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THE P.E.O.P.L.E.S. RESILIENCE FRAMEWORK: A CONCEPTUAL APPROACH TO QUANTIFY COMMUNITY RESILIENCE

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Abstract. *Over the past years, the concept of resilience has gained attention recognizing the fact that not all threats or disasters can be averted. In fact, communities around the world are turning their attention to efforts and ways that can enhance their resilience against extreme events in any dimensions of life. Resilience is becoming increasingly important for modern societies as states come to accept that they cannot prevent every risk from being realized but rather must learn to adapt and manage risks in a way that minimizes impact on human and other systems. This paper presents a holistic framework for defining and measuring disaster resilience for a community at scales ranging from individual structures (e.g. hospitals) and smaller communities (neighborhoods) to entire regions. Seven dimensions of community resilience have been identified and are represented by the acronym PEOPLES: Population and Demographics, Environmental/ Ecosystem, Organized Governmental Services, Physical Infrastructure, Lifestyle and Community Competence, Economic Development, and Social-Cultural Capital. The PEOPLES Resilience Framework provides the foundation to integrate any quantitative and qualitative models that measures systems' resilience against extreme events (or disasters for that matter) in any or a combination of the above-mentioned seven dimensions. Besides a short-term gap finding analysis, this framework enables communities over the long-term to add and utilize geospatial and temporal decision-support tools that help communities in their planning efforts to assess and to enhance resilience.*

1 INTRODUCTION

Several studies on the disaster resilience of technical systems have been undertaken for quite some time [1] [2], but the societal aspects and the inclusion of various and multiple types of extreme events are new developments. This paper presents a holistic framework for defining and measuring disaster resilience for a community at scales ranging from individual structures (e.g. hospitals) and smaller communities (neighborhoods) to entire regions.

Research by the authors resulted in a) the definition of the quantitative PEOPLES Resilience Framework for communities at various scales that is based on seven distinct dimensions of resilience; b) identification of dimension subcategories and measures of functionality - at the base of resilience measurement - and related spatial-temporal scales, c) identification of gaps in definition and measurement of system functionality to determine indices and sub-indices of community resilience, and d) associated literature review [3] [4].

This new conceptual framework builds on and expands previous research at MCEER (Multidisciplinary Center for Extreme Events Research) linking the resilience dimensions (technical, organizational, societal, and economic [5]) so as to measure the disaster resilience of major components defined by the PEOPLES Resilience Framework. Seven dimensions of community resilience have been identified and are represented by the acronym PEOPLES: **P**opulation and Demographics, **E**nvironmental/Ecosystem, **O**rganized Governmental Services, **P**hysical Infrastructure, **L**ifestyle and Community Competence, **E**conomic Development, and **S**ocial-Cultural Capital.

The PEOPLES Resilience Framework provides the basis for the development of quantitative and qualitative models that already exist or will be adapted to measure continuously the resilience of communities against extreme events or disasters in any or a combination of the above-mentioned dimensions.

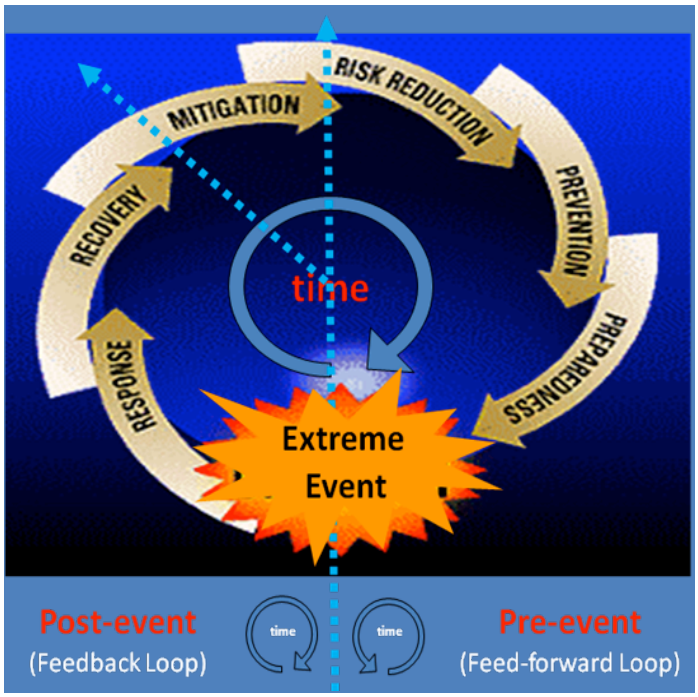

Figure 1: Extreme Events Management Cycle (Renschler et al, 2010)

This framework has been implemented in a decision-support software [6] integrating other disciplines to assess pre and post-disaster response (Figure 1) of communities in a geospatial and temporal scale. Over the longer term the software can be used as a decision support system for engineers and stakeholders as well as by emergency institutions and decision makers in general.

2 METHODOLOGY

Disaster resilience is often divided between technological units and social systems [7]. On a smaller scale, when considering critical infrastructures (for instance the closing of a local hospital), the focus is predominantly on technological and organizational aspects [8]. On a larger scale, when considering an entire community, the focus is broadened to include the interplay of multiple systems – human, environmental, and others – which combine to ensure the healthy, self-organizing functioning of a larger part of society residing in a region. At the community level, the human component is central, because in the case of a major disruptive event, in any of the seven dimensions (Figure 2) resilience depends first on the actions of people operating at the individual and neighborhood scale (Figure 3).

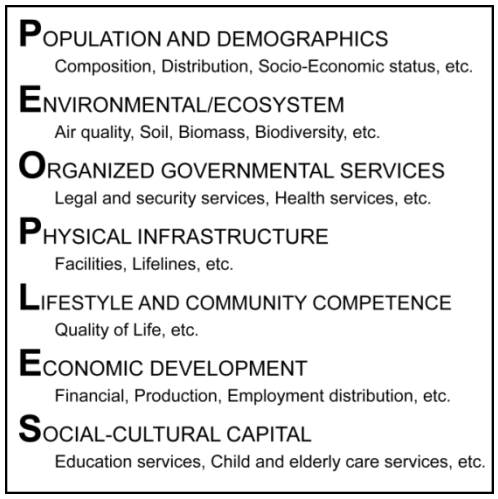

Figure 2: The PEOPLES Resilience Dimensions.

The following describes briefly each of the seven dimensions associated with the PEOPLES Resilience Framework and some potential indicators. The dimensions are neither orthogonal nor synonymous. While they are discussed as distinct dimensions and while we anticipate developing measures that are often independent, the nature of community resilience is such that interdependence between and among the dimensions is expected and necessary. The potential indicators are intended to be illustrative rather than exhaustive. Importantly, the indicators that are identified are those that may be used to describe a community and its resilience at any time, and not simply post-extreme event. Ultimately, the value of the PEOPLES Resilience Framework is that it (a) identifies the distinct dimensions and related key indicators but also (b) aggregates the dimensions in ways that reflect community realities.

2.1 Population and Demographics

A measure of functionality of population and demographics Qp within a given community could be quantified by using the social vulnerability index (SoVI) proposed by Cutter [9]. Social vulnerability (a counterpart of social resilience) is defined as the inability of people, organizations, and societies to withstand adverse impacts from multiple stressors to which they are exposed. These impacts are due in part to characteristics inherent in social interactions, institutions, and systems of cultural values. Social vulnerability is a pre-existing condition of the community that affects the society's ability to prepare for and recover from a disruptive event. It affects and is affected by both evolutionary occurrences (e.g., slow changes in median age) and transformative events (e.g., wholesale shifts in dominant ethnicity).

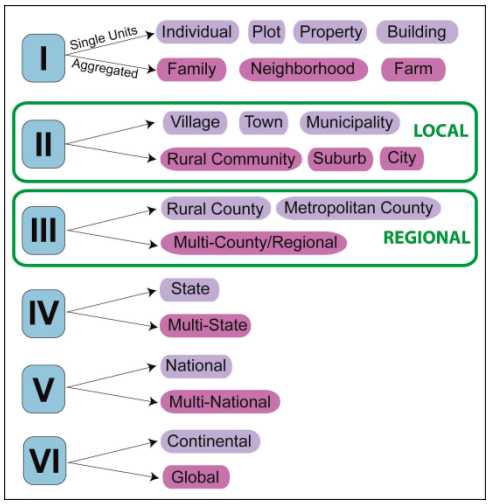

Figure 3: The Peoples Resilience Scales.

2.2 Environment/Ecosystem

Ecological or ecosystem resilience is typically measured by the amount of disturbance an ecosystem can absorb without drastically altering its functions, processes and structures [10], or by the ability of an ecosystem to cope with disturbance. In the context of the PEOPLES Resilience Framework, environmental and ecosystem resources serve as indicators for measuring the ability of the ecological system to return to or near its pre-event state.

2.3 Organized Governmental Services

In contrast to the more or less spontaneous individual and neighborhood responses to extreme events, organized governmental services are designed to allow an orderly response. Organized governmental services include traditional legal and security services such as police, emergency and fire departments and in extreme cases, the military. In this dimension, we also include the services provided by public health and hygiene departments as well as cultural heritage departments. Each of these organized government services plays a key role in sustaining communities both before and after extreme events. A good example of the necessity of a well functioning government may be seen in the devastating January 12, 2010 earthquake in Haiti. In the aftermath, the news media reported a lack of government services and orderly control, and a general perception that the government was not in a position to help its people [11].

2.4 Physical Infrastructure

The physical infrastructure dimension incorporates both facilities and lifelines. Within the category of facilities, we include housing, commercial facilities, and cultural facilities. Within the category of lifelines, we include food supply, health care, utilities, transportation, and communication networks. In terms of housing, key indicators may include proportion of housing stock not rated as substandard or hazardous and vacancy rates for rental housing [12]. In terms of communication networks, key indicators may include adequacy (or sufficiency) of procedures for communicating with the public and addressing the public's need for accurate information following disasters, adequacy of linkages between official and unofficial information sources, and adequacy of ties between emergency management entities and mass media serving diverse populations [12].

2.5 Lifestyle and Community Competence

This dimension reflects the reality that community resilience is not simply a passive "bouncing back" to pre-disaster conditions [13] but rather a concerted and active effort that relies on peoples' ability to creatively imagine a new future and then take the requisite steps to achieve that desired future. It captures both the raw abilities of the community (e.g., ability to develop multifaceted solutions to complex problems, ability to engage in meaningful political networks) and the community's perceptions of its ability to effect positive change. Communities that collectively believe that they can rebuild, restructure, and revive themselves are more likely to be persistent in the face of environmental, governmental, and other obstacles. Communities with positive experience dealing with extreme events may be more likely to possess high degrees of community competence. For example, in the wake of the 2011 earthquake and tsunami that devastated Japan, it is expected that Japan will recover relatively quickly because it has experience dealing with extreme events (e.g., the 1995 Great Hanshin or Kobe earthquake).

2.6 Economic Development

Resilient communities are characterized by their involvement in a diverse array of products and services that are both produced in and available to the community. Diversity in production and employment is linked to a community's ability to substitute goods and services and shift employment patterns as the situation demands. Efficient redundancy in operations and information systems enables relatively swift reopening of critical employers. The PEOPLES Resilience Framework incorporates three illustrative subcategories within this dimension: industry – production, industry – employment distribution, and financial services. Primary indicators of this dimension include the proportion of the population that is employed within the various industries, and the variability that might characterize a community's industrial employment distribution. This dimension is closely interwoven with the Population and Demographics dimension. For example, key indicators of economic development beyond employment and industry distribution include literacy rates, life expectancy, and poverty rates. Disaster-specific indicators related to economic development include extent of evacuation plans and drills for high occupancy structures, adequacy of plans for inspecting damaged buildings following disasters, and adequacy of plans for post-disaster commercial reconstruction [12].

2.7 Social-Cultural Capital

Measuring social/cultural capital requires acquisition of tallies, such as the number of members belonging to various civil and community organizations. It also requires surveys of community leaders and their perceptions (e.g., quality of life surveys). Communities with high degrees of social-cultural capital create "friction to exit" for their members, encouraging people to invest in those activities and organizations that make the community a "good place to live," and encouraging people to return and reinvest in their communities after an extreme event. Disaster-specific indicators include existence of community plans targeting transportation-disadvantaged populations, adequacy of post-disaster sheltering plans, adequacy of plans for incorporating volunteers and others into official response activities, adequacy of donations management plans, and the community's plans to coordinate across diverse community networks [12].

3 RESILIENCE COMPONENTS AND SUBCOMPONENTS

The PEOPLES Resilience Framework requires the combination of qualitative and quantitative data sources at various temporal and spatial scales, and as a consequence, information needs to be aggregated or disaggregated to match the scales of the resilience model and the scales of interest for the model output. Table 1 shows the complete list of components and sub-components. In the following sections a detailed description of each component is complemented by attempts of quantification.

4 INTEGRATION

Within the PEOPLES Resilience Framework, each dimension and its indicators or term of functionality and/or service will be represented with a GIS layer of the area of interest as suggested in the example portrayed in Figure 4, where Q_{pop} = functionality of population; Q_{env}= functionality of ecosystems; and so on. Additional terms for subcategories of resilience dimensions can be added, such as functionality of schools, dams, fire stations, oil and natural gas systems, emergency centers, communication towers/antennae, etc.

5 CONCLUSIONS

The seven dimensions of community resilience are indentified within the new PEOPLES Resilience Framework as Population and Demographics, Environmental/Ecosystem, Organized Governmental Services, Physical Infrastructure, Lifestyle and Community Competence, Economic Development, and Social-Cultural Capital.

PEOPLES builds on and expands previous research at MCEER linking the four resilience properties (robustness, redundancy, resourcefulness, and rapidity) and resilience dimensions (technical, organizational, societal, and economic) so as to measure the disaster resilience of capital assets (e.g., hospitals) and asset classes (e.g., health care facilities).

The PEOPLES Resilience Framework has been implemented in decision support software to assess pre and post-disaster response of communities. Over the longer term, the software can be used as decision support system for engineers and stakeholders as well as by emergency institutions and decision makers in general. Such a system should enable decision makers to prioritize resource allocations and take the steps needed to enhance community resilience before and after an extreme event.

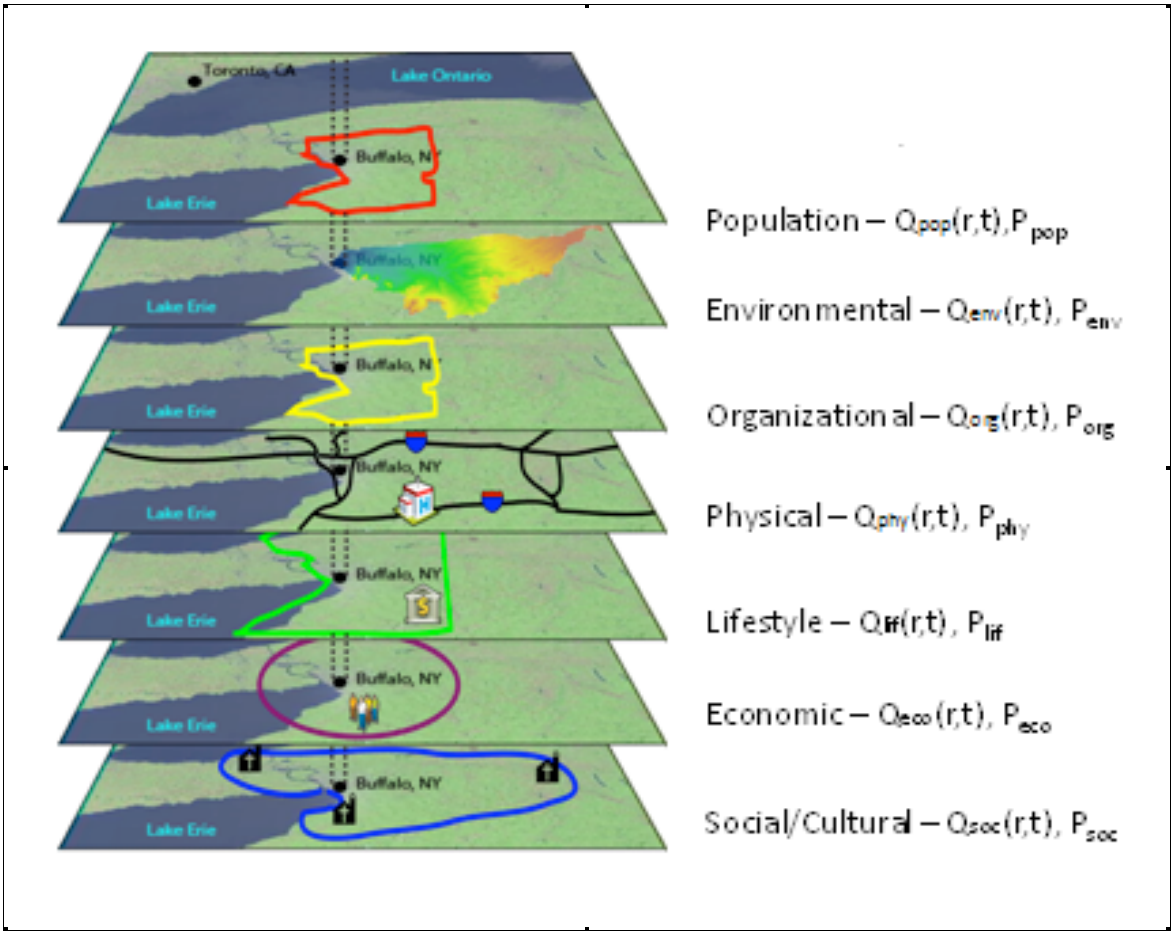

Figure 4: Layer model for Rural PEOPLES (Renschler et al, 2010)

Table 1 Complete list of components and sub-components.

1) POPULATION AND DEMOGRAPHICS
- a) Distribution/Density
  - i) Urban
  - ii) Suburban
  - iii) Rural
  - iv) Wildland
- b) Composition
  - i) Age
  - ii) Gender
  - iii) Immigrant Status
  - iv) Race/Ethnicity
- c) Socio-Economic Status
  - i) Educational Attainment
  - ii) Income
  - iii) Poverty
  - iv) Home Ownership
  - v) Housing Vacancies
  - vi) Occupation

2) ENVIRONMENTAL/ ECOSYSTEM
- a) Water Quality/ Quantity
- b) Air Quality
- c) Soil Quality
- d) Biodiversity
- e) Biomass (Vegetation)
- f) Other Natural Resources

3) ORGANIZED GOVERNMENTAL SERVICES
- a) Executive/ Administrative
  - i) Emergency Response and Rescue
  - ii) Health and Hygiene
- b) Judicial
- c) Legal/Security

4) PHYSICAL INFRASTRUCTURE
- a) Facilities
  - i) Residential
    - (1) Housing Units
    - (2) Shelters
  - ii) Commercial
    - (1) Distribution Facilities
    - (2) Hotels - Accommodations
    - (3) Manufacturing Facilities
    - (4) Office Buildings
  - iii) Cultural
    - (1) Entertainment Venues
    - (2) Museums
    - (3) Religious Institutions
    - (4) Schools
    - (5) Sports/Recreation Venues
- b) Lifelines
  - i) Communications
    - (1) Internet
    - (2) Phones
    - (3) TV
    - (4) Radio
    - (5) Postal
  - ii) Health Care
    - (1) Acute Care
    - (2) Long-Term Acute Care
    - (3) Primary Care
    - (4) Psychiatric
    - (5) Specialty
  - iii) Food Supply
  - iv) Utilities
    - (1) Electrical
    - (2) Fuel/Gas/Energy
    - (3) Waste
    - (4) Water
  - v) Transportation
    - (1) Aviation
    - (2) Bridges
    - (3) Highways
    - (4) Railways
    - (5) Transit
    - (6) Vehicles
    - (7) Waterways

5) LIFESTYLE AND COMMUNITY COMPETENCE
- a) Collective Action and Decision Making
  - i) Conflict Resolution
  - ii) Self-Organization
- b.) Collective Efficacy and Empowerment
- c.) Quality of Life

6) ECONOMIC DEVELOPMENT
- a) Financial Services
  - i) Asset Base of Financial Institutions
  - ii) Checking Account Balances (Personal and Commercial)
  - iii) Consumer Price Index
  - iv) Insurance
  - v) Number and Avg. Amount of Loans
  - vi) Number of Bank and Credit Union Members
  - vii) Number of Banks and Credit Unions
  - viii) Savings Account Balances (Personal and Commercial)
  - ix) Stock Market
- b) Industry – Employment - Services
  - i) Agriculture
  - ii) Construction
  - iii) Education and Health Services
  - iv) Finance, Insurance and Real Estate
  - v) Fortune 1000
  - vi) Fortune 500
  - vii) Information, Professional Business
  - viii) Leisure and Hospitality
  - ix) Manufacturing
  - x) Number of Corporate Headquarters
  - xi) Other Business Services
  - xii) Professional and Business Services
    - (1) Employment Services
      - (a) Flexibilities
      - (b) Opportunities
      - (c) Placement
    - (2) Transport and Utilities
    - (3) Wholesale and Retail
- c) Industry – Production
  - i) Food Supply
  - ii) Manufacturing .....

7) SOCIAL/CULTURAL CAPITAL
- a) Child and Elderly Services
- b) Commercial Centers
- c) Community Participation
- d) Cultural and Heritage Services
- e) Education Services
- f) Non-Profit Organizations
- g) Place Attachment

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