical built environment planning processes.

Approach—A participatory research and place-based education project was developed that enhanced co-learning between residents and researchers while collecting and analyzing local data on flood resilience in the built environment. Five research activities constitute the curriculum of resilience education on stormwater infrastructure: 1) establishment of partnership agreement/ MOU, 2) participatory GIS to identify flooding issues, 3) water quality testing and health survey, 4) stormwater infrastructure assessment, and 5) urban/landscape design. Partners included high school and college students, residents, and environmental justice organizations.

Findings—Outcomes include a stakeholder approved infrastructure assessment smartphone application, neighborhood maps of drainage issues, a report of water containments, and neighborhood-scaled green infrastructure provisions and growth plans. Findings indicate that participatory research positively contributed to resilience knowledge of participants.

Value—This paper outlines an interdisciplinary pedagogical strategy for resilience planning that engages residents to assess and monitor the performance of stormwater infrastructure and create resilience plans. The paper also discusses challenges and opportunities for similar participatory projects.

Introduction

Urban environments face numerous challenges from the impacts of natural and technological hazards and climate change, including chronic (e.g., drought, changes in the range for infectious diseases vectors) and acute hazards (e.g., flooding, storm surge) (Leichenko, 2011; Rosenzweig *et al.*, 2011). Researchers working in conjunction with residents in participatory action research and using new technologies such as mobile applications can improve understanding of problems and solutions while building collective efficacy and knowledge to address current and future environmental challenges within the built environment (Evers *et al.*, 2016). Successful participatory projects may increase knowledge for both residents and experts working in hazard-prone areas (Berke *et al.*, 2011), yet hazard risk assessments and urban planning for hazard impacts frequently operate within expertise-driven groups lacking significant community engagement (Archer *et al.*, 2014; Godschalk *et al.*, 2003; Horney *et al.*, 2013; Horney *et al.*, 2015; Hurlimann *et al.* 2014).

This paper discusses the Resilience and Climate Change Cooperative Project through the Institute for Sustainable Communities at Texas A&M University. It is a participatory research project designed to create an educational curriculum that supports vulnerable urban populations in understanding current hazards and future climate change impacts, identifying components of the built environment in need of renewal and adaptation, and collecting and preparing data at a neighborhood level to advocate for resilience planning. This interdisciplinary curriculum targets two goals: a) measurement of associations between the built environment and neighborhood flooding and environmental contamination, and b) assessment and design of infrastructure that addresses identified neighborhood concerns. Five educational activities make up this curriculum and are discussed in this article: establishment of partnership agreement/Memorandum of Understanding (MOU), participatory Geographic Information Systems (PGIS) research to document flooding issues, water quality testing and resident health surveys, stormwater infrastructure assessment, and low-impact urban/landscape design. University faculty and staff partnered with high school and college students, residents, community and environmental justice organizations, and regulatory agencies to develop and implement the curriculum.

Resilience, Disasters, and Participatory Action Research Pedagogy

Resilience can be defined as the ability of communities to reduce or adjust to hazard vulnerabilities, including implementing strategies to reduce environmental risk, increasing disaster and hazard preparedness, and enabling collective action (Berke and Campanella, 2006; Norris *et al.*, 2008). Common resilience activities involving the built environment, such as hazard mitigation plans, regulatory ordinances, infrastructure investments, and land acquisition programs, are often government-led (Burby *et al.*, 1997; Godschalk *et al.*, 1998). Public participation in these processes may be limited or become dominated by interest groups or elite residents who have the time and resources to participate (Irvin and Stansbury, 2004; Radil and Jiao, 2016). Some of the most socially vulnerable communities in the U.S.—low-income, marginalized, racial minorities—have less voice to influence these types of actions, even though they face the most risk from environmental change and disasters (Ojerio *et al.*, 2011; Van Zandt *et al.*, 2012). Neighborhoods with a high proportion of socially vulnerable populations also often experience increased deterioration of the built environment that protects health and property. For example, these neighborhoods have less access to jobs, transit, health care facilities, and other public services and are more likely to be located near undesirable facilities, such as waste incinerators, landfills, or refineries that contribute to public health issues (Bullard, 1993; Mohai and Saha, 2007).

Without adequate infrastructure and limited access to services, residents' vulnerability increases and property values decrease—perpetuating health and wealth inequalities (Marsh *et al.*, 2010). For example, research following Hurricane Ike in Galveston, Texas, found that poor and minority neighborhoods experienced greater degrees of damage even after controlling for housing age, proximity to water, flood zone, and other physical explanatory factors (Highfield *et al.*, 2014). This finding suggests that one or more neighborhood-level characteristics, such as infrastructure adequacy or condition, may account for the observed neighborhood variation in damage. Construction, development, and other anthropological factors (e.g., non-official housing or trash dumping) can also result in a fluctuating state of civil infrastructure capacity and highlight the need for regular assessments of the built environment and educational programs to support local assessments.

To address these issues, data on the built environment at a neighborhood scale and various hazard adaptation options are needed (Nillesen, 2014). However, relevant secondary data on the condition of the built environment are often only accessible from municipalities or subject matter experts. Many of these data may be out of date, include large amounts of missing data, or in formats that are difficult for non-technical audiences to use (Stevens *et al.*, 2010). In comparison, residents have local knowledge about problematic areas in their neighborhoods, such as areas impassable after a heavy rain, but lack the capacity or forum to turn that knowledge into useable data. No such systems to incorporate resident knowledge are currently widely available to planners despite calls for their development (Elwood, 2012; Evers *et al.*, 2016).

Participatory action research (PAR)—and PGIS as a geospatial version of PAR—offers a way to address these issues. PAR is similar to other forms of action research in which local contexts and residents' perspectives and experiences are central to the research, but PAR expands general action research by including local residents as both subjects and co-researchers (Argyris and Schon, 1989; Whyte *et al.*, 1989). PAR and PGIS projects include various levels of resident participation from providing feedback on results to collecting data to developing research questions and selecting methods (McCall, 2003; Conrad and Hilchey, 2011; Goodchild and Li, 2012). Studies have shown that well-trained residents can collect data that is valid and reliable according to scientific standards (Lue *et al.*, 2014; Bonney *et al.*, 2014). One study demonstrated that community members competently completed physical building damage assessments, and several senior disaster management practitioners advocated for resident inclusion in these assessments (Méheux *et al.*, 2010).

This project was designed to address the growing need for tools that support the incorporation of resident knowledge of built environment concerns into planning processes. The following curriculum combines PAR with traditional scientific assessment to build knowledge of how the built environment relates to flooding and water concerns and, subsequently, improve residents' and professionals' understanding of neighborhood environmental issues. A feedback loop of knowledge transfer between researchers and engaged partners in one socially vulnerable and environmental justice community was created with the following goals: 1) fully understand the extent of risk facing the community, 2) align research goals with the community's vision of environmental justice, 3) disseminate new knowledge in culturally appropriate frames and 4) position community partners to act on a set of strategies grounded in empirical reality. This curriculum calls for experts and researchers to work alongside community partners and residents to improve community resilience (Habermas, 1984; Innes and Booher, 2004). Figure 1 shows the framework for the project, the academic disciplines involved and the main components; each component is discussed below.

Collaboration with Socially Vulnerable and Environmental Justice Communities

Establishing partnerships and developing a unified agenda that fostered trust, co-learning, and full engagement was the first component of this curriculum. High-impact service learning was used as it facilitates a "learning ecosystem," which results in a greater understanding of complex issues by all project participants and uses approaches and processes that support community empowerment (Shiel *et al.*, 2016). An ecosystem is a biological community of interacting organisms within a physical environment; a learning ecosystem combines technology and educational support resources to assist individuals within this environment to adaptively acquire and disseminate information continuously (Croslinga *et al.*, 2015; Corin *et al.*, 2017). Service learning can range from informing, consulting, involving, collaborating, to empowering communities (Glackin and Dionisio, 2016). "Informing" and "consulting" dominate service learning such that university students may benefit more, though career relevance, faculty/student collaboration, than communities (Miller *et al.*, 2011). University-community partnerships are criticized when they meet only the needs of academia, without considering impacts of non-academic partners (Nixonn and Salazar, 2015). Hence, it is critical universities respond to community priorities and co-create knowledge by partnering in the larger "learning ecosystem."

In this project, high school and university students, community activists, and researchers were co-learners and co-beneficiaries. Project leadership took precautions to avoid those common pitfalls of collaboration between universities and community partners. Therefore, recognizing that successful learning takes place with community engagement and public participation, the approach was adapted to suit the articulated goals of community partners (Kernaghan, 2009). The first component of the project involved over one year of relationship and trust building between all participants to ensure mutual benefit.

We began by identifying historically marginalized communities in Houston's high-risk hazard areas. Tropical storms affect this area of Texas regularly, making Houston—one of the nation's largest and fastest growing metropolitan areas with over six million residents—one of the most physically vulnerable population centers in the U.S. (U.S. Census, 2016). The Houston Ship Channel area is also one of the most contaminated marine sites in the country with numerous listed or proposed Superfund sites (EPA, 2016). The neighborhoods located near the Channel have high physical risk to acute disasters and sea level rise and are populated by socially vulnerable groups including low-income and racial minorities. Manchester, the neighborhood selected for this project, is 93% Hispanic and 40% of households make less than $25,000 annually (U.S. Census, 2016). It is within one mile of 22 facilities that report to the EPA's Toxic Release Inventory (EPA, 2017) and often floods during regular rainfalls. Figure 2 shows the study area.

After identifying neighborhoods of concern, key informants with community-based organizations were asked to identify a list of potential community partners. Prospective partners were gauged for their interests in resilience and willingness to work with the research team to identify issues, gather and analyze data, and review adaptation strategies. Two community groups emerged—the Texas Environmental Justice Advocacy Service (t.e.j.a.s.) and Furr High School. t.e.j.a.s, founded in 1994, works with local residents to create sustainable, environmentally-healthy communities. Furr High School has a cadre of students known as the Green Ambassadors who work together to learn about nature and environmental impacts while performing hands-on service activities aimed at addressing environmental problems in the area.

Understanding and Communicating Community Conditions, Concerns, and Capacities

Following the success of informal discussions, a dinner with researchers and community partner leadership was held. The dinner allowed for more intentional brainstorming of mutual interests, project deliverables, and timelines. This meeting resulted in agreement on the need for a better understanding of the impacts of climate change, environmental toxins, and inequitable land use planning. Partner roles and responsibilities, including expectations for sharing relevant data and findings in easily understandable non-scientific language and co-authorship of scientific papers, were determined at this dinner.

Next, a kickoff meeting was held at a local Catholic church to present initial data from a hazard vulnerability assessment. Meeting participants received an overview of the project followed by a presentation of maps developed by university researchers depicting current and future sea level rise and floodplain changes. Residents asked questions about the information presented and shared their knowledge of hazardous or problematic areas of the neighborhood. This feedback about daily experiences in the neighborhood added context to the scientific flood modeling, fostered greater trust in the partnership, and together generated new knowledge about the effects of climate in the neighborhood (Brabkam, 2009; Corburn, 2005).

It is worth noting that turnout for the kickoff meeting was low (12 persons). After a year of developing relationships and planning, the participants and community partners in the room indicated that resident participation could be limited due to over-researching (numerous surveys have occurred in the neighborhood), distrust of academics, lack of feedback from previous research into the community, limited English proficiency, and a lack of time because many residents work one or more low-wage jobs. As a result of these concerns, it was collectively agreed to conduct future engagement efforts through partners at Furr High

School where faculty advisors could incorporate the activities into the Green Ambassador curriculum and students, parents, and family members could become involved.

Place-based Education, Service-learning, and Participatory Action Research

Working with t.e.j.a.s. and the teachers at Furr High School, the current high school curriculum was expanded to include this project as place-based curriculum. Place-based curriculum—an important and emerging learning model within the school—involves the use of the local community and environment for learning activities and projects that address numerous subjects (Gruenewald and Smith, 2014; Sobel, 2004; Woodhouse and Knapp, 2000). University-community partnerships for service-learning programs rest on the interaction among the community, university, and local organizations (Nixonn and Salazar, 2015). Likewise, the place-based curriculum with PAR was mutually beneficial to all groups involved. Students in the Green Ambassador program developed knowledge about technology and environmental research and had additional extra-curricular involvement for their college applications. University students completed high-impact service learning. Researchers collected primary localized data.

A few months after the kickoff meeting, Furr High School partners requested an overview of the detailed curriculum. Three teachers and seven student leaders participated, and this resulted in a redesign of the curriculum to include more in-depth, train-the-trainer lessons for teachers and student leaders as well as more involved information packets for participants. The changes allowed participants to learn the material and learn how to teach, share, and organize the project as a whole for future independent data collection. Specific trainings for each activity included:

- Identifying infrastructure issues and how they can modify outcomes related to climate change;
- Developing data collection applications for smart phones that could be used by community members; and
- Highlighting potential career paths for high school students and fostering more interest and preparedness for college.

University graduate students led these sessions to build trust and rapport with the high school students and gain experience working with community members. Over the course of the 18-month curriculum, the graduate students worked directly with the teachers and student leaders in the design and execution of the activities. After teachers and student leaders were trained, graduate students, teachers, and student leaders collectively led further trainings and data collection efforts with other high school student participants. This allowed teachers and student leaders to practice the activities before taking on full leadership of data collection activities. One faculty member provided support at each training and data collection activity. The number of high school students participating in each activity varied and was a challenge for the project as a whole. Having student leaders who were already trained helped address this challenge by providing peer support for students who enrolled later into the project.

Curriculum to Build Adaptive Capacities

The activities within this curriculum fall into two larger goals. The first goal focused on measurement of outcomes related to infrastructure integrity and design and included PGIS and water quality testing with health surveys. The second goal addressed assessment of infrastructure and adaptation options and included stormwater infrastructure assessment and urban/landscape design. The full curriculum of activities offered professional education in identifying consequences for the health and safety of residents due to the built environment then assessing the quality and layout of the built environment to suggest adaptations that would improve resilience.

Goal 1: Infrastructural Outcomes

The design and condition of infrastructure can affect a human-environment system's ability to operate optimally. Infrastructure in poor condition often produces negative outcomes for residents. Stormwater infrastructure, for instance, is expected to manage water runoff to prevent inundation of streets, sidewalks, and homes. When these systems are in disrepair, they produce standing or pooling water, which in turn increases hazard exposure and potential negative public health impacts. Therefore, the first set of activities worked to help participants identify the existence and nature of these outcomes, particularly standing water and surface water contaminants.

PGIS Research—Various levels of government have called for participatory and cooperative management of climate and flood risks (e.g., UNECE 2009). Information technology has become more influential in helping local residents negotiate urban change and contribute to planning processes. Through use of smartphones and GIS-enabled applications (apps), residents collect data and communicate with each other and local institutions to produce spatial narratives of local needs, conditions, and assets (Corburn, 2005; Craig and Elwood 1998; Schlossberg *et al.*, 2012).

This project introduced participants to GIS technologies and provided data on standing water in the neighborhood. Standing water is potentially indicative of drainage issues and increases possible public health consequences by providing breeding locations for mosquitoes or holding toxins. Twenty high school students (19 Hispanic and one African American) were trained on the ESRI (Environmental Systems Research Institute) "Collector for ArcGIS" app. The training began with discussion of why standing water was an indicator of infrastructure quality and contributor to resident health. Participants described areas they knew that were problematic and engaged in discussion about reliability and validity of data collection. After the discussion, students were signed up with an account on the Collector app and walked around the school in pairs to practice using it.

The total area of 0.68 square miles in Manchester was then divided into 11 sections, so that groups of three students covered two to three sections. Data was collected within 48 hours of rainfall ending. The first data collection event was February 24, 2016 and the second was March 11 and 12, 2016. In February, 109 blocks were surveyed, of which 68 percent had standing water. In March, 94 blocks were surveyed, of which 79 percent had standing water.

To ensure the reliability of the data, blocks should be measured by two groups, which was an improvement identified by this pilot project.

The app recorded latitude and longitude of standing water, photographs, a description of the size (length and width) and color (e.g., brown, clear, muddy, oil sheen) of the water, any additional notes, and date and time of observation. Photos should include an identifiable object, such as a ruler, for size comparison. If the block had no standing water, students recorded that before proceeding. Several teachable moments arose including the need to identify areas that lacked standing water and a methodology discussion about where to record water (i.e., street, ditch, on private property). Data points were uploaded to an online map for visualizing spatial patterns. Figure 3 shows the app used by participants.

Water quality testing and health surveys—Since exposure to the standing water identified in the PGIS activity could have negative health outcomes, residents of the community were interested in conducting environmental testing to ascertain what pollutants were present. The neighborhood was partitioned into 30 separate clusters using the Thiessen polygon technique in ArcGIS from the GPS locations and water sampling was conducted within each cluster (Figure 4).

Two high school instructors, along with nineteen high school students, participated in this training. Students identified locations they felt needed water sampling and bodies of water that are overlooked by the city during routine water testing. Students asked questions to clarify the types of water appropriate for testing (i.e., stagnant, pooled surface water, cloudy). Students were highly attentive to health concerns that standing water creates, including being a site for breeding mosquitoes that are a vector for disease and containing toxic chemicals from nearby industrial facilities. Students again used areas around the school to practice data collection.

Water sampling collection methods outlined by the US Environmental Protection Agency (EPA) Industrial Stormwater Monitoring and Sampling Guidelines were used to ensure quality sample collection procedure (EPA, 2009). Location of water draws, tool used, and amount sampled were consistent in every location. To reduce the risk of cross contamination between samples a new pair of nitrile gloves were donned during each collection and laboratory field requirements were maintained. Due to time constraints related to university scheduling, one graduate student collected the 30 water samples.

The lab provided data on the type and concentration of total metals (As, Ba, Cd, Cr, Pb, Se, Ag) and Mercury. These results indicated that many of the metals were ubiquitous in this community, for instance, concentrations of barium were found in every location sampled. Arsenic, chromium, lead, and mercury, all having well-established adverse health outcomes, were found throughout the community. Many of the locations exceeded the levels set by the EPA (EPA, 2015). The levels of lead in the surface water samples showed a great amount of variation, and in one instance levels were far above state and national levels.

In addition to the environmental sampling, an attempt was made to characterize the general mental and physical health of the community. In December 2015, one professor, five graduate students, 25 high school students, two teachers, and one parent, collected household survey data about health issues in the neighborhood. Participants were trained in ethical survey data collection and how survey data can be combined with water sampling data to identify community problems. The group was split into 15 teams of two or three individuals each. Each team had either one graduate student or teacher and one Spanish speaker.

Due to the compact geography of Manchester, a complete census was attempted. The trained survey teams used paper surveys and walked every public road and passed every home within the neighborhood. Homes that were completely fenced off, abandoned, or deemed unsafe by the interview team were the only homes not approached.

The survey consisted of 24 questions that included demographic information (gender, race, age, and language proficiency). It also asked questions about the participant's view on environmental issues impacting their community, such as pollution and natural disasters, and their own physical and mental health. Physical and mental health were assessed with the Short Form Health Survey (Tarlov *et al.*, 1989), which produces a composite score for mental and physical health between 0 and 100 and allows for comparisons between different study populations and national averages (Ware *et al.*, 2000). Findings showed that the community had a significantly lower physical composite score compared to national and state scores, while their mental composite ratings were relatively in line with expectations. The longer individuals had lived in Manchester, the lower their physical composite scores were (Sansom *et al.*, 2016). This activity helped participants learn about collecting information on social outcomes from hazard exposure and how hazards affect the daily life of residents.

Goal 2: Infrastructure Assessment and Design

Previous literature has noted that variations in infrastructure may result in disparate disaster outcomes across social groups (Hirsch *et al.*, 2016; Highfield *et al.*, 2014; Parker *et al.*, 2013). The first activities of our project also pointed to potential infrastructure issues such as the high amounts of standing water following small rainfalls. However, these outcomes alone do not provide empirical data on the quality of the infrastructure itself nor do they offer insight or education on how these systems can be rehabilitated for improved outcomes. Therefore, participants completed two more activities to move from knowledge of impacts to discussion of mechanisms that improve resilience: an infrastructure condition assessment and landscape design process. This part of the curriculum allowed for education on new strategies for reducing negative health and well-being consequences.

Infrastructure assessment—Participatory infrastructure assessment provides an alternative to the typical assessment process conducted by government agencies or technical consultants and supports residents to identify physical vulnerabilities based on local knowledge of flood-prone areas. Project partners helped design and conduct three tests of a participatory stormwater infrastructure assessment tool that can be incorporated into disaster resilience curriculums to foster multi-disciplinary thinking and hands-on education. As supported by previous literature (Méheux *et al.*, 2010), classroom and in-the-field training for the participants on basic infrastructure issues of interest, including what are the components of a stormwater drainage system in local communities and how do we assess the conditions of these components, were used to increase the validity of data collected. Participants also received a detailed field guide.

Several existing tools used to assess the quality of infrastructure were adapted for this activity (Gharaibeh and Lindholm, 2014; Gharaibeh *et al.*, 2009). These existing assessments were designed for engineering experts. Thus, participants helped researchers revise these tools to be more widely useable by a general audience. The assessment tool consists of a protocol of criteria to evaluate the capability of different infrastructure elements to reduce flooding and water ponding, including: ditches and front slopes, culvert and pipes, drain inlets, curb and gutter, sidewalks, and pavement. Each element is evaluated based on short and carefully worded statements that require a pass, fail, or not applicable response. An example statement for drain inlets is: “Grates are unbroken and in place.”

The infrastructure assessment tool was transferred to a mobile interface using an ESRI survey/mapping application called “Survey 123.” Survey 123 is a platform that provides a set of survey questions and then geocodes the location of where the survey is taken. A random sample of “face blocks” – one side of a neighborhood street between intersections – within the neighborhood was determined to be a practical sampling strategy for doing neighborhood-level assessments. Ongoing work by the authors indicates that 100 feet along residential streets is an appropriate sample unit.

On average, 12 high school students participated in each of three field trials held between February and June 2016 with the support of one graduate student and one faculty member. The tool was revised after each field trial to address concerns with usability. With each new field trial, participants gave increasingly consistent responses. Likewise, the feedback from post-trial focus groups showed that participants were more comfortable and confident in the refined versions of the tool and able to clearly articulate identified concerns with stormwater drainage. This pilot work has also provided evidence that this type of work can be useful and needs to be expanded to include a larger sample of field trials.

Urban and landscape design—Connecting identified issues with standing water and the infrastructure assessment, the final activity was participatory development of sustainable urban design visions for Manchester. Twenty-eight undergraduate students, four graduate students, and two faculty members developed conceptual master plans and provided provisions for land use and open space planning, green infrastructure, and hydrological management for the neighborhood. Because Manchester is a socially and physically vulnerable neighborhood, the project sought to provide growth options to address problems while minimizing the displacement of existing residents.

Site analyses suggested that 68% of the neighborhood’s surface was considered impervious and there was a lack of open space. Protecting open space in flood-prone areas can significantly reduce the adverse effects of floods by providing buffers to surrounding properties (Brody *et al*, 2008). Relatedly, non-structural approaches to stormwater management have the capability to mitigate stormwater issues in flood-prone areas

(Newman *et al.*, 2014; Newman *et al.*, 2016). Many existing approaches for integrating flood-risk and spatial design seek to simply exploit the development potential for locations where low flood-risk and spatial opportunities coexist. To sidestep this issue and help prevent potential displacement, the designs employed Low Impact Development (LID) techniques, a method of design/planning that seeks to mitigate stormwater at its source.

Participatory involvement was initiated four times within a five-month period (Figure 5). The master plan incorporated information provided by the community assisting in: 1) the conduction of a site inventory, 2) the spatial location of flood-prone areas, 3) the identification of desired functions for new land uses, open spaces, and recreational activities, and 4) the suggesting of new job opportunities for enhancing the neighborhood economy. Initially, residents took professors and students on a tour of the neighborhood to reveal primary issues, initiating a general discussion about the settling areas and flow lines of floodwaters. At a second meeting, the discussion focused on how the identified issues could be treated through low impact, evidence-based design solutions. Undergraduate students presented the community with findings from the site analyses. Feedback from the community provided further insight in identifying unseen conditions and generated ideas for future functions to be incorporated in the master plan. The top five design options identified by community members included green space, drainage infrastructure, recreational space, an educational center, and new water features; the top five elements listed to remove included unused parking lots, impervious surfaces, abandoned structures, litter, and chain restaurants. A third and fourth meeting involved presentation of a series of design scenarios that were critiqued by neighborhood members. Responses were utilized to condense the scenarios into one singular master plan (Figure 6). The plan increased green space nearly seven times its current amount to help attenuate stormwater flooding while simultaneously decreasing vacant and abandoned lots by nearly 90%. This design also strengthened the capability of stormwater detention by nearly 20 million gallons per year, thereby decreasing water quality issues through natural remediation processes.

Pedagogy of Participatory Action Research for Resilience

This project involved several participatory activities that each addressed disaster resilience issues related to the built environment, specifically stormwater infrastructure. As one participant described in the quote below, each activity helped participants understand the connections between their daily experiences, infrastructure condition, and land-use planning:

> I think this whole project [and] field research team, it’s eye opening and helpful because it makes you understand that there’s a reason why water is stagnant. There’s a reason why there are front planes [on ditches]. There is a reason why we need to educate ourselves so that we can start taking notes and getting data. So we can push that paperwork to the city and pressure them to do something about the infrastructure of our communities, the social disparities, and the health issues that pop up. This whole collaborative really helps get a wider spectrum over the issues that we are facing and the effects of those issues….

The project highlighted two central points to help those seeking to create a “learning ecosystem” for successful PAR programs. First, university faculty and students from

Science, Technology, Engineering, and Math (STEM) fields may need training on the science and art of community building and the value of cultural competency before working alongside community members. While faculty and students often understand the importance of diversity and the range of issues facing marginalized communities, those skilled at establishing and managing the collaborative relationships required to face complex societal issues are needed to coordinate the entire process. The university-community partnership calls for approaches that are inclusive and enable participation of multiple sectors of society. Faculty and students must understand that while they have knowledge of how to provide scientifically sound methods, the relevance of the data produced and salience of results is limited without regard for resident knowledge. Listening to community perspectives can reveal necessary improvements in project scope and the willingness to account for community concerns. For example, this project required one year of partnership building, then 1.5 years for activity completion. These discussions helped bridged differences between academic language and resident language. Additionally, when scientists are patient in the co-learning approach, the quality of the research end product is likely to be improved.

Second, as discussed above, when university researchers treat community partners as collaborators and co-learners, the relationship is likely to be more productive for both. In this study, not only did community members possess intuitive knowledge about the structure and function of community-level infrastructure systems, but they also received classroom and hands-on training from expert graduate students. Likewise, the extent to which community partners are able to participate meaningfully depends on their level of preparation. To that end, community partners should receive an orientation designed to expose them to key research questions and protocols and allow for revision of these research questions.

Two lessons learned were to allow for flexible timing of activities and provide training reviews to address intermittent participation. Community partners should be made aware of the relative inflexibility of semester schedules and the importance of feedback and event coordination throughout the whole project. Researchers should be ready and willing to start over as new data or issues present themselves. Training an initial group of student leaders addressed the various levels of participation throughout the project. Thus, each data collection day included mini-training sessions to refresh the material and engage new participants. On the back end, community partners should be encouraged and have time to review all material before it is published, whether media, awards nominations, peer-reviewed journals, etc., and offered co-authorship on materials produced. This kind of gesture is one way to acknowledge the contributions in community project outcomes.

Conclusion

Participatory action research supports the idea that local people have the power to build capacity within their communities. Ultimately, it is about respecting the capabilities of local people, developing a commitment to work collaboratively with investigators, and recognizing of the rights of community members involved. Conventional research and educational curriculums must adapt to increasingly participatory approaches to ensure that research and training address locally defined needs and solutions and improve the reliability and validity of data. It requires new roles for researchers within a process that leaves open space for dialogue and co-learning and is flexible and self-directing rather than carefully scripted, linear, and orderly. Finally, the disparities between disadvantaged people and the general population and perceptions of the ability to self-govern are deeply entrenched and cannot be undone through a single, short-term participatory research initiative. Expectations for making real progress should take a long-term view, requiring fundamental transformations in which experts and local people are viewed as equal partners in co-developing information and in strengthening local capacity. This curriculum provides one method for using participatory research to learn more about the local built environment and foster the next generation of building professionals.

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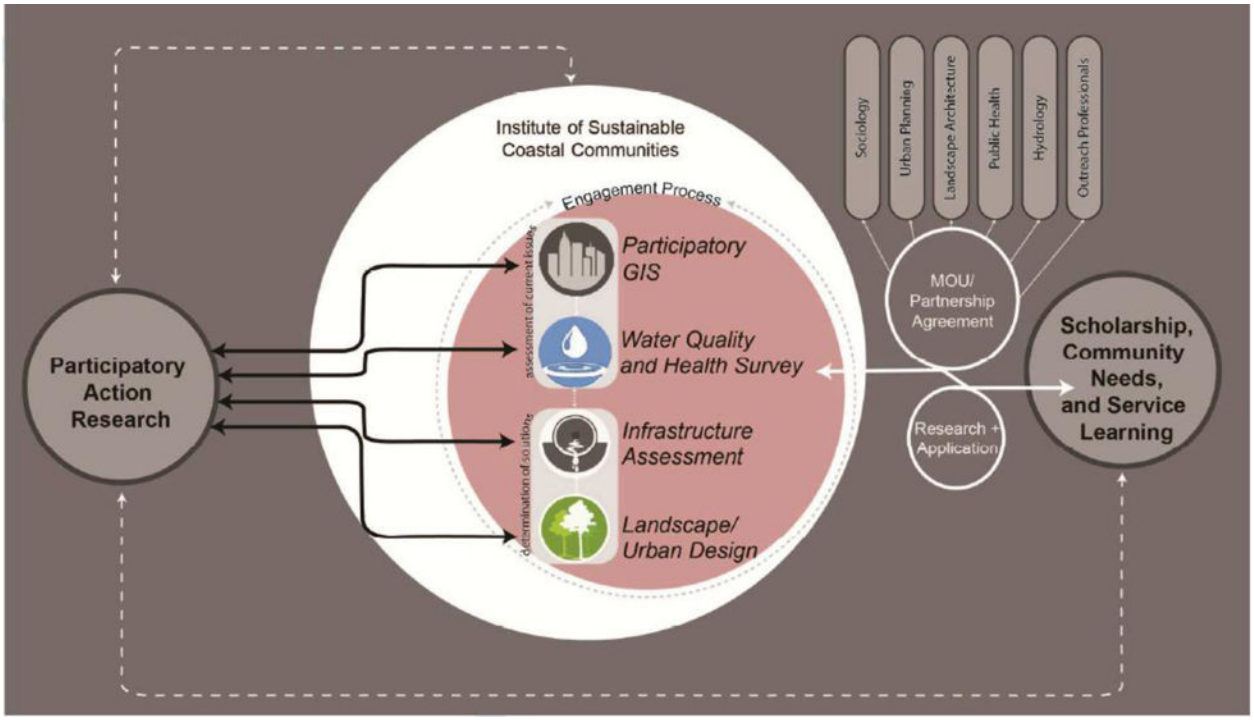

Figure 1.
Resilience and Climate Change Cooperative Curriculum Framework

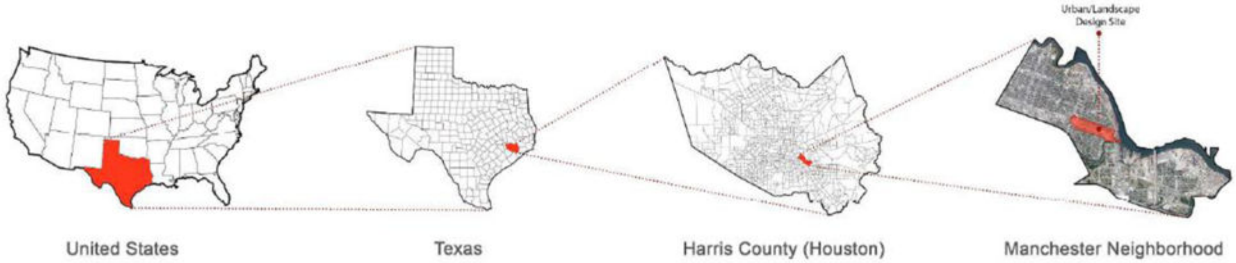

Figure 2.
Case Study Location, Manchester neighborhood, Houston, Texas

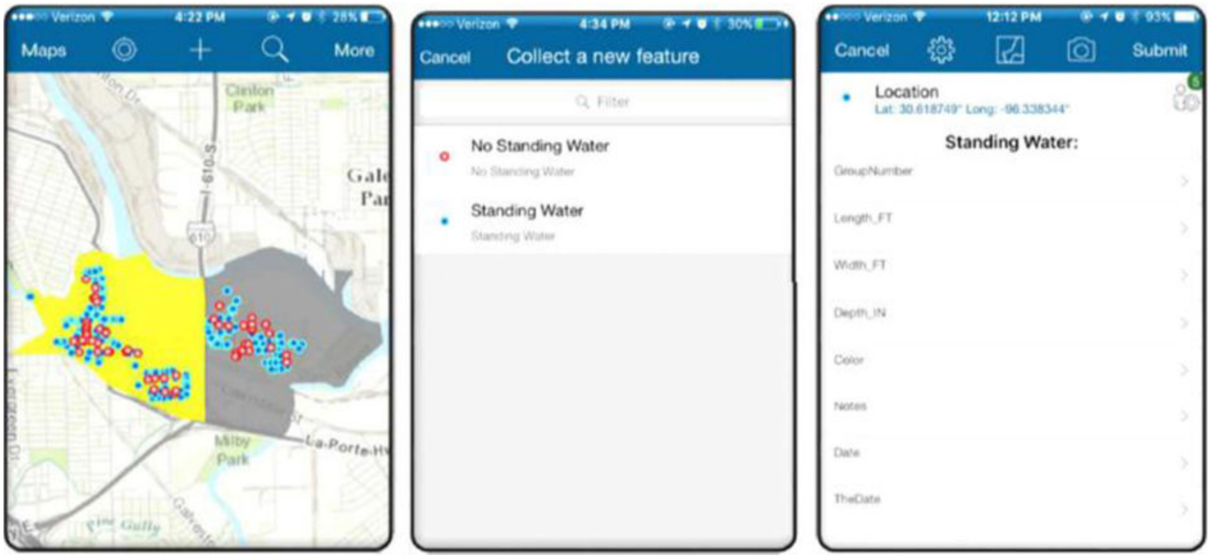

Figure 3.
PGIS Standing Water Data Collect App

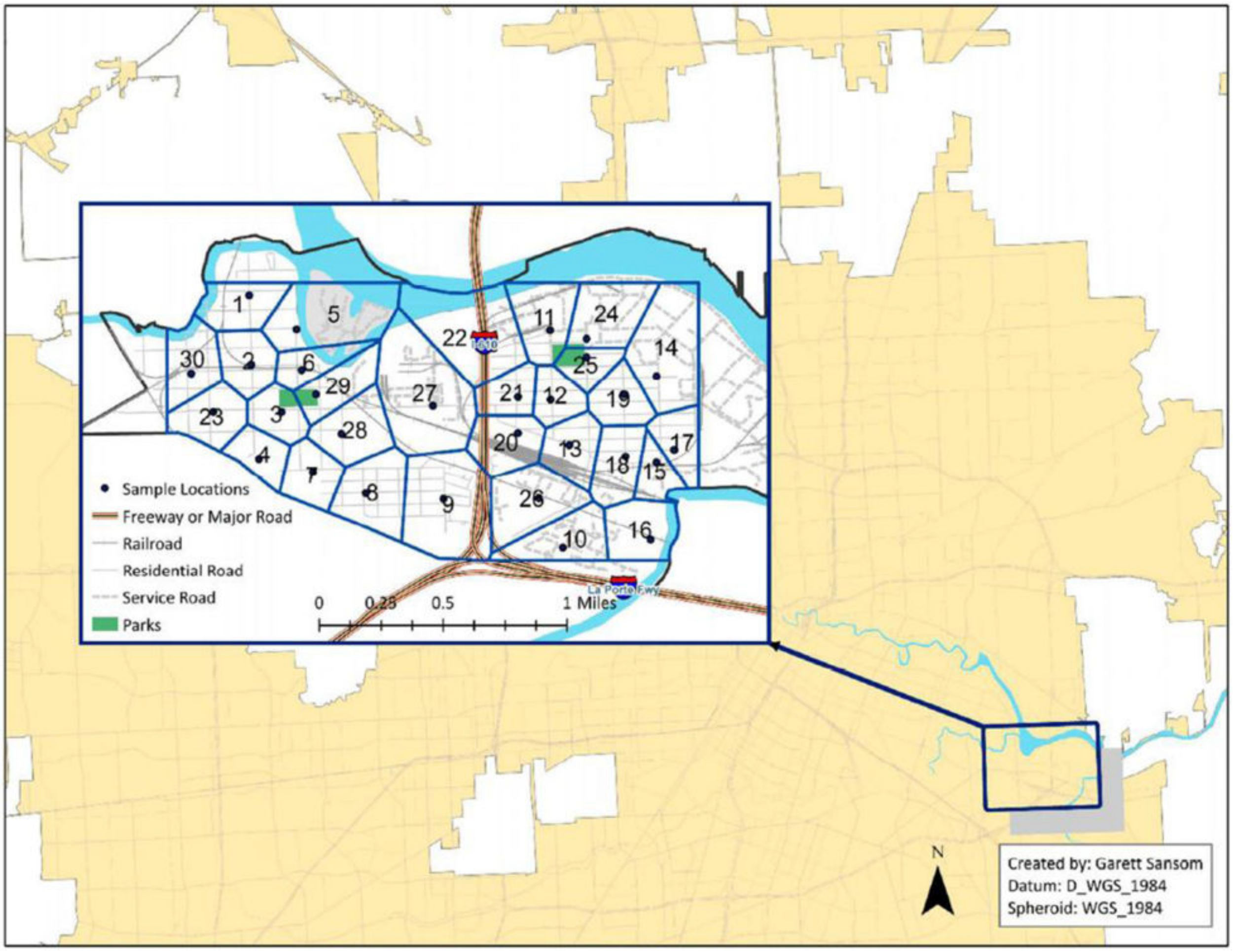

Figure 4.
Water Quality Sampling Locations with Thiessen Polygon Zones

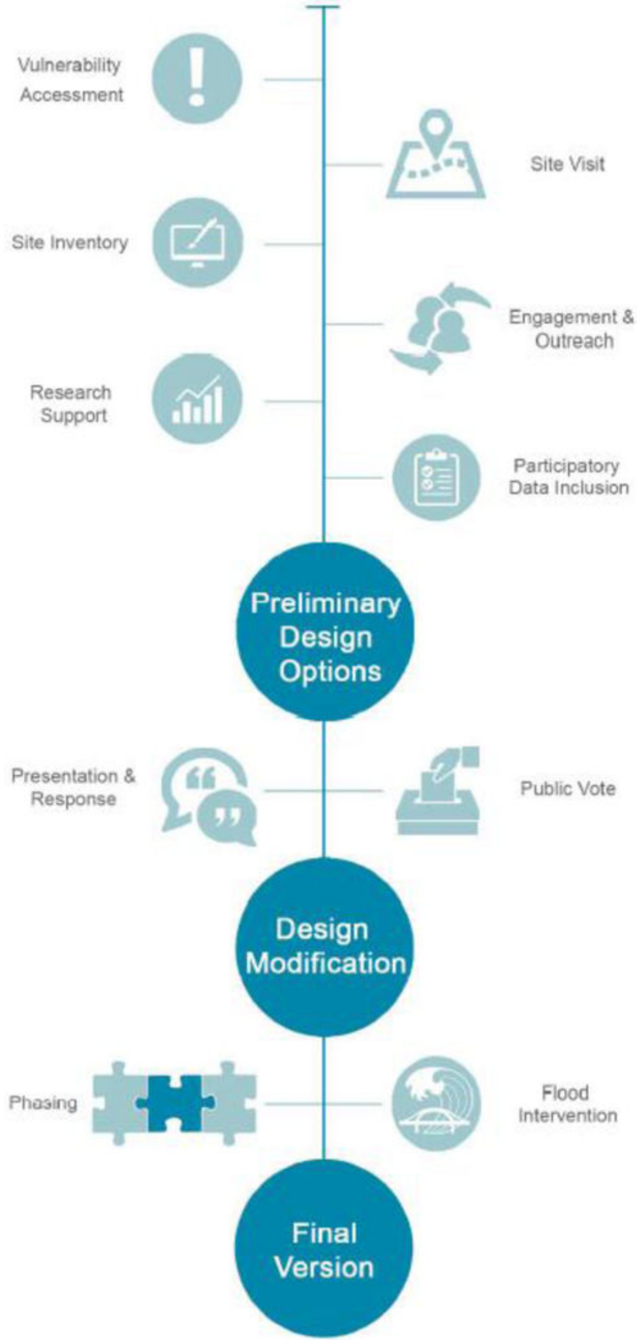

Figure 5.
Activity 5, Participatory Process for Master Plan Development

Figure 6.

Final Master Plan of Selected Site in Manchester Neighborhood