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Measuring Community Resilience: The Role of the Community Rating System (CRS)

Ajita Atreya and Howard Kunreuther[1]

Abstract:

Community resilience has become an important concern due to the increasing scale and frequency of natural and technological disasters. Although several frameworks have been introduced to measure resilience, there has been no systematic process that captures all the key sectors of a community. This paper introduces a holistic approach to measure community resilience by specifying the Human, Social, Physical, Natural, Financial and Political sectors of a community [labeled the six capitals (6Cs)] and characterizing four properties of resilience (4R) (robustness, resourcefulness, redundancy and rapidity). The 6C-4R framework is linked to the National Flood Insurance Program's (NFIP) Community Rating System (CRS) that rewards communities for adopting flood risk reduction activities using illustrative examples of resilience strategies adopted by communities and examining the challenges facing the city of New Orleans today after suffering severe losses from Hurricane Katrina. We conclude the paper with a case study of Cedar Rapids, Iowa that joined the CRS in 2010 following a severe flood in 2008. The community has recently undertaken several efforts to reduce future flood losses, notably higher regulatory standards, such as requiring buildings to be higher than the base flood elevation and acquisition and relocation of property to less flood prone areas. Although the CRS captures several sectors of a community, it lacks a measure of social vulnerabilities, which is an important element for community resilience. Future studies are needed to show how one can integrate measures of social vulnerabilities with the CRS for a more holistic view of community resilience.

Keywords: resilience, disasters, National Flood Insurance Program, Community Rating System
JEL: G22, Q54

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1. INTRODUCTION

Community resilience has become an important concern due to the increasing scale and frequency of natural and technological disasters. The term "resilience" has been defined in the literature in a variety of ways. A 2013 report by the Community and Regional Resilience Institute (CARRI) presented 45 of the most widely cited definitions of resilience published between 1973 and 2009 while also identifying their intended use. Out of the 45 definitions, 25 were intended to define community resilience.[2] The report concluded that it is difficult to select one definition as "the best" since each leads to a positive contribution within its domain.

There is general agreement that resilience is a desirable property of natural and human systems given the wide variety of threats that communities, regions and countries face today (UN/ISDR, 2002), as the term implies a proactive and positive expression of community engagement with natural hazard reduction (Cutter et al., 2008). Furthermore, there is consensus that resilience is multifaceted and can be achieved via improvements in several sectors of a community such as social, economic, institutional, infrastructural and natural/ecological (Bruneau et al., 2003, Norris et al., 2008; Cutter et al., 2010; NRC, 2012). However, in order to determine the priorities and needs of a community and to monitor changes over time, one needs to compare the benefits of increasing resilience with its associated costs (NRC, 2012).

Several tools have been developed by federal agencies, national and international organizations, communities and cities to measure resiliency at different levels (local to global), pre-disaster to post-disaster, top down to bottom up, hazard specific to general proneness to multi-

[2] Other definitions alluded to resiliency in ecosystems, social systems, at regional level, at city level and at personal level.

hazards. For example, the San Francisco Planning and Urban Research (SPUR) framework measures resilience by determining the community's ability to recover from earthquakes with a focus on building and infrastructure. Baseline Resilience Indicators for Communities (BRIC) measure overall pre-existing community resilience by evaluating the community's economic, social, institutional, ecosystem, and infrastructure capacities. Resilience United States (ResilUS) measures recovery over time of critical infrastructure. The NOAA Coastal Resilience Index assists communities by specifying key indicators that provide a preliminary assessment of a community's disaster resilience. This index can be used to determine if the community can function well after a disaster in the areas of critical infrastructures, transportation, and community plans, mitigation measures, social systems and business plans.

Other tools such as THRIVE (Toolkit for Health and Resilience in Vulnerable Environments) are focused on health resilience. CART (Communities Advancing Resilience Toolkit) is designed to enhance community resilience by bringing stakeholders together to address community issues through a process that includes assessment, feedback, planning, and action. This publicly available toolkit includes a field-tested community resilience survey and other assessment and analytical instruments[3] (Pfefferbaum et al., 2013).

In this paper, we utilize a holistic framework and associated matrices to measure community resilience in a systematic way by incorporating key sectors of a community. We then tie the framework to the National Flood Insurance Program's (NFIP) Community Rating System (CRS) and demonstrate how this program can play a role in measuring and enhancing community resilience. The CRS is a voluntary incentive program that encourages communities to go beyond

[3] Other instruments include community conversations, neighborhood infrastructure maps, key informant interviews, capacity and vulnerability assessment, etc.

the NFIP's basic requirements to reduce the flood risk. Although it is a long standing program, to our knowledge no paper has tied the CRS to community resilience.

A number of theoretical frameworks have been proposed in the literature to measure resilience, on the social and ecological systems of a community (see Tobin, 1999; Adger, 2000; Gunderson and Holling, 2001; Cutter et al., 2008). Some other frameworks involve engineered systems such as buildings and infrastructure where the properties of resilient infrastructure – robustness, redundancy, resourcefulness and rapidity – reduce the probability of failure (Bruneau et al., 2003; Tierney and Bruneau, 2007). In recent years, however, there is been a call for a holistic and integrated approach that is concerned with connections and relationships and not just the structural integrity of a building (Geis, 2000). One recent paper (Burton, 2015) provided an externally validated set of matrices to measure community resilience at sub county levels covering social, economic, institutional, infrastructural, community based and environmental dimensions of resilience. They also validated the metrices using Hurricane Katrina and recovery of the Mississippi Gulf Coast in the U.S. as a case study, which is commendable.

In developing a holistic approach for measuring community resilience, in this paper, we focus on the flood hazard, but the framework can be applied to other hazards as well. In the next section we introduce the 6 capital (6C) measures of resilience – financial, human, natural, physical, social, political and their properties (the 4Rs). Section 3 describes the NFIP's CRS program and shows that it can be tied to the 6C-4R framework. In Section 4, we illustrate the strategies that communities have adopted to become more resilient, and then illustrate challenges associated with Hurricane Katrina as measured by the 6C-4R framework (Section 5). A case study of Cedar Rapids, Iowa is presented in Section 6 where we examine its current status and propose strategies

to further enhance resilience. The concluding section summarizes the key findings and proposes future research directions.

2. RESILIENCE, 6C (Capitals) AND 4R (Resilience Properties) FRAMEWORK

Defining Resilience

We use the following definition of resilience adopted by the Zurich Flood Resilience Alliance (Keating, et al., 2014):

Disaster resilience: The ability of a system, community, or society to pursue its social, ecological, and economic development and growth objectives, while managing its disaster risk over time, in a mutually reinforcing way.

This definition highlights that resilience is more than just managing the disaster risk. Being resilient also means having the ability to grow and improve in the face of the hazards.

6 Capital (6C) Framework

The Sustainable Livelihood (SL) framework (Chambers and Conway, 1992) encompasses five types of capital: financial, human, natural, physical and social. These forms of capital characterize the wellbeing of a community holistically while at the same time suggesting ways to enhance its resiliency. One other important element for building resiliency in a community is the ability of the people in power to support change. We therefore, introduce a sixth capital (C) – political capital.[4] It measures the ability of the community to influence decisions, engage state and federal

[4] We thank the National Academy of Sciences roundtable members and the participants of National Association of Counties (NACo) conference in Colorado for suggesting that political capital should be added to the 5C framework as it focuses on whether or not a community has the ability to move forward to build resiliency.

agencies in the projects, and discover new funding sources to enhance community resiliency. It is important to note that there are interdependencies across these six capitals in the sense that enhancing one form of capital may lead to resiliency in some or all of the other five.

Financial Capital: Financial capital denotes the financial resources at the household and community levels that can support the community's resilience goal. Financial resources at household level consist of savings and investments, access to credit, wealth (property) and regular inflow of income via wages and salaries, pensions and other retirement benefits and remittances. At the community level, financial resources to reduce or recoup losses may include insurance and funds to invest in mitigation measures. Among other factors, financial capital can be measured by evaluating household incomes, property values and investments in a community (Peacock et al., 2010). Higher levels of financial capital increase the abilities of households and communities to absorb disaster impacts and speed the recovery process.

Human Capital: Human capital refers to skills, knowledge, health and access to labor that enable people to cope with and recover from the impacts of hazards. Human capital can be measured by evaluating employment records, formal and informal educational attainments and infant mortality rate (Cumming et al., 2005; Cutter et al., 2003). Knowledge about hazard exposure and hazard protection, and awareness of resources available for disaster management are important aspects of human capital for community resilience. For example, knowledge about the flood risk helps individuals make informed decisions on where to locate their homes.

Natural Capital: There is wide variation in the resources that make up natural capital, ranging from intangible public goods such as the atmosphere and biodiversity, to divisible assets used directly for production (trees, land, etc.). Natural capital of a community can be measured using the proportion of wetlands, undeveloped lands such as community parks, and forests (Mayunga,

2007, Cutter et al., 2008). Wetlands in particular act as a natural sponge to soak up excess flood water and reduce the impacts of floods and therefore, can be considered a very important defense system against flooding.

Physical Capital: Physical capital refers to infrastructure such as electricity, water, and transportation lifelines and the built environment of a community such as residential, commercial and public buildings. Strength of these infrastructures to withstand the shocks of natural disaster is a proxy for the strength of the physical capital of a community. The percent of buildings constructed to code (ensures the strength of the building), the number of temporary shelters such as schools (ensures availability of safe buildings in case of evacuation), percent of non-mobile homes (represents vulnerability of the population) are some ways to measure physical capital (Cutter et al., 2010, H. John Heinz III Center, 2002). Strengthening physical capital is expensive, therefore the economic health of a community largely dictates the resiliency of its physical capital.

Social Capital: There is considerable debate as to what is meant by the term social capital. With respect to community resilience, social capital reflects networks and connectedness that increase people's trust and ability to work together and expand their access to wider institutions, such as political or civic bodies. Social capital can be measured through variables such as voter participation, the number and roles played by non-profit organizations, voluntary associations and religious organizations (Mayunga, 2007, Cutter et al., 2010). These measures ensure that there are networks to foster connectedness among the people living in the community which is very important if a disaster strikes. The larger the organizational membership in the community, higher is the collective action (Yip et Al., 2007).

Political Capital: Political capital affects how decisions are made in the community and how the outside resources are achieved and utilized to foster resiliency. Individuals and special interest

groups or persons possess political capital if they have the voice, power, and ability to influence the distribution of resources (Jacobs, 2007). In some communities, voice and power is held by elected officials while in others an unelected community leader has the reputation of being the key decision maker. In this paper, following Jacobs (2007), we consider presence of political capital as having the ability to influence decisions, engage state and federal agencies in the projects, discover new funding sources and possess the leverage to get things done.

4 Resilience Properties (4Rs)

Bruneau et al., (2003) and Tierney and Bruneau (2007) developed the 4R framework of resilience by characterizing four properties of resilient infrastructure: robustness, rapidity, redundancy and resourcefulness.

Robustness: Ability of a system to withstand given levels of stress without suffering degradation or loss of functionality.

Rapidity: Capacity to meet priorities and achieve goals in a timely manner to contain losses, recover functionality and avoid future disruption.

Redundancy: Extent to which alternative elements or other measures are substitutable, that is, capable of satisfying functional requirement in the event of disruption.

Resourcefulness: Capacity to identify problems, establish priorities, and mobilize resources when existing conditions threaten to disrupt the system.

Although the 4R approach has been applied to the resiliency of physical capital (i.e., infrastructure and built environment) this approach can be used to measure the resilience of all the six capitals.

Below we present an example of how the 6C and 4R can be utilized to characterize community resilience holistically.

Table 1. Indicators of 6Cs and their associated 4Rs

Capital (C)/ Resilience (R)	Financial	Natural	Human	Physical	Social	Political
Robustness	*Income/Wealth*	*Floodplain conservation*	*Family emergency plans*	*Strength of critical infrastructure and housing to withstand shock*	*Proportion of socially vulnerable population*	*Ability to withstand and manage a disaster efficiently*
Rapidity	*Insurance Availability*			*Multiple communication sources*	*Interval to restore life line services*	*Respond immediately to the disaster*
Redundancy	*Alternative sources of income*		*Skills for alternative income*	*Availability of alternate routes*	*Availability of housing options for victims*	*Generate reports at local, state and federal level*
Resourcefulness	*Funds set aside for emergency*	*Regulations to limit the use of natural resources*	*Ability to maintain livelihood*	*Availability of materials for restoration*	*Capacity to address the needs of victims*	*Creating funding for disaster management*

Each box in Table 1 presents an indicator or source of the corresponding capital (C) and the corresponding resilience property (R). For example, the *strength of critical infrastructure and housing to withstand shock* is a source of robust physical capital that enhances resiliency in a community. Similarly, *insurance availability* enhances the rapidity of the recovery process after a disaster by providing financial capital in a timely fashion.

3. THE NFIP'S COMMUNITY RATING SYSTEM (CRS) PROGRAM

The National Flood Insurance Program in the United States was established in 1968 to provide flood insurance to homeowners residing in flood-prone communities. In response to the low take-up rates, the NFIP mandated homeowners purchase flood insurance if they live in the special flood hazard areas (SFHA) and have mortgages from a federally-backed lender. In 1990, the NFIP

introduced the Community Rating System (CRS), a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. The CRS illustrates the use of a federal program to directly engage local governments in integrating flood risk reduction in their plans and enhancing community flood resilience (Sadiq and Noonan, 2015). Currently, over 1,200 communities voluntarily participate in the CRS and earn credit points across 19 creditable activities of the CRS that fall into four major categories; public information, mapping and regulations, flood damage reduction, and warning and responses. Based on community activities and credit points earned, flood insurance premium rates are discounted in increments of 5% for insured properties in the high risk SFHAs and between 5% and 10% for those outside of the SFHAs. Table 2 shows the CRS classes, required credit points, and premium reductions for the SFHA and non-SFHA properties in a community that agree to participate in the CRS program.

Table 2. CRS credits, associated classes, and the NFIP premium discounts

CRS Class	Credit points	Premium reduction for residences in SFHA	Premium reduction for residences outside SFHA
1	>4,500	45%	10%
2	4,000-4,499	40%	10%
3	3,500-3,999	35%	10%
4	3,000-3,499	30%	10%
5	2,500-2,999	25%	10%
6	2,000-2,499	20%	10%
7	1,500-1,999	15%	5%
8	1,000-1,499	10%	5%
9	500-999	5%	5%
10	0-499	None	None

All the activities under the four major categories are listed in Table 3. The numbers in parenthesis denote the maximum points or credits that a community can earn for that particular activity. For example, a community can earn a maximum of 116 points for the activity "Elevation Certificates." Within each activity there are one or more discrete elements and each receives a certain number of credit points. "Elevation Certificates" for instance, encompasses three elements: (1) credits for maintaining elevation certificates on all buildings in the SFHA since CRS application, (2) credits for maintaining elevation certificates before the CRS application but after the initial date of Flood Insurance Rate Maps (FIRM) and (3) credits for maintaining elevation certificates on buildings built pre-FIRM as indicated in Table 3.

Table 3. Activities included in the Community Rating System Activity Series

Public Information (Series 300)
310 Elevation Certificates (116)
320 Map Information Service (90)
330 Outreach Projects (350)
340 Hazard Disclosure (80)
350 Flood Protection Information (125)
360 Flood Protection Assistance (110)
370 Flood Insurance Promotion (110)

Mapping and Regulations (Series 400)
410 Floodplain Mapping (802)
420 Open Space Preservation (2020)
430 Higher Regulatory Standards (2042)
440 Flood Data Maintenance (222)
450 Storm water Management (755)

Flood Damage Reduction (Series 500)
510 Floodplain Management Planning (622)
520 Acquisition and Relocation (2250)
530 Flood Protection (600)
540 Drainage System Maintenance (570)

Warning and Response (Series 600)
610 Flood Warning and Response (395)
620 Levees (235)
630 Dams (160)

310 Elevation Certificates

(1) Credit for elevation certificate since CRS application (38 pts)
(2) Credit for post-FIRM elevation certificates (48 pts)
(3) Credit for pre-FIRM elevation certificates (30 pts)

Note: The maximum possible points are as of 2014.

In general, series 300 (Public Information) credits programs that advise people about the flood hazard, encourage the purchase of flood insurance, and provide information about ways to reduce flood damage. These activities also generate data needed by insurance agents for accurate flood insurance rating. Series 400 (Mapping and Regulations) credits programs that provide increased protection to new development. Series 500 (Flood Damage Reduction) credits programs for areas in which existing development is at risk. Series 600 (Warning and Response) provides credit for measures that protect life and property during a flood, through flood warnings and response programs. Credit is also given for maintaining levees and dams and for programs that prepare for their potential failure. Communities can also propose alternative approaches to reducing the risk of flooding. FEMA evaluates the alternative approach and provides appropriate credit for those activities. For example, communities that are prohibited by state law from adopting and enforcing building codes may submit comprehensive building construction regulations, administration and inspection procedures for review to determine the equivalent Building Code Effectiveness Grading Schedule (BCEGS) classification. Such regulations must be enforced throughout the community, not just in the floodplain.

The distribution of CRS points across the activities captures the community's preparedness and hence its resiliency. CRS activities can be mapped into one of the 6Cs and 4Rs in regard to its contribution to improving resiliency. It is worth noting that activities such as open space preservation, storm water management, and buyouts cut across several capitals and impact on several of the 4Rs. Table 4 relates the CRS activities to the 6C-4R framework.

Table 4. CRS Activities Linked to the 6C-4R framework

Series	CRS Activities	Capital	Resilience Properties
Series 300	***Public Information Activities***		
	Elevation Certificates	Physical /Human	Robustness
	Map Information Services	Human	Resourcefulness
	Outreach Projects	Social/Human	Rapidity, Resourcefulness
	Hazard Disclosure	Social	Resourcefulness
	Flood Protection Information	Social	Resourcefulness
	Flood Protection Assistance	Human	Resourcefulness
	Flood Insurance Promotion	Financial	Rapidity/Redundancy
Series 400	***Mapping and Regulation***		
	Floodplain Mapping	Human/Social	Resourcefulness
	Open Space Preservation	Natural/Social	Robustness
	Higher Regulatory Standards	Physical/Social	Resourcefulness Robustness
	Flood Data Maintenance	Human	Resourcefulness
	Storm Water Management	Physical/Social	Robustness
Series 500	***Flood Damage Reduction***		
	Floodplain Management Planning	Social	Rapidity, Resourcefulness
	Acquisition and Relocation	Physical/Political	Robustness, Rapidity
	Flood Protection	Physical	Robustness
	Drainage System Maintenance	Physical /Social	Robustness
Series 600	***Warning and Response***		
	Flood Warning and Response	Physical / Social/Human	Resourcefulness
	Levees	Physical	Robustness
	Dams	Physical	Robustness

As shown in Table 4, all the 19 CRS creditable activities can be tied to one of the 6Cs which in turn enhances one or more of the 4Rs. For example, communities that adopt elevation certificates ensure that the *physical capital* such as buildings are *robust* and can withstand the impacts of a disaster. Having map information services and flood protection information is being *resourceful* and allows individuals of a community to be knowledgeable about their location, thus enhancing *human capital*. Outreach projects makes *social capital* more resilient by bringing the individuals of a community together and increasing their capacity to prioritize and contain losses in a timely manner (i.e., addressing *rapidity).* Promotion of flood insurance may lead more people to purchase coverage thus enhancing *rapidity and addressing redundancy* of *financial capital* of the community. Preservation of open space ensures the *robustness* of *natural capital*. Acquisition and relocation of property is largely determined by the *political capital* especially the abilities of leaders to bring funds for such purposes and ensures that the *physical capital* is away from the harm's way. While CRS activities are not an exhaustive list that enhances community resilience, we believe they reflect a wide range of measures for tracking the progress of communities in preparing for and recovering from floods.

4. EXAMPLES OF STRATEGIES FOR RESILIENT COMMUNITIES

In this section we highlight the strategies adopted by communities across the 6C.

Financial Capital

Insurance availability. The income and wealth of individuals in a community largely dictates its financial resiliency. Flooding is the leading cause of property loss from natural disasters in the United States. A rationale for encouraging the purchase of flood insurance is that property owners are likely to recover more quickly from a disaster if they have flood coverage than if they are

uninsured. Kousky and Shabman (2012) note that insurance speeds recovery by making available funds for rebuilding in the immediate aftermath of flood. A report that examined the post-Katrina rebuilding found that residences that had been insured before the storm were 37 percent more likely to have been rebuilt (Turnham et al., 2011).

To protect themselves against this flood risk, residents in the United States can purchase flood insurance through the National Flood Insurance Program (NFIP). Owners of homes, businesses, and other structures may purchase building coverage, and owners and renters can buy contents coverage. The maximum residential coverage is $250,000 for structures and $100,000 for contents. Limits for business policies are $500,000 for structures and $500,000 for contents. Households that have purchased flood insurance coverage are also eligible for Increased Cost of Compliance (ICC) that provides up to an additional $30,000 for hazard mitigation should their property be substantially damaged, thus reducing the damage from future floods.

To be a class 1 CRS community and earn a 45% discount in insurance premium, one of the prerequisites is that at least 50% of the buildings in the community's SFHA are covered by NFIP policies. In 2013, the CRS added *flood insurance promotion* under the ***public information activities*** for communities to play a more active role in encouraging households to purchase and maintain adequate flood insurance coverage.

Human Capital

Public education. The capacity of individuals to cope with and recover from a hazard largely defines resilient human capital. In the case of floods, the impact may vary from damage to home and consequent displacement, compromised personal hygiene, contamination of water sources, disruption of sewage service, to stress related mental health and deaths due to drowning (Keim,

2008). Public education plays a vital role in making people aware of the consequences of a disaster and ways to cope with the event. For example, public health communications can encourage preparedness in the home, in schools, in the work place, and at healthcare facilities; health communications can also raise public awareness of evacuation routes, flood zones, and community response plans (Keim, 2008).

Ottawa, Illinois located at the confluence of the Illinois River and the Fox River provides an example of how public education can lead to flood mitigation and flood control efforts so as to make the city resilient. Some of the City's public information activities include holding outreach meetings in conjunction with FEMA public meetings; forming a Flood Commission composed of staff and residents that held sessions with experts on many topics dealing with flood control and the impacts of flooding; and developing a website with flood information (FEMA, 2011). As a result of this initiative, the constituents voted to buy out a school in the district that was heavily damaged when Hurricane Ike flooded the Illinois River and the Fox River in 2008. The Ottawa city council voted to acquire the school and the surrounding property from the school district for $375,000 and build a new school well outside of the 100-year floodplain. FEMA funds were combined with special state allocations and local resources to build a new school through the active role played by elected representatives in the state legislature and the U.S. Congress (FEMA 2011, Newstribune 2012). This also highlights the importance *political capital* to build resiliency in a community. The decision to move the school to higher ground was justified in 2013 flooding which broke the 2008 record stage by 1.5 feet.

Physical Capital

Well-enforced building codes. The activity *"elevation certificates*" in the CRS program encourages communities to have stringent building codes. To participate in the CRS, a community must obtain FEMA elevation certificates on all buildings constructed, substantially improved, or residing in SFHA after the community applies for participation in the CRS.[5] Since 2012, in an effort to strengthen adoption and enforcement of disaster-resistant building codes, a V zone[6] design certificate is needed for new construction in the V zone in addition to an elevation certificate (FEMA, 2012). As of 2013, all the CRS participating communities earn some credit under the elevation certificate with 45 points on an average.

Several studies measure the effectiveness of well-enforced building codes in reducing the damages caused by natural disasters by characterizing *avoided losses* and *reduction in insurance claims,* both of which enhance the *robustness* of the system. Those jurisdictions with effective and well-enforced building codes reduce hail damage on the order of 10 percent to 20 percent compared to those without these codes based on Missouri hail claim insurance data from 2008 to 2010 (Czajkowski and Simmons, 2014). Hurricane Charley in 2004 demonstrated that homes built following the 1996 wind resistant standard in Florida had a claim frequency that was sixty percent less than those built prior to that year (Kunreuther and Michel-Kerjan, 2009). Due the lack of enforcement of building codes in Florida in the period between 1960 and 1992, homes built after 1960 sustained more damage from Hurricane Andrew (1992) than did houses built earlier. If these

[5] For flood proofed buildings, a FEMA flood proofing certificate is needed instead of an elevation certificate.
[6] A V zone is a Special Flood Hazard Area subject to coastal high hazard flooding. The V Zone Design Certificate is found in FEMA's Home Builder's Guide to Coastal Construction, Technical Fact Sheet No. 1.5.

building codes had been enforced, the damage from the hurricane would been reduced by at least 33 percent (Fronstin and Holtmann, 1994).

Physical and Natural Capital

Property acquisitions or buyouts. Buyouts or property acquisitions – removing properties (physical capital) from harm's way – is an important policy intervention for making communities resilient, but these measures are very difficult to implement. The CRS program incentivizes *acquisition* by providing points based on the number of buildings that have been removed from the floodplain with a maximum of 2250 credit points, the largest of any activity. The number of credit points is a function of the percentage of all the buildings in the SFHA that have been acquired or relocated.[7] According to the CRS manual, double and triple points are provided for removing repetitive loss properties and severe repetitive loss properties.[8]

Buyouts and acquisition programs have been highly effective in reducing future flood losses. The State of Iowa acquired over 1,500 properties in Special Flood Hazard Areas over the past two decades to mitigate adverse effects of riverine flooding. A study of 12 communities that removed the structures, revealed that $98.7 million in potential losses were avoided from floods that occurred during this time period (DHS, 2010). Disaster delarations in 1993 and 2002 led the city of Marion, adjacent to Cedar Rapids, to acquire 15 total properties and convert them to open space. Cedar Rapids and Marion reduced their potential losses from the 2008 floods by $2.2 million having previously acquiring and moving this property out of the flood hazard area (DHS, 2010).

[7] Includes the buildings cleared form the regulatory floodplain (bAR), clearing buildings listed on FEMA's repetitive loss list (bRL), clearing severe repetitive loss properties (bSRL), removing critical facilities such as schools from the regulatory floodplain (bCF) and removal of V zone buildings (bVZ).
[8] See the Coordinator's manual for detailed credit calculation method.

The City of Birmingham in Alabama is subject to flash flooding, notably along Village Creek due to high density population and development. According to FEMA, several residential areas in Birmingham in the floodplain of Village Creek were repeatedly flooded, displacing residents and creating community hazards due to sewage backups. With a cooperative effort by the community, the state, and the federal government, 735 structures from the floodplain were removed in the span of 20 years, avoiding losses of over $60 million from floods in 2000 based on an investment of $37.5 million. During the 2000 floods that replicated the 13.6 ft. flood level of 1996, when hundreds of properties in Village Creek were damaged, there was almost no residential property damage, no relocation of residents and no disaster assistance was required. Elsewhere in the city, the damage was serious enough to result in a Presidential disaster declaration.

Acquisition projects not only remove the physical capital of a community from harm's way but also add to its *natural capital*. For example, the acquisition project in Village Creek returned the floodplain to its natural state as a retention basin for floodwaters. Additionally, the financial savings realized by the community as the direct result of implementing the acquisition project can be put toward other civic improvements/projects adding to the *financial capital* of the community.

Social Capital

Connectedness within community and the role of non-profit organizations. Social capital, that is, the benefits of social relationships that accrue to individuals and groups through membership in a social network is particularly important for a community's post disaster resilience (Breton, 2001; Kimhi and Shamai, 2004; Magis, 2010). In the aftermath of Hurricane Katrina, it was evident how differences in social capital impacted on the resilience of different neighborhoods (Elliott, et al. 2010). Interviewing 100 residents from two of the neighborhoods, the Lower Ninth Ward primarily made up of African-Americans who lived below the poverty line, and Lakeview,

a neighborhood made up primarily of affluent white residents, the authors sought to understand how networks – especially bonding and linking social capital – played a role in recovery after the storm. Overall, it took more than twice as long for residents of the Lower Ninth Ward than their counterparts in Lakeview to return to their homes. In Lakeview, individuals were about 14 percent more likely to contact a neighbor compared to individuals in in the Lower Ninth Ward.

Non-governmental organizations (NGOs) play a significant role in the development of social capital and community empowerment (Islam, 2014). Additionally, NGOs also support human recovery after disasters by connecting individuals who lost their homes with local agencies and services (Chandra and Acosta, 2009). For example, the St. Bernard Project in Louisiana supports families in rebuilding their homes and offers services to promote psychological healing, and local, neighborhood-driven service centers.[9]

Political Capital

Regulation to enhance resiliency. In 2013, Illinois State Senator Sue Rezin (R - 38th District) helped establish the Illinois Valley Flood Resiliency Alliance (IVFRA) bringing communities, local governments, and emergency personnel together to help them prepare for floods, in particular through education, communication, and the purchasing of flood protection materials. Currently there are 24 certified floodplain managers in the 38th District as a result of Senator's Rezin's involvement in forming the IVFRA.[10]

Creating new funds for relief efforts. In New York City, 21,000 donors contributed more than $60 million to the Mayor's Fund for the City's emergency response needs and long-term restoration efforts following Hurricane Sandy. The funds were used for home repairs and

[9] For more details on the St. Bernard Project see http://www.stbernardproject.org
[10] For details on IVFRA see http://www.senatorrezin.com/ILValleyFloodResiliencyAlliance.aspx

rebuilding, housing advocacy and legal assistance, loans and grants for non-profit and small businesses, immigrant outreach, volunteer efforts, public education, youth development and employment, parks and open spaces, public libraries, emergency food services.[11] For example, the grant program helped small businesses to restore their operations through the replacement of damaged inventory, supplies and equipment. Similarly, supporting the non-profits had a direct impact on restoring the communities in which they work and serve. Such activities through the Mayor's initiative helped the communities affected by Sandy bounce back.

5. COMMUNITY RESILIENCE: LESSONS FROM KATRINA

In order to build a community's resilience, it is imperative to understand what challenges the community might potentially face. In this section we present the case of Hurricane Katrina and elaborate on challenges in city of New Orleans in context of the 6C-4R framework. While the list of challenges presented below is not exhaustive, it provides lessons learned for other communities to prepare themselves against potential future disasters.

The city of New Orleans is located in the Mississippi River delta on the east and west bank of the Mississippi River and south of Lake Pontchartrain. In response to Hurricane Betsy in 1965, Congress passed the Flood Control Act of 1965 giving authority to construct flood protection in the New Orleans metropolitan area. When Katrina made landfall in 2005, the levee protecting New Orleans failed and approximately 80 percent of the city was flooded. Hurricane Katrina and the levee failure resulted in the death of at least 986 Louisiana residents mainly due to drowning (40 percent), injury and trauma (25 percent) and heart conditions (11 percent) (Data Center, 2015). According to the 2000 census, New Orleans is a city in which 27.9 percent of residents live below

[11] For details see http://www1.nyc.gov/office-of-the-mayor/news/347-13/mayor-bloomberg-mayor-s-fund-advance-new-york-city-release-one-year-on-hurricane/#/0.

the poverty line, 11.7 percent are age 65 or older, only 74.7 percent are high school graduates and 27.3 percent of households do not have cars. Furthermore, a larger than average percentage of residents have disabilities: 10.3 percent of 5-20 year olds, 23.6 percent of 21-64 year olds, and 50.1 percent of those age 65 and older, indicating that the city is socially vulnerable and hence *lacking robustness*. New Orleans' plan for evacuation during Katrina was strongly shaped by the income-level and age of the population, access to information, access to private transportation, physical mobility and health, occupation and social network outside of the city (Fussel, 2006). It is also worth noting that the city of New Orleans joined the Community Rating System in 1991 as a class 9 community and currently is a class 8 community, suggesting that not much has been done in the city across CRS activities before or after Katrina.

The case of New Orleans (Hurricane Katrina) is a good example where different forms of capital were not responsive to the 4Rs. Table 5 presents several challenges identified in the literature including a report by the White House (2006) that details why New Orleans was not a resilient city following the hurricane.

Table 5. Challenges facing New Orleans following Hurricane Katrina across 6Cs and 4Rs

Capitals	Challenges / Indicators
Physical	Failure of levee (lack of robustness); no timely information to evaluate which critical infrastructure were damaged*
Social	Social vulnerability, no timely warning for non-English speakers, lack of mass care and housing*, lack of hazard related information in alternative languages
Natural	Loss of coastal wetlands
Human	Lack of expertize to evaluate protection and evaluation needs*, lack of awareness in prioritizing competing important needs*, lack of planned logistics and evacuation*
Financial	Shut-down of crude oil and natural gas production, no alternative income source
Political	Poor government performance in relief effort

Note: * denotes the critical challenges identified by the White House (2006)

Financial Capital

Following Hurricane Katrina, the financial capital of the area *lacked robustness* since most crude oil and natural gas production in the Gulf of Mexico and eleven petroleum refineries, (one-sixth of the nation's refining capacity) were temporarily shut down. More than 2.5 million customers suffered power outages across Louisiana, Mississippi, and Alabama. Non-governmental and faith-based organizations, as well as the private sector made substantial contributions; however, the monies received were not effectively used as there was no plan to integrate these contributions into

the response and recovery effort implying a *lack of rapidity* in handling the financial capital.[12] The *lack of redundancy* in financial capital was revealed in the unavailability of alternative sources of income and employment.

Human Capital

Lack of access to human resources or knowledge can limit the ability of some socio-economic groups to respond adequately to a disaster (Masozera et al., 2007). In regard to human capital, New Orleans' biggest challenge was its high percentage of minorities and lower income households that hampered their ability to respond and recover from the disaster. Furthermore, the officials responsible for responding to the disaster also lacked the resources needed for recovery processes. According to the White House (2006) report, federal officials had difficulty determining what resources were needed and their availability, indicating a *lack of robustness*. The report also noted that federal officials could not readily determine whether there were alternative sources of supplies and individuals to assist in the recovery process, thus suggesting that there was a *lack of rapidity, redundancy and resourcefulness* in human capital for various operations.

Natural Capital

While the extent of flooding is largely dependent on natural conditions such as the duration of precipitation and previous ground-saturation levels, human actions in addition to flood control projects affect flood frequency and height (Berger et al., 2008). Wetlands act as a natural sponge, absorbing floodwaters and slowly releasing them; when wetlands are paved for real estate

[12] According to a report prepared by FEMA, total contributions from NGOs to Hurricanes Katrina and Rita relief efforts were almost $800 million. Available at: http://www.floods.org/PDF/Patchwork_NGO_Resources_04-13-06.pdf.

development, this natural function is lost. In New Orleans, wetlands had long been exploited. Louisiana wetlands represent 30 percent of the total coastal wetland in the U.S., which account for 90 percent of coastal loss nationally (Carbonell and Meffet, 2009). It is estimated that Louisiana has lost more than 3,000 square miles of its coast in the last 70 to 80 years alone, at a rate of nearly 24 squares miles/year (Reed and Wilson, 2004). The loss of coastal wetland in New Orleans points to *lack of robustness* in the natural capital.

Physical Capital

Critical infrastructures that make up majority of *physical capital* are important assets to a community for its functioning and economic health. Hurricane Katrina had a significant impact on critical infrastructures, notably the breaching of the protective levee, causing flooding in more than 70 percent of the area. This highlights *lack of robustness* in physical capital. The White House report indicated that "the Federal government lacked the timely, accurate and relevant ground-truth information necessary to evaluate which critical infrastructures were damaged, inoperative or both" (White House, 2006) which reveals the *lack of rapidity* with respect to restoring physical capital. *Lack of redundancy* in physical capital is illustrated by lack of transportation alternatives for those in the affected area to evacuate and reach safer ground (Litman, 2006). From a transportation planning perspective, the greatest mistake made in New Orleans was the failure to deploy buses to evacuate transit-dependent residents. Thousands of affected people in New Orleans who were unable to move due to health reasons or lack of transportation had significant difficulty finding suitable shelter after the hurricane, suggesting the *lack of resources.*

Social Capital

Access to timely information was one of the other major issues for non-English speakers indicating the *lack of rapidity and resourcefulness*. Hurricane Katrina resulted in the largest national housing crisis from any disaster in the United States since the Dust Bowl of the 1930s (White House, 2006). According to Current Population Survey (CPS), an estimated 1.504 million individuals aged 16 years and older evacuated their homes, even temporarily because of Hurricane Katrina. Of those who fled, 75 percent were living in Louisiana, 19 percent in Mississippi and 6 percent in Alabama prior to the storm (Groen and Polivka, 2008). However, thousands of people were unable to leave despite mandatory evacuation orders due to disabilities or lack of transportation. Those who were forced to leave their houses had difficulty finding shelter after the hurricane had devastated the city. This problem of mass care and housing indicate a *lack of redundancy*.

Political Capital

Hurricane Katrina is a classic example of a disaster where poor governmental performance at the local, state, and federal level led to anger, frustration, and distrust of those in power. The confusion associated with relief efforts in the aftermath of Katrina was soon followed by reports of misappropriated funds. The Government Accountability Office reported that the cost of fraud and abuse in rebuilding could top $2 billion (Boettke et al., 2007). These concerns illustrate the lack of *robustness and resourcefulness* in the political system following Katrina. The community leaders struggled with how NGOs should provide case management services, which entities should fund those efforts and for how long, and how the various agencies involved in human services should coordinate their activities. As a result, some constituents experienced long delays in securing supports (e.g., health, housing, economic assistance, employment) to transition

successfully through recovery, or those supports were depleted before recovery was achieved (Chandra and Acosta, 2009).

6. COMMUNITY RESILIENCE CASE STUDY: CEDAR RAPIDS, IOWA

In 2008, the City of Cedar Rapids was severely affected by an extreme flood event that impacted 7,198 parcels including 5,390 households, dislocating more than 18,000 residents and damaging 310 city facilities (Cedar Rapids Flood Facts, 2008). Since then, the city has adopted number of activities to mitigate the damages from the June 2008 flood in an effort to make the city more resilient to future floods. In this section we highlight different activities undertaken by Cedar Rapids, focusing on the Community Rating System (CRS) activities and how the actions taken relate to the 6C and 4R framework.

In regard to flood insurance, as of 2012, there were 1,098 active single family flood insurance policies in Cedar Rapids, of which 146 policies were SFHA policies, and 215 policies were B zone (areas protected by levees or 500-year return period) policies. The remaining 728 policies were for properties in the X zone, that are not required to buy flood insurance. On average, the cost of the insurance premium was $2.6 per thousand dollar of coverage. The market penetration was low at fewer than four policies per 100 households. The City of Cedar Rapids began participating in the CRS program in 2010 and was initially classified as a class 8 community earning a 10% flood insurance premium discount for policies within the Special Flood Hazard Area (SFHA). Since 2010, the city has made several efforts to reduce the risk from future floods; Cedar Rapids is currently a class 6 community earning a 20% discount for flood insurance policies in the SFHA. Table 6 lists the CRS activities that the City is credited for (as of 2014) and links them to the 6C-4R framework.

Table 6. CRS Activities in the City of Cedar Rapids, Iowa linked to 6C and 4R Framework

CRS Activities	***Points Earned (of maximum allowable)***	***Capital***	***Properties***
Elevation Certificates	48%	Physical	Robustness
Outreach Projects	11%	Social	Rapidity /Resourcefulness
Hazard Disclosure	18%	Social	Resourcefulness
Flood Protection Information	12%	Social	Resourcefulness
Floodplain Mapping	8%	Human	Robustness
Open Space Preservation	11%	Natural	Robustness
Higher Regulatory Standards	14%	Physical	Robustness/Redundancy
Flood Data Maintenance	47%	Human	Resourcefulness
Stormwater Management	10%	Physical	Rapidity
Acquisition and Relocation	58%	Physical	Robustness

Note: The points earned (as of 2014) is calculated as the percentage of maximum possible points.

We see from Table 6 that CRS activities in Cedar Rapids cover each form of capital that contributes to resiliency. For example, having elevation certificates in place ensures that the buildings are built to code, leading to *robust physical capital* by reducing future flood damages. Similarly, outreach projects insures risk communication with residents in the community which enhances *social capital*. Open space preservation addresses *natural capital* and flood data maintenance is a form of *human capital.*

To determine whether the city of Cedar Rapids is now more resilient than it was several years ago, we compared credit points earned in 2011 to those earned in 2014 across the CRS activities listed above. We find that most of the improvements were made with respect to *higher regulatory standards* and *acquisition and relocation* of the CRS. Figure 1 depicts the increase in

the percentage of total possible points earned by the city of Cedar Rapids over these two activities in 2014 relative to 2011.

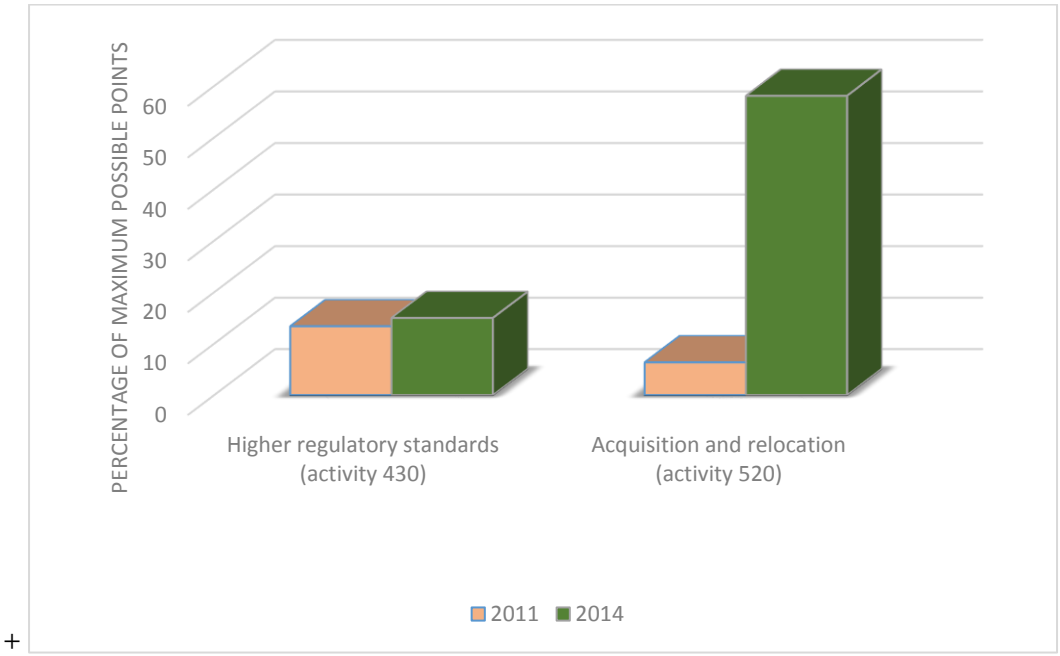

FIGURE 1. PERCENTAGE OF MAXIMUM POSSIBLE POINTS EARNED BY CEDAR RAPIDS IN 2011 AND 2014

CRS Activities in Cedar Rapids

We now discuss different CRS activities including higher regulatory standards and acquisition and relocation that Cedar Rapids is currently undertaking in order to improve its CRS rating and hence provide all residents of the city with lower insurance premiums.

Higher regulatory standards: Development limitations in SFHA, freeboard (requiring buildings to be higher level than the base flood elevation), protection of critical facilities, local drainage protection, and building codes are activities among others included in this category. The adoption by Cedar Rapids of the International Building Code in 2009 has led to improved protection standards for flooding, wind, and other hazards over previous codes and aligns the city with

standard for Iowa. Additionally, the city has also implemented a regulation requiring that new construction must have one foot of freeboard above the Base flood Elevation (BFE). Well-enforced building codes and freeboards strengthen the *physical capital* of the community.

Acquisition and relocation: In Cedar Rapids, after the 2008 floods, voluntary property acquisition has become a major component of flood mitigation and long term recovery process. More than 1300 properties that were in the inundated area[13] were bought using funds from two types of mitigation grant program – the Hazard Mitigation Grant Program (HMGP) and the Community Development Block Grant Program (CDBG). After the 1993 floods (Mississippi River), the buyout program gained momentum and led to political shifts at the federal level toward non-structural mitigation (Fraser et al., 2003). Following the amendment to the Stafford Act in 1993, the allowable portion of relief funds that could be applied to voluntary buyouts and other mitigation projects increased to 15 percent, and the federal cost share also increased from 50 to 75 percent (Conrad et al., 1998). The HMGP grants are deed restricted against structural improvement, reverting in perpetuity to open space, recreation use, or natural floodplains (Conrad et al., 1998). Ninety seven properties in Cedar Rapids were acquired and demolished using the HMPG grant with an average cost of $79,286 (Tate et al., 2015). The remaining 1259 properties were acquired using the CDBG grant and included businesses that were demolished or redeveloped depending on their location, use, and severity. Four percent of the properties bought using the CDBG grant were demolished; while rest were either revitalized or reconstructed with an objective to develop affordable replacement workforce housing. The focus of the Neighborhood Revitalization Area was to develop affordable replacement in neighborhoods incorporating walkability and a sense of

[13] The inundated area included the 100-year floodplain, the 500-year floodplain and even the areas beyond the 500-year floodplain.

place, while also providing opportunities for recreation and transportation (Tate et al., 2015). A majority of revitalization properties were outside the 500 year floodplain. Under both the programs, property owners were offered 107 percent of the pre-flood assessed value, adjusted downward in cases with "duplication of benefits," such as funds already received through flood insurance payouts or FEMA Individual Assistance grants (Tate et al., 2015).

Open space preservation: Out of the 1356 properties that the city of Cedar Rapids acquired after the 2008 floods 556 are located in a proposed Greenway project that will add 110 acres to the city's open space at a cost of approximately $56 million through the FEMA mitigation grant programs noted above. Open space in a community not only creates an amenity value that is capitalized into property prices (Atreya et al., 2016) adding to the *financial capital* of a community through improved tax base but also enhances hazard mitigation by avoiding future property losses.

Other environmental benefits of preserving open space include expanded ecological habitat, flood storage and conveyance, and recreational opportunities which adds to the *natural capital* of a community. In Cedar Rapids, the planned activities for the newly created open space via buyouts are: 8-block promenade, 4 miles of restored river edge, 8 acres of wetland, 15 acres of playing fields and 12 miles of trail. The promenade, restored river edge and trails provide the recreational value while the preservation of wetlands can act as a natural defense structure to diminish the impacts of floods.

Stormwater management. Stormwater management reduces the quantity and improves the quality of the stormwater runoff. In the CRS there are four elements under stormwater management: (a) stormwater management regulation that provides credit points for regulating development on a case-by-case basis to ensure that the peak flow of stormwater runoff from each site will not exceed the pre-development runoff; (b) watershed masterplan for regulating

development; (c) erosion and sedimentation control regulations for land disturbed by construction or farming, and (d) water quality regulation to reduce stormwater runoff. In the city of Cedar Rapids, a cost-share program called the Stormwater Best Management Practices (BMPs) is available to private property owners. The program provides technical and financial assistance for implementing stormwater BMPs. The financial assistance includes the reimbursement of up to 50 percent of the stormwater BMP project cost or $2000, whichever is less. The common stormwater BMP includes the creation of rain gardens, rain barrels, redirecting downspouts, making pervious pavement, soil conditioning, etc. All of these activities reduce the impact of urbanization that produce large stormwater runoff volumes due to impervious surface. The stormwater BMP prevents stormwater pollution, improving the quality of *natural capital* and reducing the impact of floods to *physical capital*. The CRS doesn't provide credit for erosion and sediment control regulations or water quality unless those measures are enforced throughout the entire community.

Hazard disclosure. Hazard disclosure informs the prospective buyers of the potential flood hazard before the lenders notifies them of the need for flood insurance. In the city of Cedar Rapids, residents can see the anticipated inundation area based on river height up to 34.5 ft in a GIS map maintained by the city's IT department. The map is searchable by address and has a number of basemap images including one taken shortly after the crest in 2008. A layer that indicates the floodplain boundaries based on FEMA's Flood Insurance Rate Maps is also available for residents to view which makes residents more informed about the risk they face. The flood insurance rates in Cedar Rapid are based on the Flood Insurance Rate Maps that became effective in 2010. The 2010 flood insurance rate maps changed the flood risk category of approximately 1900 properties in Cedar Rapids, half of which were designated in higher flood risk category and the other half in a lower flood risk category.

Apart from all the activities listed above, public information workshops on emergency preparedness also have taken place in the city, particularly post 2014 flash flood. Overall, the city is dedicated to making their community resilient to future flood.

7. CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH

The concept of *resilience* is gaining momentum in the wake of catastrophic events in the United States and around the world in recent years. Although several frameworks have been introduced to measure resilience, there has been no systematic process that captures all the key sectors of a community. This paper utilizes the 6C-4R (6 capital, 4 resilience) properties) framework to measure community resilience holistically and ties it to the NFIP's Community Rating System (CRS).

In this paper, we demonstrate that several features of the 6Cs and 4Rs are captured by the CRS program. The program can therefore be used to visualize the current resilience status of a community and track improvements over time. A community might be heavily involved in making the physical capital robust by enforcing the building codes while it might be lacking in keeping the natural capital in its natural state which might hinder resilience goals. The CRS can help communities track different activities over time and identify the areas where more focus is needed. Over 1,200 communities currently participate in the CRS program while there are more than 22,000 communities participating in the NFIP. We recommend that the non-participating communities use the CRS program as a starting point to enhance their resilience. Apart from enhancing community resilience, the program has the added benefit of reducing insurance premium of all residents in the community.

One of the caveats of relying on CRS data to measure resilience is that it does not cover all the aspects of a community's status and activities, such as the measurements of social vulnerabilities and the level of engagement of diverse populations such as people with special needs and immigrats that are key to preparing for disasters. Previous research has quantified the performance of CRS activities in terms of reported property damage but other measurements such as the proportion of population below poverty, proportion of population with special needs may be necessary to capture the resilience holistically.

One strategy that communities have adopted to address the vulnerability of the population is to work with local non-profit organizations and to support families in rebuilding their damage homes and coping with the impacts of a disaster. The availability of programs that support the vulnerable population is therefore an important indicator that should be included to measure resiliency.

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