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A QUALITATIVE COMPARATIVE ANALYSIS OF NEIGHBORHOOD RECOVERY FOLLOWING HURRICANE KATRINA

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ABSTRACT

In recent years, there have been a number of catastrophic disasters. Recovery from these disasters takes years, if not decades, and more effort must be focused on strengthening local capacity to plan for long-term development and reduce vulnerability to future disaster events. This research will examine why communities facing the same disaster recover differentially and determine pathways to successful disaster recovery in the research setting of New Orleans neighborhoods affected over six years ago by Hurricane Katrina. Previous individual case studies in this area suggest that there are a variety of pathways to recovery. However, a broader cross-case comparison is necessary in order to generalize these pathways into a recovery framework. Specifically, this study seeks to determine what pre-disaster and post-disaster causal factors, either alone or in combination, were important to recovery following Hurricane Katrina. We preformed a cross-case comparative study of neighborhood-level recovery in New Orleans using Qualitative Comparative Analysis (QCA). QCA was selected due to its ability to analyze both quantitative and qualitative data for smaller-n case studies. Furthermore, it retains sensitivity to interactions between conditions. Based upon our prior work, which used the Delphi method to determine indicators of recovery and suspected causal conditions of recovery, we collected data through publically-available sources, including the U.S. Census, the Greater New Orleans Community Data Center, and previously completed studies for eighteen neighborhoods impacted by Hurricane Katrina. We used fuzzy-set QCA (fsQCA) to analyze combinatorial causal conditions of pre-disaster community factors and post-disaster actions and found multiple pathways to recovery, as measured by population return to the neighborhood. For example, economic capacity is nearly sufficient for recovery, but a combination of low social vulnerability, post-disaster community participation, a high proportion of pre-WWII housing stock and high amounts of post-disaster funds also led to recovery. This research links pre-disaster measures of resilience and vulnerability to recovery outcomes and, through cross-case comparison, generates results that will enable researchers to develop a theory of sustainable community recovery following a disaster. In addition, these results will allow communities to focus development efforts on key areas in order to reduce vulnerability.

KEYWORDS: disaster recovery, cross-case comparison, Qualitative Comparative Analysis

INTRODUCTION

Despite efforts to improve community resilience to disasters, over the past 25 years the number and economic impact of disasters has increased annually (Pelling et al. 2004). While the immediate phase of disaster response is well-studied, strategies for long-term recovery have not been studied extensively (Rubin 2009). Disaster recovery is a highly uncertain, dynamic, and non-linear process. Some groups in a community impacted by a disaster will not regain their pre-

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disaster standard of living. Alternatively, some subsets of society may be able to improve their pre-disaster conditions during the post-disaster recovery process (Smith and Wenger 2006). This differential recovery implies that there are multiple pathways to recovery from disaster. While some of the factors that influence community recovery have been well studied, many aspects of recovery are still not well understood. There are numerous variables that may influence recovery outcomes, and the interactions between these are not well-understood (Olshansky 2005).

The neighborhood recovery from Hurricane Katrina in the city of New Orleans provides a useful setting for a cross-case comparison of recovery. More than six years after Hurricane Katrina, it is clear that recovery has been unequal among the affected populations. As is common following disasters, those with the most resources (economic, social, institutional, etc) are able to rebuild and recover fastest (Haas et al. 1977). Case studies of individual neighborhoods have shown that there are multiple combinations of resources that lead to successful recovery.

As a result, this paper studies neighborhood recovery in New Orleans following Hurricane Katrina. Because differences exist between communities in how recovery occurs, we wish to analyze the various pathways that lead to recovery. To do this, we employ Qualitative Comparative Analysis (QCA) to determine what pre-disaster conditions and post-disaster actions lead to success or failure of the recovery.

BACKGROUND

We describe the research setting and the motivations for pursuing this research due to the dearth of comparative recovery studies in disaster research. We then describe our research method, which includes additional theoretical underpinnings in the selection of variables for our study as well as the methods for analysis of the data. Finally, we report and describe the implications of our findings.

Research Setting

Hurricane Katrina made landfall as a Category 3 storm in southeast Louisiana on August 29, 2005, causing severe destruction along the gulf coast. Much of the destruction was due to the storm surge (Knabb et al. 2006). In the city of New Orleans, more than 50 different levee breaches occurred, resulting in the flooding of 80% of the city. Floodwaters were over 10 feet high in some locations and dewatering the city took weeks (Andersen et al. 2007). Most of the major roads traveling into and out of the city were damaged. Hurricane Katrina was the most expensive disaster in U.S. history, resulting in \$81billion (FY 2005) in property damages (Blake et al. 2007). Given the high levels of damage the city's entire population of 455,000 was forced to evacuate (Sastry 2007).

More than six years after Hurricane Katrina, there have been numerous studies of how the city of New Orleans and individual communities have recovered. For example, the Brookings Institution has been tracking indicators such as population, economic growth, household income levels, housing and other metrics annually in order to measure citywide recovery (Liu 2010). In addition, there have been many academic studies of why neighborhoods have or have not recovered. Many of these studies have focused on issues of how race and economic class led to differences in disaster impacts (Colten 2006; Elliot and Pais 2006). Although it is clear from such studies that economic resources are important in recovery, some researchers have focused solely on low and moderate-income neighborhoods in order to determine how communities achieve recovery when financial resources are absent. For example, in studies of the Lower Ninth Ward and the New Orleans East Vietnamese community, Chamlee-Wright and Storr (2009a; b) found that attachment to place was a key factor in recovery differences. However, other studies of the Vietnamese community suggest that attachment to place alone was not sufficient to generate population return, but must be combined with other factors such as strong social networks, external financial support, and community institutions (Airriess 2008). In a study of the recovery of the Lakeview and Lower Ninth Ward neighborhoods, Elliott et al. (2010) also concluded that the difference in social network strength is important in determining recovery outcomes. Such case studies of recovery point to the variety of pathways to recovery. However, a broader cross-case comparison is necessary in order to generalize these pathways into a recovery framework.

Comparative Recovery Studies

Disaster recovery has been studied from a variety of perspectives including: engineering, urban planning, sociology, geography, and policy implementation. Smith and Wenger (2006) suggest that disaster recovery can be defined as "the differential process of restoring, rebuilding, and reshaping the physical, social, economic, and natural environment though pre-event planning and post-event actions." In order to capture all of these aspects of recovery, a multi-factor approach to measuring recovery is required.

Studying disaster recovery is also complicated by the fact that the unit of analysis for recovery studies also varies widely among researchers. Some are concerned with individual or household recovery, while others focus on businesses, infrastructure systems or communities (Miles and Chang 2003). For the purpose of this analysis, we focus on recovery at the community level; however it is important to remember that this is not the only possible unit of analysis and that different conclusions on recovery may be reached at different scales.

When hypothesizing the important causes of successful recovery, it is necessary to consider community attributes that create both vulnerability and resilience. Many researchers in disaster recovery often base their work, either explicitly or implicitly, on vulnerability theory, which states that disaster risk and access to recovery programs is not equal among all social groups (Wisner 2004). Previous studies have confirmed that communities have differing levels of vulnerability and resilience to disaster, and several authors have developed indicators for resilience and vulnerability (Cutter et al. 2003; Tierney 2006)

Despite a recent focus on measuring vulnerability and resilience among academics and practitioners, a thorough assessment of how these resilience frameworks lead to post-disaster recovery is still lacking (Norris et al. 2008). Such an assessment is critical for validating the indicators of resilience. We will use the existing frameworks and indicators of resilience and vulnerability to inform the variable selection for this study. The assessment of how resilience frameworks map into recovery is critical for validating these indices. Doing this requires studying recovery over a longer time frame than is common. For instance, the majority of research efforts have focused on the immediate response and early recovery phases of disaster management (Rubin 2009). However, because sustainable recovery may take years, measurements of post-disaster capacity must be taken well after a disaster has occurred.

Although there have been increasing numbers of individual case studies of disaster recovery in recent years, there have been few comparative studies (Chang 2010; Olshansky 2005). Hurricane Katrina and the subsequent recovery in New Orleans, however, provide a useful case for a comparative recovery study. Specifically, differential recovery patterns in New Orleans have been well documented through comparisons between a few neighborhoods (e.g. Elliott et al. 2010; Green et al. 2007; Cutter et al. 2006) but few broader comparative case studies of the recovery including both pre and post-disaster factors exist. Therefore, this research used a novel method, QCA, to analyze combinations of pre- and post- disaster community factors. This study examines causes of differences in recovery and identifies pathways to successful recovery.

RESEARCH METHOD

We employed a multi-method approach that began with a content analysis of existing literature, followed by a Delphi survey to determine important independent and dependent conditions, and culminated in a cross-case comparative study, using QCA, of New Orleans neighborhoods recovering from Hurricane Katrina.

Qualitative Comparative Analysis

Studying different pathways to recovery implies that a purely statistical analysis cannot be used, as it is important to maintain sensitivity to interactions among causal conditions. However, traditional case study analysis makes generalization of results difficult. As a result, we used qualitative comparative analysis (QCA), which provided a middle ground between case-studies and statistical analysis through set theory, Boolean algebra and fuzzy logic (Ragin 1987; Rihoux and Ragin 2009). QCA involves identifying a specific outcome of interest, along with conditions that are posited to affect that outcome. Both qualitative and quantitative data are collected across multiple cases, which must be quantified and calibrated for each causal factor and outcome in the analysis. Finally, patterns in the resulting data array are identified to highlight combinations of factors that support a given outcome, or, conversely, the lack of attainment of an outcome (Jordan et al. 2011).

There are three main variants of Ragin's method: crisp-set (csQCA), fuzzy-set (fsQCA) and multi-value (mvQCA). For this study, we used fsQCA, in which each condition and outcome was assigned a value from the range of 0 (fully out of the set) to 1 (fully in the set). We selected this method because we expected that there would be a wide range of data values collected. In comparison, csQCA restricts all conditions to dichotomous values, which would be highly restrictive and result in a loss of detail in the cases, and mvQCA is best suited for studies in which causal factors may have multiple states instead of representing membership in a set

QCA analyzes data via a truth table, which includes the values for each case's causal conditions and outcomes. It is important to select a wide diversity of cases as this truth table should include a variety of values for both conditions and outcomes to determine variation and similarities amongst the cases (Gross 2010; Jordan et al. 2011). For this study, we used the fs/QCA software (Ragin et al. 2006) to analyze the truth table. Values were determined for each outcome and condition after raw data were calibrated by defining threshold values that indicated inclusion in a set. We then minimized the truth table, through the use of fuzzy logic, to determine the logical equations that describe the pathways to an outcome. Through this process, we also determined the causal conditions that were either necessary or sufficient to produce the outcome of interest, in this case successful recovery. We then measured consistency and coverage. While consistency measures the degree to which cases with a given set of causal conditions exhibit the outcome; coverage measures the degree to which a given pathway explains the cases analyzed and is used to determine the relevance of each causal "recipe" (Ragin 2008a).

Identification of Causal Conditions

The causal conditions are the distinctive features of the cases that are predicted to affect community recovery. The set of causal conditions and indicators of community recovery were selected through a previously completed content analysis of journal articles on disaster recovery and a sequence of Delphi panel surveys.

To identify causal conditions of community recovery and metrics for measuring recovery, we analyzed articles from four top disaster focused journals that included authors from the fields of engineering, social science, and economics as well as disaster practitioners: *Disasters*, *Earthquake Spectra*, *The International Journal of Mass Emergencies and Disasters (IJMED)*, and *Natural Hazards Review (NHR)*. We selected articles within these journals from 2000 to 2011 through a keyword search of titles and abstracts using the terms "disaster recovery," "resilience" or "vulnerability", resulting in a sample of 202 articles. We then imported and coded these articles for references to causal factors of recovery (or non-recovery) and indicators of recovery in QSR NVivo®. From this analysis, we identified causal factors in five macro-categories: economic, infrastructure, institutional, social and post-disaster recovery strategy, with a total of 34 sub-categories.

Following the content analysis, we conducted a Delphi survey of experts in the area of disaster research. The Delphi method, a multi-round survey of experts, is a widely used technique for obtaining the consensus opinion of a geographically dispersed group of experts. In a Delphi survey, after the first questionnaire, the group responses, including median rating and anonymous comments justifying any variable ratings that did not conform to the median are also provided to the experts. This allows panelists to consider the reasoning for outlying responses, which results in decreased variability among responses (Hallowell and Gambatese 2010). For this study, we asked the experts to rate the importance of each causal factor and recovery indicator.

Twelve panelists were initially recruited for the study; eleven of these completed all three rounds. The panel consisted of experts from a variety of disciplines in disaster response or recovery qualified based on pre-determined criteria. All panelists have (1) a PhD in a relevant field (2) at least five years of experience in disaster response or recovery (3) have authored at least five journal articles on the topic of disasters and (4) have had field experience in disaster mitigation or recovery situations. The survey, administered using SurveyGizmo®, lasted three rounds, after which time the panel came to consensus on approximately half of the causal factors and recovery indicators. The panel rated all of the items under consideration as at least "important," validating the results of the content analysis. Additional details on this phase of the study can be found in Jordan and Javernick-Will (201Xa) and Jordan and Javernick-Will (201Xb).

The purpose of the content analysis and Delphi panel was to generate a comprehensive list of factors that could be used for future research studies. Clearly, as noted by the Delphi panel, not every causal factor identified will be important for every disaster. And, not all studies will be able to include all factors. Some conditions may not vary between communities and others may be specific to certain types of disasters. For this study, we used a subset of the causal factors identified through the content analysis and Delphi survey based on their relevance to the disaster type - hurricanes - and based upon the availability of data at the neighborhood level for the neighborhoods included in the study.

Furthermore, for this study we excluded a sixth macro category relating to the level of damage sustained by a community. Clearly, we recognize that the level of damage will affect how well the community recovers; however, in this study we are interested primarily in how communities that faced significant damage were able to recover. Therefore, in this analysis we only analyzed highly damaged communities, as measured by flood depth. The combination of eliminating the macro category of damage and eliminating sub-factors that were not relevant or available reduced our set of sub-factors to the 17 shown in Table 1.

Data Sources

Hurricane Katrina and the subsequent recovery have been studied widely by academics, government agencies and other organizations. Therefore, data on the pre-disaster conditions and recovery was largely available. For this study, we used publically available data from the U.S. Census Bureau, the Greater New Orleans Community Data Center (GNOCDC), the Neighborhood Partnership Network (NPN) and a Louisiana State University (LSU) survey of area residents. The GNOCDC gathers, analyzes and disseminates data for use by civic leaders and non-profit organizations. Data are collected from a wide variety of sources including the U.S. Census Bureau, U.S. Postal Service, U.S. Bureau of Labor Statistics, and U.S. Department of Housing and Urban Development (GNOCDC 2012). The LSU survey, funded by NSF, involved telephone, face-to-face and internet surveys of 7000 current and displaced residents starting in 2006 (Weil 2010). Sampling was performed through many partners and was weighted according to pre-Katrina census data. Results were mapped to census tracts using a seven step range (Weil 2010).

Communities have been defined in a variety of ways based on geography, social connections or other factors. We used the neighborhood level to represent communities within New Orleans in this study because the existing data from the recovery in New Orleans has used this unit of analysis. The New Orleans City Planning Commission designated 13 planning districts and 72 neighborhoods (GNOCDC 2012), which we used for this study. Furthermore, because these neighborhoods are aligned with existing census tract boundaries, they are useful for cross-comparison of recovery.

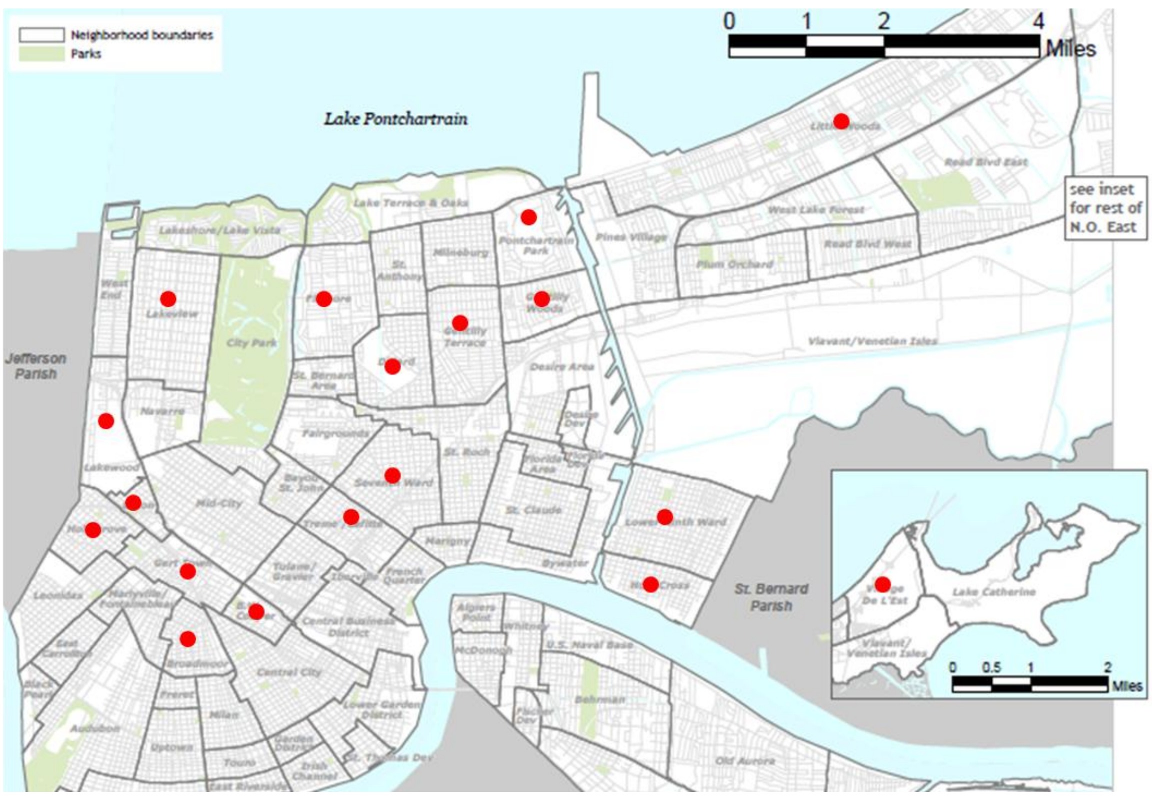

Figure 1: New Orleans Neighborhoods
(Figure from GNOCDC https://gnocdc.s3.amazonaws.com/maps/PDFs/Neighborhood.pdf)

Figure 1 depicts the New Orleans neighborhoods graphically. The neighborhoods selected for this study are denoted by a red dot. Each of these neighborhoods suffered an average flood level of at least 2 feet, requiring significant repairs to be made to housing. The set of neighborhoods was also selected to provide diversity amongst causal conditions and recovery outcomes.

Causal Condition Operationalization & Calibration

Based on the data available, metrics were created for seven causal factors. Some of these factors contained multiple sub-indicators that were related. In these cases, we combined the indicators to create the seven causal factors listed in the left column of Table 1. These factors align with the five categories of causal conditions identified previously; however, we divided the social conditions category according to whether the conditions are assumed to create vulnerability or resilience. In addition, we identified two separate components of the post-disaster recovery strategy: funding and community participation, which were included as separate categories due to a lack of correlation between these conditions.

Because there was no discernible variation at the neighborhood level for some of the sub-factors initially identified as potential causal conditions, including: building codes, emergency preparedness, previous disaster experience, recovery planning and post-disaster NGO presence, we eliminated these from the analysis. For example, building codes are consistent throughout the city of New Orleans, and there are no metrics available to determine whether the enforcement of those codes varied pre-Katrina. Other possible causal factors, such as pre-disaster infrastructure maintenance and response agency capacity, could not be analyzed due to a lack of available data at the neighborhood level.

Table 1: Causal Factors Analyzed for Hurricane Katrina Recovery

Economic Capacity	Average income level per neighborhood Self-reported level of insurance coverage by census tract
Infrastructure Quality	% of housing built prior to 1949
Institutional Capacity	Longevity of neighborhood association
Social Capital	% homeowners % population in same home since 1989 Self-reported social trust rating
Social Vulnerability	% without car % population over 65 % population under 12 % disabled % without high school diploma % non-White % non-English Speakers % single mothers
Recovery Funds	Amount of CDBGs to neighborhood
Recovery Participation	Self-reported post-Katrina civic engagement

Each of these seven causal conditions was assigned a fuzzy-set value for each case. We combined the indicators of each condition and calibrated the data to a fuzzy-set score. The majority of the conditions were calibrated directly in the fs/QCA software, based on three anchor points: fully in the set (0.95), fully out of the set (0.05) and the cross-over point, which is the point representing maximum ambiguity between membership and non-membership in a set (0.5).

Where possible, these anchor points were set based on external standards. However, in many cases they were determined based on case knowledge. These three anchor points were entered into the software to compute the fuzzy-set scores for each case. This calibration procedure has the effect of condensing the scores at either end of the scale because we do not consider all variation to be equally relevant. For example, if we set an average income of $80,000 as the point of full membership in the set of high-income communities, then we are not interested in variations above this point.

However, some of the variables were calibrated indirectly, which entailed grouping the cases into either four or six categories based on their degree of membership in the set. This method was preferred when the raw data could be easily grouped into clusters and had the added benefit of creating a smaller logic space than fully continuous scores.

Economic Capacity

Economic capacity is represented by two indicators: average income level, as reported by the 2000 U.S. Census, and insurance coverage, as reported by respondents in the LSU Katrina survey (Weil 2010). The U.S. Census reported the average total income of households, where wages, self-employment income, interests, dividends, social security, pensions, public assistance and any other income were included in total income (U.S. Census Bureau 2000).

Income was calibrated to a continuous fuzzy-set variable using the fs/QCA software. We were interested in the set of high-income communities, as high incomes imply that people in the community are likely to have financial resources (such as savings), which would enable them to recover. Communities with an average income of $80,000 were considered in the set of high-income communities, while communities with an average income of $20,000 were considered fully out of the set of high-income communities. We selected a crossover point of $50,000, which is the average income in the U.S. for households earning less than $200,000 per year.

Insurance coverage was assessed based on responses to the LSU Katrina survey (Weil 2012). Respondents were asked to rate what percentage of received recovery funds was obtained from various sources including insurance. Therefore, this metric includes not only a measure of who had insurance, but also whether funds were available for rebuilding. Each census tract was assigned a score on a seven point scale for receiving insurance funds (Weil 2010). We then averaged these scores across the census tracts in a neighborhood (weighted by the population in each tract). Anchor points of 6.5 (fully in), 4 (crossover) and 1.5 (fully out) were used to calibrate these scores.

Because either income or insurance payments can provide resources for recovery, the fuzzy-set scores for these two values were averaged to obtain a score for economic capacity in each neighborhood. For example, the Gentilly Terrace neighborhood had an average income of $42,321 in 2000, and the LSU survey measured insurance funds in Gentilly Terrace as 5.03 on the seven-point scale. The calibration process resulted in an income score of 0.32 (more out of the set of high-income neighborhoods than in) and an insurance score of 0.77 (mostly in the set of highly insured neighborhoods). These two scores were averaged, resulting in an economic capacity score of 0.545, which signifies that Gentilly Terrace is slightly more in than out of the set of high economic capacity neighborhoods.

Institutional Capacity

Institutional capacity at the neighborhood level is largely a function of the capacity of the local neighborhood association. For this study, we identified which neighborhoods had formal associations before Hurricane Katrina, and for how long these associations had existed. The longevity of the neighborhood associations served as an indicator of how well-organized and politically engaged the neighborhood is. These data were available through the Neighborhood Partnership Network (NPN) and the individual websites of the associations ("New Orleans Neighborhoods Partnership Network"). These data were calibrated indirectly on a four-point scale. Neighborhoods with associations in existence for longer than 50 years were considered to be fully in the set of high institutional capacity and assigned a value of one. Neighborhoods that did not have an association pre-disaster were fully out of the set and were assigned a zero value. Neighborhoods with less than 10 years were assigned 0.33 (more out of the set than in) while those with 11-50 years were assigned 0.67 (more in than out). These assignments match the natural groupings of the raw data and ensure that similar scores are not artificially divided.

Infrastructure Quality

Unfortunately, data on the pre-Katrina condition of housing, roads and utilities is not available at the neighborhood level. Therefore, infrastructure quality was measured based on the age of the housing stock in each neighborhood. The U.S. Census reports the percentage of housing in each tract built prior to 1949 (U.S. Census Bureau 2000). The age of housing is an indicator of the architectural styles. Older homes tended to be built in the shotgun or Creole style, which generally included fired brick or concrete block pier foundations. Post-WWII construction was generally in the ranch style with slab-on-grade foundations that did not provide any flood protection (Green et al. 2007). Homes built on raised foundations generally performed better during Hurricane Katrina. However, the NIST Infrastructure Reconnaissance Report stated that "The effects of aging, such as corrosion, deterioration, physical damage, and decay appeared to be a factor in the level of observed damage. For example, some structures exhibited significant corrosion in key elements of connection systems, framing, and bracing" (NIST 2006 p. 158). Therefore the age of the housing stock in a neighborhood may have both positive and negative impacts on recovery outcomes.

This condition was directly calibrated in the fs/QCA software using anchor points at 20%, 40% and 60% of housing stock built prior to 1949. Therefore, a neighborhood with less than 20% of its housing stock built prior to 1949 was out of the set of neighborhoods with older infrastructure. In contrast, a neighborhood with 60% or more of its housing stock built prior to 1949 was in the set of neighborhoods with older infrastructure. These points were selected to match gaps in the data set.

Social Capital

The social variables identified through the content analysis and Delphi surveys were categorized based on whether they contributed to the social capital or social vulnerability of a community. Social capital is a function of the community members' attachment to place, which is hypothesized to lead to higher commitment to returning and rebuilding the community (Chamlee-Wright and Storr 2009b; Crittenden 2002), and social network strength, which may enable community members to share knowledge and resources after a disaster (Elliott et al. 2010; Nakagawa and Shaw 2004). In this study, attachment to place is measured based on the percentage of homeowners (versus renters) and the length of residency in a given neighborhood, both of which serve as a proxy for commitment to the neighborhood. Attachment to place is calibrated directly as a continuous fuzzy-set variable with anchor points for the percentage of homeowners in a community at 80% (fully in), 60% (crossover) and 30% (fully out). The percentage of residents in the same home since at least 1989 was calibrated with anchor points at 60%, 40% and 20%. These fuzzy-set variables were averaged to obtain a score for each community's attachment to place. Social network strength was rated based on responses to the LSU survey questions relating to social trust. For example, survey respondents were asked how much they trusted people in their neighborhood, co-workers, police, people outside the community and people of various races. The responses ranged from "trust them a lot" to "trust them not at all." These responses were aggregated by census tract and reported on a seven-point scale. We then averaged these to obtain a neighborhood level rating. The anchor points for the calibration were set at 6, 3.5 and 1.5. A score of 6 represents a high level of trust for neighbors, co-workers, police, and people outside the community. A score of 1.5 corresponds to little or no trust for these groups. We then averaged the social network strength rating with the attachment to place rating to create an overall social capital score for each neighborhood.

Social Vulnerability

Social vulnerability is measured by a number of demographic indicators, which many researchers have linked to overall vulnerability (Cutter et al. 2003; Tierney 2006; Wisner 2004). These demographic indicators are reported by the U.S. Census Bureau (2000) and include the percent of the population in a neighborhood: without a vehicle, over 65, under 12, with disabilities, without a high school diploma, non-white, single mothers and non-English speakers. For each neighborhood we summed these percentages and then calibrated the scores directly in the fs/QCA software with anchor points at 350, 225 and 100. For example, B.W. Cooper received a social vulnerability score of 365.2, the highest of the neighborhoods included in the study; whereas Lakewood received the lowest score of 68.7. B.W. Cooper's vulnerability is driven by the high rate of non-white, less educated, and community members without cars. In contrast, Lakewood's vulnerability is largely a function of the high rate of community members over the age of 65. However, by summing the different vulnerable populations before performing the QCA calibrations, all sources of vulnerability are equally weighted.

Table 2: Social Vulnerability Calculations

Social Vulnerability	**B.W. Cooper**	**Lakewood**
% without car	75.40%	3.70%
% population over 65	5.10%	22.10%
% population under 12	35.80%	16.70%
% disabled	39.3%	13.3%
% without high school diploma	50.70%	4.0%
% non-White	99.80%	6.00%
% non-English Speakers	0.00%	0.00%
% single mothers	59.1%	2.9%
Total	**365.2**	**68.7**

Recovery Funds

Post-disaster recovery funds were measured based on the amount of U.S. Department of Housing and Urban Development (HUD) Community Development Block Grants (CDBG) allocated to each neighborhood. These grants are used for community development programs, public facility improvements, and economic development activities. Each census tract was assigned to one of four categories: no funds, less than $10,000, between $10,000 and $30,000, between $30,000 and $100,000, and more than $100,000 (HUD 2012). Based on the funding per census tract, we calculated a per capita funding level for each neighborhood. The results were then calibrated indirectly to a four-point scale, as shown in Table 3.

Recovery Participation

Participation in the recovery process was assessed based on the results of the LSU Katrina Survey (Weil 2012). The results combined answers to questions about attendance at public meetings, participation in neighborhood/homeowner associations, activities with charity or welfare organizations and service either as an officer or on a committee for a local club or organization. Each census tract was assigned a value on a seven point scale. These scores were averaged to obtain a single value for each neighborhood. These neighborhood scores were converted into continuous fuzzy-set values with anchor points at 5.5, 3.5 and 1.

These causal factors and calibration are summarized in Table 3. The last column in this table also designates whether the presence or absence of the condition is expected to lead to successful recovery.

Table 3: Summary of Causal Conditions and Calibration

Causal Condition	Fuzzy-set Scoring	Presence/ Absence?
Economic Capacity (EconCap)	Average of fuzzy-set scores for membership in high income and well-insured neighborhoods. Both directly calibrated with anchor points: Income: : $80,000, $50,000, $20,000 Insurance: 6.5, 4, 1.5	Presence
Institutional Capacity (Instit)	Longevity of neighborhood association 0 no pre-Katrina association 0.33 1 – 10 years 0.67 11 – 50 years 1 > 50 years	Presence
Infrastructure Quality (Infra)	Proportion of homes in neighborhood built prior to 1949. Directly calibrated with anchor points at 60%, 40% and 20%.	Unknown
Social Capital (SocCap)	Average of fuzzy-set scores for attachment to place and social network strength. *Attachment to place:* Average of fuzzy-set scores for rate of homeowners and percent in same residence since at least 1989. Directly calibrated with anchor points: Homeowners: 80%, 60%, 30% % Resident since 1989: 60%, 40%, 20% *Social networks:* Self-reported social trust score, directly calibrated with anchor points at 6, 3.5, 1.5.	Presence
Social Vulnerability (SocVul)	Combined demographic vulnerability factors. Directly calibrated with anchor points at 350, 225, 100.	Absence
Recovery Funds (Funds)	Amount of HUD CDBG funds received per capita 0 <$30 .33 $31-$50 .67 $51-$100 1 >$100	Presence
Community Participation in Recovery (Part)	Self-reported civic participation scores. Directly calibrated with anchor points at: 5.5, 3.5 and 1	Presence

Outcome

For this study, the outcome of interest is successful recovery at the neighborhood level. According to our content analysis and Delphi surveys, this can be measured through a variety of indicators, including assessing the recovery of the economy, environment, infrastructure, and social systems. Here, we analyze a single recovery outcome: population return, which was identified as an indicator of social recovery. Population return is based on the change in population between the 2000 census and the 2010 census. While there was some reduction in the population of New Orleans between 2000 and 2005 that cannot be attributed to Hurricane Katrina, this was minor in comparison to the post-Katrina population loss. We used a six-point fuzzy-set variable to represent this outcome and performed indirect calibrations, as shown in Table 4. There was only one community with less than 20% loss of population, Lakewood, which we scored as 1. Two communities (B.W. Cooper and the Lower Ninth Ward) lost approximately 80% of their population and were rated as 0. The remainder of the outcome scores was assigned to match natural clusters in the data set. While a 20% loss of population may not seem to be a successful recovery, the city of New Orleans had a 29% decrease in population between the 2000 and 2010 U.S. Census, and all of the neighborhoods analyzed for this study have shrunk since Hurricane Katrina. Therefore, population losses in the 25% - 34% range, which are similar to the city-wide numbers, are assigned a score of 0.6, or slightly in the set of successful recovery.

Table 4: Outcome Scores

Population Loss	Outcome Score
< 20%	1
20% - 24%	0.8
25% - 34%	0.6
35% - 40%	0.4
41% - 60%	0.2
> 60%	0

Other recovery indicators are not assessed in this study due to a lack of data at the neighborhood level. For example, infrastructure recovery was not included in this analysis because the utility repair (such as gas and electric service) was conducted by a single utility. As a result, repair time was mainly based on flood depth in order to restore service to portions of the city as quickly as possible. In addition, measuring population return serves as a proxy measurement for housing repair because often these occur simultaneously. Similarly, environmental recovery, which includes air quality, water quality and debris removal, is difficult to measure at the neighborhood level as such measures are not easily aligned with neighborhood boundaries.

Analysis

We analyzed the calibrated data using the truth table analysis feature of Charles Ragin's fs/QCA software (Ragin et al. 2006). For fsQCA studies, the truth table summarizes the case configurations based on their membership in corners of the logic space. Table 5 shows the truth table containing the calibrated conditions and outcome for each case.

Table 5: QCA Input Variables by Neighborhood

Neighborhood	EconCap	Infrast	Instit	SocVul	SocCap	Funds	Part	PopRec
Bayou St John	0.35	0.99	0.33	0.35	0.43	0.33	0.74	0.6
B.W. Cooper	0.025	0.78	0.67	0.97	0.17	0.67	0.05	0
Broadmoor	0.48	0.94	1	0.37	0.51	0.67	0.84	0.6
Dillard	0.405	0.26	0.33	0.4	0.435	0.33	0.51	0.6
Dixon	0.08	0.94	0	0.7	0.22	1	0.68	0.6
Gentilly Terrace	0.545	0.92	0	0.22	0.8	0.33	0.56	0.8
Gentilly Woods	0.4	0.02	0.67	0.18	0.87	0	0.68	0.4
Gert Town	0.095	0.83	0.33	0.58	0.41	0.67	0.35	0.8
Hollygrove	0.25	0.79	0	0.63	0.56	0.33	0.14	0.4
Holy Cross	0.205	0.3	0.67	0.64	0.22	0.67	0.68	0.2
Lakeview	0.815	0.57	1	0.03	0.83	0	0.98	0.4
Lakewood	0.96	0.15	0.67	0.02	0.97	0	0.99	1

Little Woods	0.545	0	0.67	0.31	0.27	0	0.76	0.6
Lower Ninth Ward	0.065	0.19	0	0.71	0.45	1	0.74	0
Pontchartrain Park	0.43	0.01	0.67	0.45	0.82	0.33	0.68	0.2
Seventh Ward	0.11	0.94	0	0.75	0.13	0.67	0.18	0.4
Treme'/Lafitte	0.225	0.99	0.33	0.81	0.17	0.67	0.4	0.2
Village de l'est	0.485	0	0	0.57	0.42	0	0.33	0.4

In this study, our eighteen cases only represent 15 of the possible configurations. Therefore, we we used the fs/QCA to include logical remainders, or non-observed cases, in the analysis (Ragin 2008b). Where reasonably justified by existing knowledge, assumptions about whether the presence or absence of a given condition relates to successful recovery were used as logical remainders (Ragin 2008a) to generate an intermediate solution. The assumption used for each condition is shown in the last column in Table 3.

Two key measures are used to analyze QCA pathways: consistency and coverage. Consistency (calculated by the fs/QCA software) represents the extent to which the cases represented by a given configuration are consistent in displaying the outcome of interest. A score of 1 would indicate perfect consistency; that is all cases in the configuration show the outcome. This score is used to determine value assignments for the outcome, population recovery. The minimum consistency used by fsQCA scholars is 0.75; however a higher consistency is preferable (Ragin 2008a). In this study, we used a consistency score of 0.85 for the analysis of successful recovery and a consistency score of 0.95 for the analysis of non-recovery. All configurations with a consistency above this threshold are assigned a positive recovery outcome of 1; others are assigned a negative outcome of 0.

Coverage measures the degree to which a given pathway, or set of pathways, explains the observed cases. This metric is used to determine the relevance of the pathways identified. For example, a highly consistent solution may only be applicable to a single case, limiting its importance.

RESULTS & DISCUSSION

We conducted two separate analyses for this study, both of which used the outcome of population return. For the first, we analyzed the causal conditions that lead to population recovery of neighborhoods. In the second, we analyzed causal conditions that lead to "non-recovery" of population in neighborhoods. We conducted separate analyses on these because it is likely that the solution for the negative outcome will not simply be the logical negation of the pathways to the positive outcome.

Outcome 1: Population Recovery

This analysis resulted in three main pathways which are sufficient for successful population recovery, shown in Figure 2. For the analysis of this outcome we used a consistency cutoff of 0.85 for sufficiency of the causal recipes. This was selected because 0.85 corresponded to a significant break in the consistency scores and is above the recommended cutoff of 0.75 for fsQCA. Figure 2 also indicates the specific neighborhoods that correspond to each of the pathways. Combined, these solutions have a consistency of 0.85 and coverage of 0.83. Importantly, two of the three pathways include common conditions of community participation and low social vulnerability. In addition to these common conditions, communities with successful population recovery had either low institutional capacity *or* high economic capacity *and* a high proportion of newer (post-WWII) housing stock. The third pathway to recovery is a combination of high social capital and a high proportion of pre-WWII housing stock.

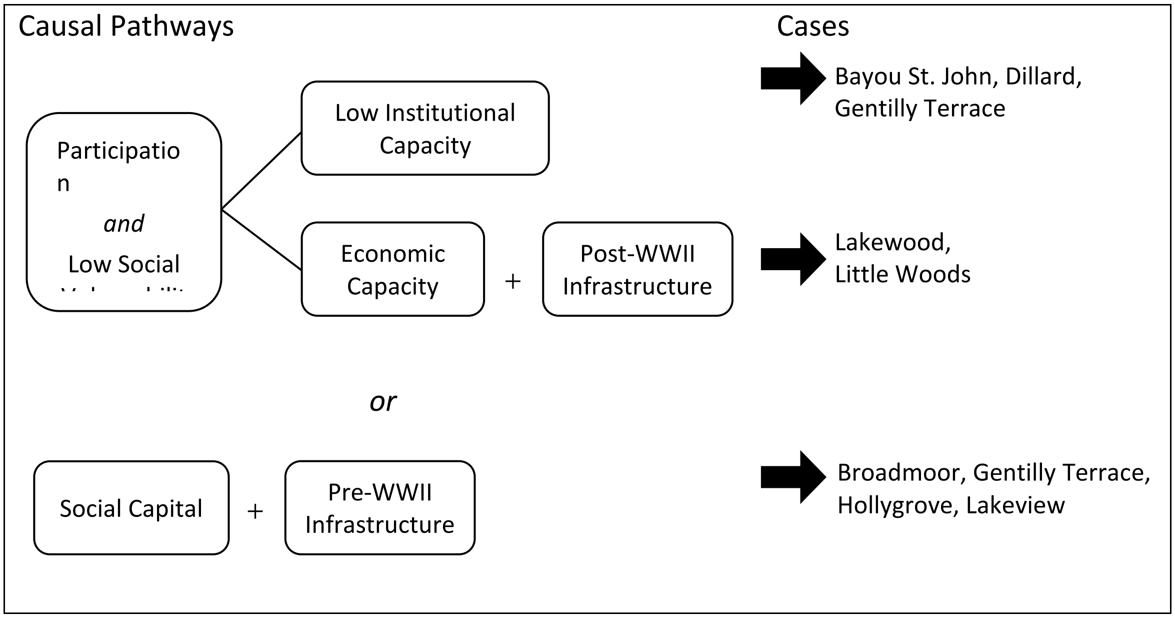

Figure 2: Pathways to Successful Population Recovery (Intermediate Solution)

While many researchers have linked economic capacity to successful recovery, it is interesting to note that economic capacity only appears in one recovery pathway. This shows that even a low income, uninsured neighborhood such as Bayou St. John may recover given the presence of other conditions such as high post-disaster participation and low social vulnerability. It is also significant that pre-WWII infrastructure appears in one pathway while post-WWII infrastructure appears in another. This implies that older infrastructure has benefits in some situations while newer infrastructure has benefits in others, specifically when combined with high economic capacity.

We should note that while the coverage score of 0.83 is relatively high, there are some communities which are not represented by the pathways in Figure 2. For example, both Dixon and Gert Town do not appear in Figure 2. However, both were more "in" the set of successful recovery than "out", despite high social vulnerability and low participation, respectively. Both of these neighborhoods did receive high amounts of recovery funds, which is hypothesized to lead to more successful recovery. It is also possible that recovery of the neighborhoods which do not appear in the pathways in Figure 2 could be explained through other variables which were not a part of this analysis. For example, funding sources other than HUD grants or active NGOs, may have influenced recovery in Gert Town and Dixon. A solution with complete coverage would most likely contain a large number of highly complex pathways; therefore, the intermediate solutions shown in Figure 2 are preferred to simplify the results.

In addition to the pathways shown above, QCA provides insight into what conditions are necessary or sufficient for an outcome. Necessary conditions are those that must be present for the outcome, but may not be sufficient. Sufficient conditions are those which are adequate for the outcome, although they may not be present in all pathways. Generally QCA scholars use a cutoff of 0.8 for sufficient conditions and 0.9 for necessary conditions (Ragin 2008a). Examining the necessity and sufficiency of each causal condition directly using the fs/QCA software can provide additional insight into these pathways. Necessity provides a measure of the degree to which the outcome is a subset of the causal condition. Therefore, if all (or nearly all) instances of the outcome show the condition, we would consider the condition necessary. Necessity is calculated using the equation: $\Sigma(\min(Xi,Yi))/\Sigma(Yi)$, where X is a causal condition and Y is the outcome. This ensures that larger deviations from the subset relationship are penalized more. In contrast, sufficiency, which is calculated according to: $\Sigma(\min(Xi,Yi))/\Sigma(Xi)$, provides a measure of the degree to which the causal condition is a subset of the outcome. Therefore, if a specific condition always (or nearly always) results in a positive outcome, that condition would be deemed sufficient.

Table 6: Necessary and Sufficient Conditions for Population Recovery

Condition	Necessity	Sufficiency
Low Social Vulnerability	0.89	0.78
Participation	0.84	0.67
Social Capital	0.77	0.73
Economic Capacity	0.69	0.87
Pre-WWII Infrastructure	0.66	0.57
Institutional Capacity	0.52	0.58
Recovery Funds	0.51	0.54

Table 6 shows the results of the necessity analysis for New Orleans neighborhood recovery. Despite the fact that both low social vulnerability and high participation appeared in all of the pathways in Figure 2, none of the causal conditions analyzed are entirely necessary across all cases, which is promising for practitioners looking for pathways to resilience.

The results do tell us, however, that a lack of social vulnerability and community participation are usually necessary conditions that lead to population recovery in a neighborhood. Importantly, practitioners can potentially improve population return as high levels of community participation in the recovery process relate to the post-disaster actions implemented. Nevertheless, participation is not sufficient for recovery, indicating that it is necessary to also focus on building capacity in a neighborhood before a disaster event. While social vulnerability and economic capacity are difficult to alter, planners can be prepared to provide additional aid to areas of concentrated social vulnerability during recovery to aid their population return.

Interestingly, economic capacity is not necessary for recovery (as demonstrated by Figure 2), but it is nearly sufficient (as shown in Table 6), meaning that communities with sufficient funds are likely to recovery regardless of other conditions. This makes sense because community members with financial resources are more able to evacuate, survive without jobs and rebuild without waiting for external aid. It is also significant that institutional capacity (at least as measured by longevity of neighborhood association) was neither necessary nor sufficient, indicating that it is not particularly important in determining recovery success. However, for this study institutional capacity was measured at the neighborhood level. It is possible that this variable will have increased importance when recovery is studied at different scales, such as cities, towns or nations. A high level of post-disaster recovery funding was also neither necessary nor sufficient for recovery. However, recovery funds may be more important than shown here, as we only accounted for one source of funding.

Outcome 2: Non-Recovery of Population

We also analyzed the pathways to non-recovery by negating the population recovery outcome in the fs/QCA software. This function produces the logical inverse of each outcome score (1 – score), which was used to analyze the same truth table analysis described above. For this outcome, we set the consistency threshold at 0.95, again corresponding to a significant break in the consistency scores. This analysis resulted in two unique pathways, shown in Figure 3. This set of solutions has a consistency of 0.98 and coverage of 0.48.

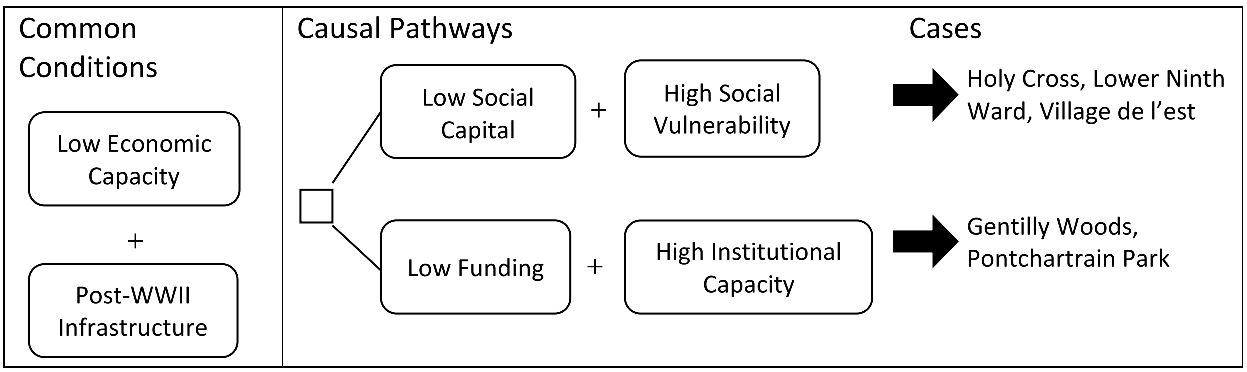

Figure 3: Pathways to Unsuccessful Population Recovery

Both of these pathways to non-recovery include low economic capacity and post-WWII housing stock. While the low economic capacity was expected, given the results of the previous analysis, it is interesting that the neighborhoods that did not experience population recovery had newer housing stock. This may indicate that communities in New Orleans with newer, post-WWII housing may be more vulnerable in a disaster. The first pathway includes low social capital and high social vulnerability, both of which have been discussed by many scholars (e.g. Finch et al. 2010; Tierney 2006). Interestingly, institutional capacity appears in the second pathway. This implies that a community with a strong institutional capacity will not necessarily recover. For example, Gentilly Woods, and Pontchartrain Park have long-standing neighborhood associations and poor recovery outcomes. However, this high institutional capacity is combined with low funding, indicating that perhaps neighborhood institutions were ineffective when there was little funding to work with. Interestingly, participation does not appear in these pathways implying that it is possible to have a non-recovered neighborhood despite the post-disaster community involvement actions taken.

Again, analysis of the necessity and sufficiency, shown in Table 7, can be helpful in understanding the results. It is important to recognize that the coverage score of 0.49 means that there are many cases not represented by the pathways in Figure 3; therefore, the necessity analysis provides additional insight. For example, while post-WWII infrastructure appears as a common condition for both pathways above, it is not necessary or sufficient for non-recovery. Many neighborhoods with older housing stock, such as B.W. Cooper, Hollygrove, Seventh Ward and Treme, did not recover successfully. In addition, the B.W. Cooper neighborhood, which had the highest population loss of any neighborhood in this study, does not appear in Figure 3. This is because B.W. Cooper is largely comprised of older housing stock. However, B.W. Cooper also had low economic capacity, low social capital and high social vulnerability, three of the four components of the first pathway.

Table 7: Necessary and Sufficient Conditions for Non-Recovery

Condition	Necessity	Sufficiency
Low Economic Capacity	0.91	0.78
Social Vulnerability	0.79	0.90
Low Social Capital	0.76	0.80
Low Participation	0.65	0.83
Low Recovery Funds	0.64	0.61
Low Institutional Capacity	0.68	0.63
Post-WWII Infrastructure	0.57	0.67

For this outcome, the lack of economic capacity is necessary to non-recovery (which is unsurprising since our previous analysis showed that economic capacity was sufficient for recovery). Social vulnerability is nearly sufficient for non-recovery. This is consistent with the previous result showing that a lack of social vulnerability is nearly necessary for recovery, and is consistent with many smaller case studies of vulnerable neighborhoods in New Orleans (Colten 2006; Cutter et al. 2006). Therefore, both economic capacity and social vulnerability should be areas of focus for practitioners seeking to improve the resilience of communities.

LIMITATIONS

This study was limited by the data available. There are many difficulties inherent in using secondary data; in particular, these data may not completely represent the underlying phenomenon of interest (Peacock 1997). Future QCA studies of community recovery from disaster should include additional depth of knowledge of cases through first-hand data collection to ensure that all relevant causal conditions have been accounted for and explained. The use of publically available data also limited our ability to determine anchor points for the calibration procedure. In this study, these points were based upon external criteria or natural breaks in the data; however, the accuracy of the calibration would be improved if these were based on in-depth case knowledge. In addition, this study only considered a single recovery outcome: population return. This should be expanded to include analysis of economic, environmental and infrastructure recovery, as it is possible that there will be different pathways to these different types of recovery. Finally, observations are limited to the research context, which included neighborhoods in New Orleans recovering from the single event of Hurricane Katrina.

CONCLUSION

This study demonstrated how fsQCA can be used to analyze combinations of causal conditions affecting disaster recovery by analyzing population recovery in 18 New Orleans neighborhoods that were highly damaged by Hurricane Katrina. Seven causal conditions (economic capacity, infrastructure quality, institutional capacity, social capacity, social vulnerability, recovery funds and post-disaster community participation) were included in the QCA model. This research linked such pre-disaster measures of resilience and post-disaster activities to recovery outcomes. This study resulted in the identification of four distinct pathways to recovery and two pathways to non-recovery. These different pathways point to various areas where neighborhoods can focus development efforts to more successfully recover from future disasters. We also identified necessary and sufficient conditions for recovery. Because no condition was completely necessary for successful recovery, different communities may be able to build capacity in different areas in order to become more resilient over time.

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