Building Community Resilience: A Proactive, Measurable, Scalable,

and Comprehensive Resilience Planning and Forecasting Model

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Abstract

Historically, community resilience planning has been disaster-focused, reactive, and left little room to build increased sustainability to face exponentially increasing climate change impacts. Defining sustainability and resilience as both separate and interdependent characteristics of a community presents challenges for comprehensive and scalable resilience planning frameworks. However, communities can improve their resilience and sustainability within their unique set of risks and stressors if provided a framework that accounts for their Capital Stocks and Resilience Properties, identifies critical performance gaps, grades existing resilience, helps forecast potential gains from implementation strategies, and measures progress. The authors and a team of University of Kansas Environmental Assessment program students expanded, adapted and applied an existing, comprehensive, resilience planning framework in cooperation with a rural municipality, a suburban city, and a tribal nation. The teams completed a vulnerability assessment, SWOT (strengths, weaknesses, opportunities, threats) analysis, resilience screening, peer community assessment, community resilience scoring, and developed resilience-building strategies. The result was a comprehensive, rigorous, scalable resilience assessment and planning framework with an adaptable grading and forecasting system. This expanded framework, named the Community Resilience Assessment and Forecasting Tool (CRAFT), reveals facets of resilience overlooked by traditional planning processes and proactively identifies critical improvement areas with actionable specificity, tied to performance metrics, empowering communities of every size to move toward greater resilience and sustainability.

Keywords: Community Resilience, Resilience Planning, Resilience Forecasting, Sustainability

Section I - Introduction

Resilience integrates natural and human systems, seeks to mutually strengthen these systems, and capitalizes on nature's regenerative potential. Facilities, communities, systems and regions that cooperate with nature are more adaptable to changing conditions, more efficient, livable, prosperous, and sustainable, translating into resilience through short term crises and maintaining long-term stability. Building resilience is a proactive approach to sustainability planning, addressing not only acute stressors but chronic ones as well, ensuring complex networks and systems are strategically prepared to withstand, absorb, and quickly rebound from stressors that might otherwise cripple them.

Development and application of real-world principles and strategies for building community and regional resilience was the focus of University of Kansas Edwards Campus (KUEC) masters and undergraduate Environmental Assessment program participants in 2019 and 2020. Students, community leaders and faculty cooperated in a rigorous resilience assessment within a variety of communities, revealing both existing resilience and performance gaps. Resulting resilience building recommendations were embraced by the partnering communities as relevant and insightful contributions to their planning efforts. The applied research was structured to fill an identified gap in knowledge regarding community resilience strategies to address chronic stressors and challenges, and a lack of widely adopted planning frameworks that promote proactive approaches to changing conditions coupled with performance measurement.

Most existing definitions of resilience are disaster-focused (Patel et al., 2017; Pfefferbaum et al., 2013), which is, by default, both short-term and reactive. Climate change, water resource depletion, and biodiversity collapse are slow-motion disasters that demand a long-term view because they fuel a wide array of acute natural catastrophes coupled with

long-term environmental changes which stress social and technological systems. Thinking in these terms, resilience planning models must work across a range of scales and timeframes. We should define resilience as the degree to which the communities are biologically healthy, environmentally and naturally vibrant, economically prosperous, and politically and socially cohesive; which in turn promotes personal, community, economic, and environmental security over the short and long term. Although a community's ability to tolerate any given stressor will vary based on specific circumstances and many complex factors, in theory the more resilient a community, the higher its threshold of resistance to, and the more rapid its recovery from a given event or series of impacts.

As climate impacts accelerate changing conditions, community needs will grow exponentially. Resilience planning must focus on more than preventing adverse outcomes and should definitively stress the upsides and incentives of pursuing strategies that will create tangible improvements in our environmental, economic, social, political, and community well-being. In other words, we should think of resilience as "The practical core of sustainability" because being resilient does not necessarily make a community sustainable, but a community cannot be sustainable unless it is resilient. Steering terminology from *sustainability* to *resilience* also may help sidestep negative political connotations and aspirational language of sustainability, and appeal to those seeking long-term stability, improved health, quality of life, and return-on-investment for public- and private-sector expenditures.

Section II - Resilience Assessment and Planning

A functional community resilience framework must be objective, empirical, and comprehensive, yet with practicality and scalability when dealing with diverse communities and conditions. Most importantly, the framework must be able to both define and assess current community resilience, and evaluate improvements and potential implementation strategies to

build greater resilience. This specification is fundamental to fully understanding a community's

pathway to greater resilience.

Community resilience assessment and planning frameworks are numerous in many

fields and disciplines. Many address singular, one-off events, are short-term in nature, or may

only address the natural hazards that threaten a community. Some frameworks are more

process-oriented, such as the Climate Ready Communities Program (Geos Institute, 2018),

while others are much more detailed and complicated (Resilient Cities Network, 2019). Some

are narrowly focused on disaster preparedness and recovery, such as the Communities

Advancing Resilience Toolkit (Pfefferbaum et al., 2013), the Community Resilience System

(Community & Regional Resilience Institute, 2011) and the Climate Resilience Screening Index

(Summers et al., 2017). These frameworks provide valuable insights over the short-term; but

they do not meet the specification of a comprehensive framework that addresses community

resilience in a holistic and proactive manner to resist impacts from chronic stressors and acute

shocks.

A concurrent and more extensive review of community resilience frameworks by the

National Academies of Sciences (NAS) Gulf Research Program came to identical conclusions,

and noted that no framework had been developed or adapted to evaluate or forecast potential

resilience gains from implementation strategies (National Academies of Sciences, Engineering,

and Medicine, 2019). The NAS review recommended that valid and useful resilience

frameworks must: 1) evaluate all six of a community's capital stocks, including both assets and

capabilities as well as political capital; 2) must be scalable and tailored to community

characteristics and needs; and 3) must be based on robust community engagement.

Observing these gaps in community resilience planning methods, the authors expanded

the "6C/4R Framework" originally created by researchers from The Wharton School at the

University of Pennsylvania (Keating, et al., 2017; Atreya & Kunreuther, 2018; Campbell et al., 2019; and Zurich Flood Resilience Alliance, 2019) in an effort to develop a comprehensive resilience planning framework, coupled with a unique system of measurement, and applied it in partnership with three very different communities within the State of Kansas. The resilience assessments performed during this practical application addressed the unique needs of each community and provided tailored recommendations and pathways toward greater resilience throughout all facets of the communities. The result was a comprehensive, rigorous, and scalable resilience assessment and planning framework.

The 6C/4R Framework

The 6C/4R Framework was originally developed and tested in the United States and abroad to assess community flood resilience (Atreya & Kunreuther, 2018) . The 6Cs, or six Capital Stocks (Financial, Human, Natural, Physical, Political, and Social), and 4Rs, or four Resilience Properties (Robustness, Rapidity, Redundancy, and Resourcefulness), are balanced categories that holistically characterize a community's resources and resilience. Tables 1 and 2 detail each Capital Stock and Resilience Property. The framework succeeds because human, social, political, natural, physical, and financial indicators of resilience can be detailed to reveal the interconnectedness and multi-dependence of the community. The scalability of the framework allows planners to identify multiple levels of resilience within a single capital stock. For example, financial resilience indicators include household savings, credit access and debt along with municipal debt, cash reserves, access to capital, and overall economic vitality.

Table 1

6C/4R Framework Capital Stock Descriptions

Capital Stocks	Description
Financial	The financial resources at the community level including households, services, and government.
Human	Individual and shared knowledge, skills, health, and capabilities.
Natural	Intangible goods, such as air quality and biodiversity, divisible assets used for production (tree cover, land use, etc.), and the quality of specific ecology and land cover that occupies the community (wetlands, floodplains, native plants, wildlife, etc.).
Physical	Infrastructure such as transportation, drinking water, electricity, etc., and the built environment which includes public buildings, housing,, and other physical resources available to respond to and mitigate impacts to the community.
Political	The characterization of how decisions are made, and how external resources are acquired and used to prevent and/or recover from events, disasters, and long-term stressors.
Social	The networks of political, civic, familial and community bonds that establish trust in the systems that can improve upon resilience for the community and which is not always tangible.

Table 2

6C/4R Framework Resilience Property Descriptions

Resilience Properties	Description
Robustness	The ability of a system, critical asset, infrastructure, service, or institution to resist impacts and stressors.
Rapidity	The ability of a system, critical asset, infrastructure, service, or institution to respond in the time required to prevent further impacts from an impact or disruption event.

Resilience Properties	Description
Redundancy	The backup capabilities of, or ability to substitute for, a system, critical asset, infrastructure, service, or institution to maintain the capability and capacity to prevent future impacts from an acute impact or chronic stressor.
Resourcefulness	The ability of the community and decision makers to develop priorities, leverage resources, and mitigate risks before they impact critical systems in the community.

Applying the Expanded Framework

The framework was adapted and expanded by the authors and applied by KUEC Environmental Assessment teams in cooperation with a rural municipality, a suburban city, and a tribal nation. After an initial capital stock and systems assessment, the teams completed a vulnerability assessment, SWOT (strengths, weaknesses, opportunities, threats) analysis, resilience screening, peer community assessment, community resilience scoring, and developed resilience-building strategies accompanied by performance improvement forecasts. Each community provided a diverse look at the differences in government operations, scales of services, cultural values, natural resource management, and political willpower.

The teams first used the expanded framework, named the Community Resilience Assessment and Forecasting Tool (CRAFT), to evaluate each community's assets and infrastructure and to identify community risks and vulnerabilities to human-induced and natural hazards. They started by identifying the communities' assets and resources - the existing physical infrastructure, services, and human, financial, social, natural, and political assets that are crucial to the operation and longevity of the community. The assets were grouped by Capital Stock category and the relationships among the capital stocks were listed to create a systems map. Capital stocks that were identified as critical infrastructure included those directly related

to community health and safety, and the capital with the most interrelationships that could cause extensive cascade effects if impacted.

Next, hazards were identified and ranked using a modified version of the process developed for university campuses by Li, et al. (2009), a qualitative risk assessment procedure similar to those commonly used for municipal hazard planning. Hazards that pose the greatest risk have the highest probability of occurrence and would cause the most serious impact. The teams evaluated potential impacts by ranking the potential for human casualties, physical damage, short- and long-term economic disruption, and social disruption. They also evaluated which capital stocks were most likely to be impacted by a given hazard, paying particular attention to critical infrastructure and the potential for widespread cascade effects.

The teams then performed a resilience screening of all three communities. The goal was to analyze sources of resilience in the community and categorize them by Capital Stock using the CRAFT framework. All communities demonstrated sources of resilience such as drinking water services, aid services for vulnerable populations, healthcare access, transportation diversity, natural land cover connectivity, and floodplain management. Once the resilience sources were detailed, each was assigned a grade based on a flexible set of rubrics the authors developed to rate a variety of indicators. The results were averaged to establish grades for each Capital Stock and Resilience Property, culminating in an overall community grade.

Grading not only established the current state of a resilience source, but also suggested a pathway to reach greater resilience and optimum performance. Most sources of resilience can be ranked by the degree to which they incorporate best practices or industry standards; the degree of risk posed to the community; or by their attributes, such as the level of planning, funding, and personnel devoted to each capital stock. The grading criteria in Table 3 below incorporates these rankings to provide standards and relative rankings on which to build further

planning efforts while recognizing that each Capital Stock and Resilience Property requires

unique descriptors for appropriate comparative evaluation due to the undefined nature of what

constitutes a perfectly resilient community. These criteria recognize that there is no one size fits

all solution and point toward solutions that may inspire other communities to follow their lead,

whether by perceived or proven success. (Byers, et al., 2019).

A simple A, B, C, D grading system over these four defining attributes was applied

across all six Capital Stocks and four Resilience Properties. An A grade represents a prime

condition, decreasing in condition from A to B, to C, and the lowest condition at grade D.

Table 3

Sources of Resilience Grading Criteria

Grade	Risk Rating	Industry Standards	Best Practices	Attribute Modeling
A	Low Risk	Exceeds Standard	Proven program	Ideal model
B	Moderate Risk	Meets Standard	Program developed, unproven	Adequate model
C	High Risk	Work in Progress or Below Standard	Program in development	Approaching model
D	Very High Risk	No indication	No Program	Inadequate

Risk rating identifies the probability and associated severity of loss associated with

hazards unique to the community, as identified in the community risk assessment, and accounts

for risk declarations such as those reported by insurance companies, independent consultants,

or government agencies. A community's specific risk tolerance does not influence risk rating;

however, it inevitably sways and determines final decisions regarding how or if risk elements will

be addressed by the community. Industry standards exist for most primary community

infrastructure systems. For example, the American Public Works Association provides

standards of road design, construction, and maintenance that could easily be used in identifying

how closely a community achieves established target standards. The availability of best

practices indicates awareness and efficacy in following established commercial or professional

protocols and may exist in the absence of or interconnected with one of the other criteria.

Finally, attribute modeling grades how closely the community's characteristics and

achievements provide a model that other communities follow or aspire to emulate.

Table 4 below provides an example grading rubric that was used in the assessment of

one community by the KUEC Environmental Assessment team. As determined during the

community assessment, the planning group found it necessary to create a unique rubric that

included a +/- system of grading as to provide the community with more attainable goals by

better recognizing incremental improvements. The Capital Stock and Resilience Property

grades found in Tables 5 and 10 were assessed grades using this rubric.

Table 4

Example Grading Rubric Used by the KUEC Environmental Assessment Team

Grade	Points
A	3.00
B+	2.67 - 2.99
B	2.34 - 2.66
B-	2.00 - 2.33
C+	1.67 - 1.99
C	1.34 - 1.66
C-	1.00 - 1.33
D	0.00 - 0.99

The assessed communities were then compared to available data from surrounding communities, states, and the country as a whole. In communities where standards were not available or rating systems had not been established, one of the other grading criteria listed above was applied to quantify past, present, and future conditions of an asset or resilience source. Table A1 in the appendix demonstrates how the resilience screening and grading rubrics were used to grade one community. Once grades were established by source of resilience, each Capital Stock and Resilience Property grade was determined by the averaged sum for relevant sources of resilience. Table 5 provides an example of how the grades assessed for each source of resilience were combined to provide a grade for each Capital Stock, Resilience Property, and the community as a whole.

Table 5

Example of Resilience Scoring by Capital Stock and Resilience Property

Rank	Capital Stock	Overall Grade (score out of 3.00; # of resilience sources)
#1	Social	B (2.36; 11)
#2	Financial	B- (2.00; 14)
#3	Natural	C+ (1.82; 11)
#4	Human	C+ (1.89; 9)
#5	Political	C+ (1.70; 10)
#6	Physical	C (1.67; 12)

Rank	Resilience Property	Overall Grade (score out of 3.00; # of resilience sources)
#1	Resourcefulness	B- (2.08; 12)
#2	Robustness	C+ (1.96; 28)
#3	Rapidity	C+ (1.83; 12)
#4	Redundancy	C+ (1.73; 15)
Overall Community Grade		**C+ (1.91 out of 3.00)**

A strengths, weaknesses, opportunities, and threats (SWOT) analysis was performed to organize data compiled from the Vulnerability Assessment and Resilience Screening into a

more concise format for further evaluation by the communities. Strategies were identified to

capitalize on their strengths, reduce weaknesses, invest in opportunities, and mitigate threats.

Research on peer communities across the U.S. provided valuable information on

actions, strategies, and experiences that have shaped their own resilience story and could be

transferable to other communities. Many communities are already taking actions to limit or

prevent future human-induced and natural impacts or stressors. Peer communities were

selected that were of similar size, regional setting, and shared similar strengths, weaknesses,

opportunities and/or threats that the researchers identified in each community. To be

considered, selected peer communities must have taken significant action towards addressing

their own vulnerabilities, weaknesses, or lack of resilience. Each example was selected for its

pragmatism, adaptability, and relevance to the communities in question.

The final and most important piece was to provide strategies that may be implemented

by the communities to improve their overall resilience to chronic stressors and/or acute impacts

and thereby improve their grades. Each community was provided strategies that addressed

vulnerabilities or sources of resilience in all Capital Stocks and Resilience Properties. The

strategies developed for each community were categorized by the CRAFT framework to show

the community how each strategy would benefit a certain Capital Stock or Resilience Property.

Table 6 provides an example of several strategies categorized by Capital Stock, its primary

benefits, vulnerabilities it addressed, and how it aligned with one or more Resilience Property.

Table 6

Resilience Strategy Examples Categorized with the CRAFT Framework

Capital Stock	Strategy	Benefits of Strategy	Vulnerability Addressed	Resilience Properties
Financial	Develop and implement a Tribal Energy Plan	Financial wellbeing, energy assurance, government service redundancy, community wellbeing, economic growth	Federal and State Actions against Tribal Sovereignty, Natural Disasters, Economic Recession/ Depression, Terrorism	Redundancy, Rapidity
Human	Expand broadband internet services to the community and throughout government systems	Disaster communication, emergency evacuation, resilience knowledge building, community connection, continuity of governance	Terrorism, Natural Disasters, Epidemic/Pandemic	Redundancy, Rapidity
Natural	Reintroduce native plant and animal species onto public lands	Ecosystem services, emergency sustenance, recreation, cultural traditions, flood management, water quality, air quality, agriculture	Natural Hazards, Epidemic/Pandemic, Economic Recession/Depression	Resourcefulness, Robustness
Physical	Establish a flood-warning system at bridges and low water crossings	Emergency management, Disaster communication, Emergency evacuation	Natural Hazards	Rapidity, Redundancy

Capital Stock	Strategy	Benefits of Strategy	Vulnerability Addressed	Resilience Properties
Political	Establish a contagious disease containment and mitigation plan	Emergency management, Disaster communication, Emergency evacuation, financial wellbeing, human health, healthcare system redundancy	Epidemic/Pandemic, Terrorism	Rapidity, Robustness, Redundancy
Social	Create a Tribal Historic Preservation Officer position within the Tribal government	Protection of historical lands and resources. Cultural resilience planning. Federal, state, and local governmental liaison for resource preservation	Federal and State actions against Tribal Sovereignty, Terrorism, Natural Hazards	Resourcefulness, Robustness

Lessons Learned

The authors improved and expanded the framework through the community assessment process. They added numerous indicators to better evaluate the Capital Stocks, and in the process realized the importance of non-physical capital. They also recognized that each community's baseline resilience is unique and integral to the assessment and resulting recommendations. Finally, they demonstrated how to both measure existing resilience and forecast potential resilience gains with prioritized resilience strategies.

Expanding Indicators and Metrics

The KUEC Environmental Assessment teams recognized that the original suite of indicators could be expanded to better assess diverse communities, and provide more options depending on available information. They added numerous indicators for Capital Stocks across the range of Resilience Properties (Table 7 below).

Table 7

Indicators of 6C/4R Framework with New Additions

Capital Stocks	Resilience Properties			
	Robustness	**Rapidity**	**Redundancy**	**Resourcefulness**
Financial	Income and wealth, affordability, income and property tax base, infrastructure and services budget, government expenditures, **economic potential, agricultural potential, economic distribution, and wealth disparity.**	Liquid assets, savings, emergency funds, insurance availability.	Alternative sources of income, credit, retirement funds, remittances, emergency assistance, social safety nets.	Emergency savings, rainy day funds, pre- and post-disaster mitigation funds, community development investment.
Human	First aid, safety, hazard and risk knowledge, continuity of operations plans, multi-hazard/resilience/ adaptation plans, population health, **Traditional Ecological Knowledge, cultural traditions.**	Emergency evacuation plans, emergency contact information, community emergency responders, **modes, and access to emergency communication.**	Education and skills for adaption and alternative income, data backups, mutual aid agreements, **access to reliable internet services.**	Emergency supplies, income and labor for recovery efforts, **emergency responders (number and skill),** general educational attainment and quality.
Natural	Floodplain conservation, **riparian, wetland, forest, and prairie health; environmental quality, biodiversity, open space (parks and natural), human-made green infrastructure, agricultural lands**	Overflow and buffer areas, floodplains, stormwater basins, stormwater/parks, natural lakes, **landscape/natural resource recovery capacity and fragility.**	**Natural buffers (floodplains, overflow paths, wetlands), water supply sources; farm and grazing land, natural resource, and agricultural management plans**	**Riparian, wetland, forest and prairie extent**, connectivity of ecosystems, watershed health, **extent of green infrastructure,** sustainability of natural resource management and use.

Capital Stocks	Resilience Properties			
	Robustness	**Rapidity**	**Redundancy**	**Resourcefulness**
Physical	Age, design, and condition for critical and non-critical infrastructure, buildings and housing, and their ability to withstand shock and chronic stress, early warning systems.	Critical infrastructure recovery time (power, water, transportation, communications, levees/stormwater management, food systems, health care, sanitation)	Alternate critical infrastructure (transportation routes/modes, power supply, water supply, communications systems, health care, food); backup shelter, commerce, and operations sites.	Availability of restoration supplies, equipment and materials, early warning and forecasting systems.
Political	**Ability to efficiently manage a disaster, post disaster, and pre-disaster mitigation, plus long-term resilience and adaptation, mutual aid and cooperative agreements (local, state, tribal, federal entities).**	Ability to respond quickly to disaster, or proactively to emergence of longer-term threats and stressors.	**Existence and effectiveness of multiple local, state, and federal level political institutions that promote and support resilience.**	Political will and effectiveness for funding disaster management, pre-disaster mitigation, and long-term resilience and adaptation, ability to leverage state and federal assistance.
Social	Proportion of socially vulnerable population, equitable food, education, energy and health care systems, locally protective regulations, **cultural strength and connection, and local and cultural historical preservation**.	Plans/systems to quickly restore lifeline services (food, health care, water, energy, sanitation, communications, etc.), schools and institutions, **community engagement and participation potential in planning and recovery efforts.**	Availability of housing, basic and long-term needs options for impacted citizens.**Communications modes and mean: social networking, social media, public engagement. Relationships between public and private sectors which directly influence cooperative resilience.**	Capacity and creativity to address victim's needs, government, social service and religion emergency response organisms, culture of community cohesiveness and cooperation.

NOTE: Adapted from Keating et al. (2017), Atreya & Kunreuther (2018), Campbell et al. (2019). **Bolded** indicators added by the authors.

Valuing Capital Stocks

Communities may never know their full resilience potential without first mapping their critical systems or addressing the conditions of their Capital Stocks and Resilience Properties. Without this introspection, planners, decision makers, and citizens will miss the weaknesses and threats that affect the known and unknown aspects of their community. This study in community resilience shows that it is very much like a comprehensive physical; it will reveal the general health of a patient and the potential acute and chronic risks that can be addressed with more rigorous and qualitative testing. Much like the human body, a community is a concentration of complex systems that rely upon one another to remain healthy. That is why the study of community resilience must undertake a multi-system, holistic approach to assess threats, categorize vulnerabilities, grade assets, and develop improvement strategies.

A strength of this framework is that it allows for critical Human and Social Capital Stocks to be fully evaluated. The framework level of detail can be adapted based on each community's budget, data, and community engagement, from preliminary screening to comprehensive resilience planning. We found that Human, Social and Political Capital Stocks often had limited standards or best practices that required more adaptive, qualitative measures to establish grades (see Table A2 in the appendix for an example). The adaptive grading rubrics in Table 3 required a significant level of information from surrounding communities, peer communities, state and federal data to create a reliable grading scale. Resources in the Physical Capital Stock could be completely populated with standard bearing assets and infrastructure that would easily be graded using the rubric from Table 3.

Identifying and grading Human, Social and Political sources of resilience is a unique challenge. Personal qualities, household emergency preparedness capacity, willingness to seek community help or help a neighbor, knowledge of farming, hunting, and gathering, and many

other skills and characteristics are difficult to understand. Often the less studied community

attributes lack data, like historical trends, decision logic, and how a community, neighborhood,

household, or individual acts when faced with a chronic stressor or acute impact. With less

attention by the government and planners, and possibly no community engagement, these

components can be easily overlooked and undervalued. As revealed during this framework

application, community engagement and intimate study highlights these lesser-known assets.

       The communities studied by the KUEC Environmental Assessment teams, while diverse,

shared common Physical Capital Stocks including: wastewater treatment, drinking water,

stormwater management, roads, waste management, energy production, and more. These vital

services are primarily managed by the government. However, ample infrastructure does not

necessarily translate into resilience. While these physical indicators dominate other planning

frameworks, the researchers sought out lesser-recognized facets of a community that make it

strong, resilient, and adaptable. Natural Capital is often overlooked as a source of resilience,

including: green infrastructure, floodplain condition, riparian quality, natural land cover quantity,

ecosystem connectivity, and the like. We found that these natural indicators play a vital role in

how a community is able to adapt to and withstand climate related change, influence how

Physical Capital is managed, and how Human Capital interacts with those Natural Capital

Stocks.

       Ultimately, we found that no one Capital Stock was more important than another. Rather,

each category, indicator, and asset should be given the same opportunity for study, reflection,

and community input. It was clear through this applied study that Capital Stocks are interwoven

and one does not exist in isolation nor above another. Thus, it is vital that each be fleshed out

as much as possible to best understand the known and lesser-studied pieces of a community

and fully complete the resilience puzzle.

Establishing Baseline Resilience

While communities are diverse in their inputs, populations, services and culture, there is a baseline of resilience needed to build a foundation. These baseline sources of resilience must meet the minimum needs of survival for the people within the community: water, food, shelter, safety, and a minimum level of prosperity. It may seem obvious that these are baseline levels of resilience, but it is worth restating that many seemingly resilient communities are deficient or unable to meet some of the needs of their people. Clean drinking water is still not assured in the United States (VanDerslice, 2011), neither are healthy and equitable food options (Heynen, et al., 2012). Economic prosperity is often inequitably distributed (Seccombe, 2004). It is important to conduct community-centered resilience planning efforts to identify deficiencies as well as encourage commitment to the process, provide future vision, and identify improvement potential.

By studying a community's assets, infrastructure, services and culture, planners can best assess if all the baseline needs are being met. These baseline needs should include:

- **Water** - reliable drinking water, effective wastewater management, redundant water sources and systems

- **Food** - equitable food options, allowance of urban and subsistence agriculture, multiple food sources.

- **Shelter** - reliable housing, vulnerable population shelter options, emergency shelters, affordable housing.

- **Safety** - law and code enforcement personnel, community leadership programs, emergency planning and operations personnel, vulnerable population supports.

- **Prosperity** - access to public schools, access to job training, access to diverse job options, access to public recreation.

This basic level of resilience provides a starting point for further resilience. Beyond these baselines more adaptive resilience can be strategized to meet a certain community's vulnerabilities, strengths and/or weaknesses.

Prioritizing Implementation Strategies and Forecasting Resilience

The authors recognized that establishing and cataloguing resilience strategies was simply not enough for communities to begin the process of building resilience. Communities must be able to prioritize strategies by relevance to their unique situation, threats and vulnerabilities, needs and opportunities, feasibility and practicality. In doing so they can create a strategic implementation plan and achieve the necessary community buy-in.

The KUEC Environmental Assessment teams prioritized resilience strategies through an interactive process, testing and combining several approaches. For example, strategies were sorted based on their applicability to the SWOT analysis. Table 8 shows how strategies would be applied to address a community's top three identified threats.

Another approach evaluated how the strategies could address and improve community vulnerabilities. Table 9 shows how strategies may be categorized by a community's top five natural and human-caused vulnerabilities identified in the Vulnerability Assessment.

Table 8

Strategies Categorized by Threats to Community

Threat	Strategy Description
Climate Change	- Develop a wildfire fighting and prevention program - Implement natural resource management plans - Develop prioritization system for infrastructure projects - Develop a flood-warning system - Establish community-owned water storage and delivery capacity

Threat	Strategy Description
Changes in Agricultural Production	- Implement an Integrated Pest Management Plan - Preserve prime agricultural lands for future use - Identify resilient livestock watering sources - Educate the community on the Agricultural Management Plan - Establish and enforce best rangeland practices for all herds
Contagious Disease Outbreak	- Improve food security across the community - Improve broadband internet services to community - Evaluate health centers for emergency response - Increase capacity of public emergency shelters - Develop a Disease Containment and Mitigation Plan

Table 9

Strategies Categorized by Community Vulnerabilities

Hazard Description	Strategies
Extreme Precipitation	- Upgrade roads to paved surfaces with safety additions - Upgrade bridges to surpass the 100-year floodplain - Develop a flood-warning system
Tornadoes	- Increase capacity of public emergency shelters - Retrofit existing buildings to be resistant to hazards - Enhance emergency communication systems
Human Disease Epidemic	- Develop a Continuity of Operations Plan - Develop an Emergency Evacuation Plan - Develop a Disease Containment and Mitigation Plan

Hazard Description	Strategies
Economic Recession/ Depression	● Increase employment in emergency response and planning ● Develop an action plan for future workforce opportunities ● Develop a Continuity of Operations Plan

Other strategy categorization options include: relative cost, implementation timeline, return on investment, lowest graded Resilience Properties, least redundant Capital Stocks, least robust Capital Stocks, or whatever fits the community's needs, culture, politics, and willpower. It should also be noted that community strategies deemed the proverbial lowest-hanging fruit should also be used in strategy categorization. To achieve the best strategic categorical method, it is necessary to fully understand the community's politics, culture, and history.

Standardized solutions can not adequately answer unique needs within the diverse array of communities which exist currently; therefore, it is unwise to enter into community resilience planning with preconceived solutions in mind. For example, the Tribal community's rural reservation lands have roads that flood and make it nearly impossible to traverse bridges and low-lying areas during or after any moderate to heavy rain event. The standard (engineering focused) recommendation to rebuild bridges and elevate roads above the floodplain to remove flood prone spots was met with opposition by the community because the rural character and other funding needs such as elder supports, healthcare, and education were of greater importance to community members. Other strategies were discussed and met with excitement, including developing a flood-warning system, improving emergency communication to homes, and establishing an emergency transportation and evacuation plan. These strategies address citizen safety during extreme rain events while honoring community values related to land use

and development. Thus, a wealth of custom resilience strategy options and their ranking order

of implementation prioritization should be developed in partnership with community members to

allow for maximum adaptation potential

      According to the NAS, no prior resilience plans or frameworks had attempted to forecast

improvements (National Academies of Science, Engineering and Medicine, 2019). This work

marks the first such application of a resilience framework. Borrowing a concept commonly used

for predicting ecosystem restoration benefits (CDM Smith, 2016), the scoring methods

described in Table 3 were used to regrade the Capital Stocks, Resilience Properties, and overall

community resilience assuming the recommended strategies were implemented. Table 10

illustrates a number of strategies for each Capital Stock, the initial grade, and the potential

grade based on the implementation of all proposed strategies, showing the projected resilience

improvement. While the researchers' projections reflected fully implemented strategies, the

technique may be used to evaluate various combinations of strategies to rank and prioritize

them as is commonly done to evaluate ecosystem projects; and if paired with implementation

costs, may be used to identify "best buy" plans for given levels of investment or expenditure

based on the most cost-effective combinations of strategies (CDM Smith, 2016).

Table 10

Example of Forecasting Potential Resilience Improvements by Capital Stocks

Capital Stocks	Number of Strategies	Current Grade	Potential Grade
Financial Capital	5	B- (2.00)	B (2.50)
Human Capital	6	C+ (1.89)	B+ (2.78)
Natural Capital	8	C+ (1.82)	B+ (2.82)
Physical Capital	17	C (1.67)	B (2.58)

Capital Stocks	Number of Strategies	Current Grade	Potential Grade
Political Capital	12	C+ (1.70)	B+ (2.70)
Social Capital	4	B (2.36)	B+ (2.73)
OVERALL	**52**	C+ (1.91)	B+ (2.67)

Section III - Communicating Resilience and Engaging Communities

As was theorized at the outset and affirmed through this work, all communities contain some elements of resilience. And whether known, unknown, inherent, or learned, diverse communities provide diverse levels of resilience. These converging and diverging sources of resilience in each community come from adaptations that each has made in response to chronic stressors and/or acute impacts. Regardless of their circumstance, location, or history, members of the community must be the driving force behind building resilience. Without their support and action, there can be no adaptation and no community-wide resilience; therefore, stakeholder and community involvement in resilience and disaster preparedness planning is critical to the success of the community. The resilience assessments also revealed performance gaps in each community's resilience and highlighted the importance of community engagement throughout the entire process. Not only will those who live and work within the community be able to provide intimate details about the community itself, planners will also learn what is most important to community members, what will garner their support and ensure success, and reveal the opportunities and strengths that already exist.

Engagement is arguably the most difficult element in building community resilience. The human factor is the defining characteristic driving resilience ability and sustainability; therefore, effective engagement determines individual and group motivation to act in ways that

build resilience. Engagement must be relevant, timely, consistent, and tied to measurable

results to successfully cultivate a resilience mindset culture within individuals and groups of any

size. For example, a worldwide alliance known as The Global Covenant of Mayors, illustrates a

unified engagement strategy across communities on a macro scale (see:

https://www.globalcovenantofmayors.org/). Within the 10,539 member cities, nearly 100 Million

people are regularly engaged in growing the culture of climate stewardship on the path toward

ever-increasing resilience. Many of the manifestations of this mass engagement effort are subtle

and woven into the fabric of everyday societal activity while others are richly forthright, such as

the Metro KC Climate Action Summit (see: https://climateactionkc.com/summit).

Considerations and Recommendations for Future Engagement

The KUEC Environmental Assessment teams learned that how engagement occurs

determines how much progress toward increased resilience is made in a given time period.

Planners should enter situations believing that people and communities are doing the best they

can with what they have; and they are ready and willing in most cases to learn more about key

aspects of their resilience and listen to strategies for improvement. Effective solutions take form

by first understanding the unique needs of the community and culture which drives their

decisions, actions, and investments; therefore, we must engage as active listeners while asking

relevant questions that help understand their story. Planners may be the first to bring new

information into the conversation and must be prepared to share it with an attitude of mutual

respect and non-judgement, engendering trust and avoiding information overload, so that

participants feel valued and encouraged to participate.

Next, planners should compile an index of planning documents and relevant data-rich

reports, generally used in communities, as a vital time-saving checklist to quickly search for,

identify and digest existing community information. Resilience plans, like many community

plans, require multidisciplinary teams of members with varying backgrounds. An index helps orient planners to potentially available information and can be presented in a way which makes the information, and its relevance to resilience in a particular case study, more easily understood. Furthermore, a community's resilience grade is heavily influenced by the existence, quality and application of such documents and an index may be utilized to illustrate both the condition of a community's competence and its areas of opportunity for improvement.

And finally, application of a standardized measurement methodology to a resilience assessment process, such as the CRAFT framework, helps generate compelling and relevant information to share throughout engagement in an organized fashion. The simple and customizable measurement application illustrated in Table 3 above empowers planners to more confidently move through the resilience study. More importantly, it builds a more cohesive, unified process as applied anywhere in the world, streamlining engagement from the very beginning, and will be translatable throughout all layers of engagement right down to the individual community member. It is this vital component of standardized, yet customizable, measurement that brings us full circle to ensuring engagement is relevant, timely, consistent, and tied to measurable results. Drawing on proven methods of success during engagement cultivates a resilience mindset culture within individuals and groups of all sizes.

As with measurement, standardized resilience assessment processes empower understanding by all manner of stakeholders, are transferable across communities, are defensible; and when tailored to each community as described in this and the previous section, produce relevant and actionable plans. While specific engagement recommendations are provided here, a good overall engagement process is needed and is beyond the scope of this study. The Climate Ready Communities Toolkit from the Geos Institute is one such model with the potential to further streamline and add value to engagement efforts (Geos Institute, 2018).

Section IV - Conclusions and Recommendations for Building Community Resilience

Entering into the effort, the KUEC Environmental Assessment teams recognized the importance of physical infrastructure, emergency response systems, and (due to their own environmental science and planning backgrounds) "green infrastructure" that provides critical ecosystem services to human and natural communities. This is understandable as community emergency preparedness and multi-hazard plans focus mostly on physical infrastructure condition and access, first responder and health care networks, and emergency aid and recovery services. Vulnerability assessments often focus on natural systems such as floodplains, the risks and infrastructure accumulated in the floodplain and behind levees, and their ability to safely convey storm flows and protect human lives and property. Green infrastructure research and design often focuses on avoiding, minimizing, and mitigating natural hazards and revitalizing natural systems for practical purposes. Related academic literature, emergency preparedness, and resilience frameworks also tend to focus on "critical infrastructure and systems" and vulnerabilities, important and easily identifiable factors during and in the immediate aftermath of an acute stressor such as a natural disaster or major industrial accident. Other benefits (like habitat value) may be noted as beneficial but are not incorporated in any comprehensive or systematic fashion.

While these Capital Stocks described above are indeed important, considering them in isolation or as limited systems (such as emergency response systems, or natural areas) reveals only a narrow slice of what makes a community broadly resilient over the long term. The KUEC Environmental Assessment teams' research, community resilience case studies, subject matter expert opinions, and applied community planning work revealed several overarching themes, patterns, and critical lessons, some of which surprised the participants.

Systems Approaches are Critical

Capital Stocks and systems are interconnected and vulnerable to cascade effects (Barth, 2019; R. Myslivy, personal communication, November 4, 2019). Resilience planning therefore requires a more systematic and explicit systems approach, which means changing our approach to problem solving. Systems are interconnected, and mapping out systems helps reveal interlinkages and identify gaps. It is intuitive that the system-of-systems is only as strong as its weakest link and it became clear that weak links or systems are more likely to trigger and amplify cascade events. For example, concentrated infrastructure assets pose a significant risk: a tornado could easily take out the rural community's law enforcement center, fire station, and power plant at the same time due to their two-block proximity to each other. (Byers et al., 2019).

Conversely, investments in resilient systems can prevent cascades during emergencies and generate positive feedback that improves a community's long-term resilience and prosperity. For example, Ponca City, Oklahoma's fiber optic broadband is designed to withstand a tornado or other significant disaster, guaranteeing emergency response communications. In normal times the system provides free citywide wifi and businesses and residents can purchase dedicated connections (Schweinberg, 2019). Collectively this investment supports social networks and community interactions, provides resources for K-12 and adult education, and facilitates information-based commerce; improving the city's Human, Social and Financial Capital Stocks.

Human and Social Capital are Undervalued

Human and Social Capital are incredibly important and also undervalued. Infrastructure and systems are not autonomous: people respond to acute and chronic stressors through physical, economic, political, and social systems supported by human, financial and natural resources. Educated and skilled professionals are needed, highlighting the importance of local

and regional school districts and higher education. Community institutions such as charities, churches, neighborhood and business associations, school PTOs, and civic clubs provide critical, informal community aid and communications networks. These two-way information conduits help identify community needs and pass on requests for assistance to authorities and may consciously or unconsciously fill gaps in the more formal or official systems.

These networks improve community resourcefulness through their capacity to self-organize, improvise, and adapt to extreme situations much more quickly. Ultimately, the Robustness of these entities derives from the community's culture. Collectively these undervalued Capital Stocks provide several Resilience Properties, adding Redundancy and improving community responsiveness; and the ability to adapt and improvise under stress may indicate greater resourcefulness than is initially recognized. The Resilience Properties of Human and Social Capital Stocks and interrelated systems are largely determined by numerous decisions over many years and decades, which both shape and derive from community culture.

Greater Equity Builds Resilience

Vulnerable community members must have their basic needs met before they can plan for and respond to additional acute and chronic threats, extraordinary events and situations. At the same time, experience shows that more vulnerable citizens often suffer more severe impacts during crises and require disproportionate assistance - for example, residents without personal vehicles or with limited physical mobility may require rescue during extreme weather or are unable to relocate to safer areas or access available resources (C. Gerst, 2019). Limited access to information (including preparedness, emergency notifications, and recovery resources), and poor education systems and lower education rates may impact decision making that improves personal and household resilience. In the suburban planning community,

emergency planners estimate that only a small percentage of residents have created a disaster plan or stockpiled supplies, much less emergency funds (Barrett et al., 2019).

Regional, National and Global Systems Support Resilience

Local communities exist within and rely upon broader regional, state, and national systems, and interconnected systems-of-systems (including ecosystems). Each community forms a unique node within its various networks of systems, even within the same state, which provides access to different resources. The assessed suburban community benefits from numerous county resources including consolidated fire, water, sewer, and stormwater management; mutual-aid agreements, regional emergency response and communications systems and an extensive healthcare infrastructure (Barrett et al., 2019). The county is economically prosperous with a well-funded government, recognized for quality governance, public services, education systems, and overall infrastructure (Department of Health and Environment, 2016). We found here that a strong performing county provides significant Financial and Political Capital, increasing Redundancy, Robustness, and Rapidity of local Capital Stocks (Kansas Division of Emergency Management, 2013).

Similar yet contrasting considerations were identified within the Tribal community. As a sovereign nation, the community's relationship to the state government differs from incorporated municipalities, potentially limiting access to some resources or requiring different processes to access them. However, the Tribal Nation can readily access federal government resources not available to municipalities such as resilience planning funding and technical assistance from the Bureau of Indian Affairs, and technical and financial resources from the Indian Health Service (Fannin-Hughes, 2020).

Financial Resilience is Broader than Most Realize

The importance of financial resilience is well established, yet the aspects of it were not entirely clear nor intuitive. For communities, Financial Capital includes the strength of its tax base and available revenues that fund the operation, maintenance and improvement of Capital Stocks like critical infrastructure, health care systems, public safety, and response programs. Critical community financial resources include tax revenues, a lack of debt, the ability to leverage debt, and the availability of adequate emergency reserves. Less obvious Financial Capital sources encompass economic diversity, so that a community is not overly dependent on a single employer or industry that may be vulnerable to shocks (lacking financial Redundancy), and is tied to the success of economic development programs and entrepreneurial culture.

Access to credit and available bonding capacity are important short- and long-term community financial resources. External financial resources include state or Federal emergency aid, infrastructure and health care funding, and economic development assistance programs. Individual or household financial resilience indicators included stable employment, wages and other non-income wealth, the availability of emergency reserve funds, access to credit (which in part depends on assets and collateral) and emergency assistance programs. Finally, unique communities were found to have unique financial resilience. For example, the studied tribal community has a significant financial source of resilience from their casino which funds most government services and provides per capita payments to tribal members. As with most resilience sources, vulnerabilities were present that could disrupt the flow of financial capital from the casino operation, including economic downturns, agricultural market fluctuations, communicable disease, terrorism, or actions by federal and/or state entities against sovereign rights. These unique findings could only be found with a holistic, systems-based approach to community resilience planning.

Political Capital is Poorly Understood but Vital

The quality and Resilience Properties of many other Capital Stocks are influenced by a community's Political Capital, which led Atreya & Kunreuther (2018) to add this sixth "C" to their resilience framework. Political Capital was nonetheless the least intuitive and most difficult Capital Stock to define and evaluate. Previously identified metrics included political will, government proficiency in funding resilient infrastructure and systems, and preparedness and response programs. Governments impact resilience through their relationships with surrounding communities and higher levels of government which influence access to emergency and non-emergency resources and funding. Based on case studies and the community planning work, the KUEC Environmental Assessment teams expanded the indicators and metrics to include the quality of government operations during planning, design, development, and day-to-day operations of infrastructure systems and programs. The overall political will and skill of a community, and the willingness of citizens and political parties to fund government, heavily influence their ability to fund resilience across their portfolio of physical, natural, human, social, and economic assets (Capital Stocks).

Political skill and willpower also drive the ability to invest wisely and effectively manage those investments at the capital and operational stages. Communities with effective political systems and relationships that are ideologically stable over long time periods are more likely to be proactive, make creative investments, develop public-private partnerships, anticipate and avoid or mitigate risks, and adapt effectively to acute and chronic stresses and changing conditions. In short, Political Capital derives from political culture and effective governance.

Quantifying the Value of Natural Resources is Crucial

The KUEC Environmental Assessment teams identified a need to more thoroughly and systematically assess a community's Natural Capital, using metrics that consider a wide variety

of resources and multiple benefits. Doing so in a systematic manner provides significant

indication of the resources' value, even without quantitative ecosystem services measures.

Metrics initially provided for the 6C/4R Framework considered "watershed health" and the

availability of floodplains and stormwater management facilities such as lakes to safely manage

flood flows, and the sustainability of natural resource management (Keating et al., 2017; Atreya

& Kunreuther, 2018; Campbell et al., 2019; and Zurich Flood Resilience Alliance, 2019).

For the regional community assessments, the authors significantly expanded the Natural

Capital indicators to consider the quantity, quality, and connectivity (or fragmentation) of other

natural areas and landscapes such as wetlands, forests, and prairies; and to include biodiversity

and ecosystem health. Human-made green infrastructure (such as constructed wetlands and

prairie restorations) was added. Large, diverse, and connected habitats will function better and

in a more self-sustaining manner, providing ecosystem services like carbon sequestration and

airborne pollutant removal, urban cooling, better absorption and retention of rainfall to maintain

aquifer levels and attenuate stream flows. Biodiversity is both a benefit and an indicator of

healthy habitat systems, which provide numerous ecosystem services and benefit human health

(Sandifer et al., 2015). Additional indicators included drinking water supplies, cropland and

rangeland that support urban and regional food and water systems. Table 7 in Section II lists the

indicators, including those added for the current study shown in bold.

Summary and Recommendations

While the applied research revealed gaps in community resilience assessments and

planning, the researchers made several important observations, most important of which were:

- Communities are more resilient than they realize.

- Non-government organizations and individuals are key contributors to the value

  of Human and Social Capital.

- Communities must invest in people, education, and training to build resilience.

- Resilience assessments and plans must be tailored to the unique community

  characteristics and diversity.

- Resilience planning must engage the entire community.

Communities may be more resilient and have greater sources of resilience than they

realize, in part due to the compartmentalization of municipal departments and planning efforts

that assess and plan for their own areas of responsibility but do not share information nor

leverage opportunities for cooperation. Other less recognized resilience sources are found in

Human and Social Capital. Critical infrastructure and formal emergency response and recovery

systems are typically assessed while the importance of non-government organizations that

create networks of mutual aid and care (charities, associations, social media groups, and

private institutions) are overlooked. Collectively, these undervalued Capital Stocks fulfill formal

and informal functions that provide Redundancy and contribute to Robustness. Less structured

and less bureaucratic private organizations are able to self-organize, adapt, and improvise

under stress, which may provide greater resourcefulness than initially recognized. The

Resilience Properties and interrelated systems within Human and Social Capital Stocks are

largely formed through numerous decisions over many years and even across generations.

Communities should build and invest in these networks as important influencers of community

cohesion and culture.

Recognizing the significant value that is often overlooked within Human Capital,

individual resilience (regardless of group affiliation) is a major contributor to community

resilience. The knowledge, skills, creativity, and adaptability of people acting in official capacities

and as private citizens, and the financial stability and resources of individuals and households

are the cornerstones of communities. Public investments in staffing, training and professional

development help ensure that adequate personnel are available to meet community needs, whether for day-to-day operations or during emergencies. Adequate staffing levels improve the Robustness and Rapidity of public systems and infrastructure and highly trained staff are better able to operate critical infrastructure and systems with greater Resourcefulness. In addition, high quality public education produces citizens that are more aware and knowledgeable of how their community operates, and about services and resources that may prepare them to better assess, deal with, and recover from acute impacts and chronic stressors. In turn, more self-sufficient and resourceful citizens place less of a burden on community resources, particularly during emergencies, stretching those resources and providing Redundancy.

As stated previously, every community is unique and must be treated as such. Communities' characteristics and Capital Stocks derive from their unique physical resources and capital, physiographic setting, natural resources, and natural and human-made threats and vulnerabilities. Because human and social systems are so critical, community culture and political culture are also critical resilience determinants. For these reasons as described previously, resilience assessments and plans must also be unique and tailored to the community. It is important to provide general assessment frameworks that assess a number of standard and universally accepted indicators across the range of Capital Stocks and Resilience Properties, which will help ensure consistency and quality of plans and a degree of comparability with peer communities. However, where needed, indicators should be tailored or added to address specialized or unique conditions (an obvious example is natural resource assessments). Scoring criteria can be tailored to increase relevance to a particular community, respect each community's unique characteristics, reveal meaningful measures of actual or potential resilience, and identify areas where significant improvements can be achieved.

Finally, plans and implementation programs will only succeed to the extent that citizens, government and nongovernment staff, and elected officials buy into and are willing to allocate resources to capitalize on strengths and address vulnerabilities. As discussed in the two previous sections, planning must include significant and robust community engagement with cutting-edge strategies to gain citizen and stakeholder interest and affect behavioral change. This is particularly important because complex issues and solutions, often involving systems mapping and "wicked problems," require values-based tradeoffs and compromises (R. Vogel-Leutung, personal communication, December 4, 2019). Politicization and polarization are also significant challenges that require effective engagement and management throughout the unending process of building resilience in a state of constant change (Miller, 2015). Finally, communities will differ in what they value and in their goals and objectives for the future. To be successful, community engagement approaches and processes must recognize and be tailored to the community's characteristics, must be capable of helping stakeholders address complex issues and challenges, and must incorporate the latest knowledge about behavioral change and human development. Community resilience begins only when a diverse coalition of community members can work together to improve their resilience systems, protect their critical assets, and ensure future generations have the knowledge and tools necessary to thrive. The CRAFT framework can provide that necessary planning process to empower communities to understand their vulnerabilities while formulating a holistic measure of their community's resilience in the face of acute impacts and chronic stressors, both natural and human-made.

References

Atreya, A. & Kunreuther, H. (2018). Assessing community resilience: mapping the community

      rating system (CRS) against the 6C-4R frameworks. *Environmental Hazards*.

      https://doi.org/10.1080/17477891.2018.1549970.

Barth, B. (2019, August/September). The falling dominos of climate change. *Planning - the*

      magazine of the American Planning Association.

      https://www.planning.org/planning/2019/aug/fallingdominoesclimatechange/

Barrett, M., Clements, J., Knaebel, D., & Wilder, A. (2019, December 16). Roeland Park

      preliminary resilience plan [Course Project]. University of Kansas Edwards Campus.

Byers, H, Hipsher, B., Moberly, J., & Snay, A. (2019, December). Preliminary resilience plan for

      Ottawa, Kansas [Course Project]. University of Kansas Edwards Campus.

Campbell, K. A., Laurien, F., Czajkowski, J., Keating, A., Hochrainer-Stigler, S., & Montgomery,

      M. (2019). First insights from the Flood Resilience Measurement Tool: A large-scale

      community flood resilience analysis. *International Journal of Disaster Risk Reduction*,

      Vol. 40. https://doi.org/10.1016/j.ijdrr.2019.101257

CDM Smith. (2016). *IWR Planning Suite II – Technical Documentation*. Prepared for the US

      Army Corps of Engineers Institute for Water Resources.

Community & Regional Resilience Institute. (2011). *Community resilience system initiative*

      (CRSI) steering committee final report: A roadmap to increased community resilience.

      https://s31207.pcdn.co/wp-content/uploads/2019/08/CRSI-Final-Report.pdf

Department of Health and Environment. (2016). *Community health assessment and community*

      profile, Johnson County, Kansas 2016. Johnson County, Kansas.

      https://www.jocogov.org/sites/default/files/documents/DHE/PBH/JOCO%20Community%

      20Health%20Assessment%20and%20Profile.pdf

Fannin-Hughes, I., Hall, A. & Schweinberg, A. (2019, December). *Preliminary community*

　　　　resilience plan: Prepared for the Prairie Band Potawatomi Nation [Course Project].

　　　　University of Kansas Edwards Campus.

Fannin-Hughes, I. (2020, May). *Community resilience plan: Prepared for the Prairie Band*

　　　　Potawatomi Nation [Capstone Project]. University of Kansas Edwards Campus.

Geos Institute. (2018). *Climate ready communities: A practical guide to building climate*

　　　　resilience. www.climatereadycommunities.org

Gerst, C. (2019, July 19). Personal communication with Scott A. Schulte regarding Johnson

　　　　County, Kansas emergency response planning.

Heynen, N., Kurtz, H. E., & Trauger, A. (2012, May 9). *Food justice, hunger and the city.*

　　　　Geography Compass. Blackwell Publishing.

　　　　[https://nikheynen.files.wordpress.com/2014/09/fhc_compass.pdf#:~:text=Food%20acces](https://nikheynen.files.wordpress.com/2014/09/fhc_compass.pdf#:~:text=Food%20access%20is%20the%20ability%20to%20produce%20and,equal%20access%202%20Food%2C%20Hunger%20and%20the%20City)

　　　　[s%20is%20the%20ability%20to%20produce%20and,equal%20access%202%20Food%](https://nikheynen.files.wordpress.com/2014/09/fhc_compass.pdf#:~:text=Food%20access%20is%20the%20ability%20to%20produce%20and,equal%20access%202%20Food%2C%20Hunger%20and%20the%20City)

　　　　[2C%20Hunger%20and%20the%20City](https://nikheynen.files.wordpress.com/2014/09/fhc_compass.pdf#:~:text=Food%20access%20is%20the%20ability%20to%20produce%20and,equal%20access%202%20Food%2C%20Hunger%20and%20the%20City)

Kansas Division of Emergency Management. 2013. *Region L Hazard Mitigation Plan - 2013 -*

　　　　2018.

　　　　[https://www.wycokck.org/WycoKCK/media/Emergency-Management/Documents/2013-2](https://www.wycokck.org/WycoKCK/media/Emergency-Management/Documents/2013-2018-Region-L-Multi-Jurisdictional-Hazard-Mitigation-Plan.pdf)

　　　　[018-Region-L-Multi-Jurisdictional-Hazard-Mitigation-Plan.pdf](https://www.wycokck.org/WycoKCK/media/Emergency-Management/Documents/2013-2018-Region-L-Multi-Jurisdictional-Hazard-Mitigation-Plan.pdf)

Keating, A., Campbell, K., Szoenyi, M., McQuistan, C., Nash, D, & Burer, M. (2017).

　　　　Development and testing of a community flood resilience measurement tool. *Natural*

　　　　Hazards Earth Systems Science, 17, 77–101.

　　　　www.nat-hazards-earth-syst-sci.net/17/77/2017/doi:10.5194/nhess-17-77-2017

Li, H., Apostolakis, G. E., Gifun J., VanSchalkwyk, Leite, S. & Barber, D. (2009). Ranking the

Risks from Multiple Hazards in a Small Community. Risk Analysis, Vol. 29, No. 3. DOI:

10.1111/j.1539-6924.2008.01164.x

Miller, B. (2015). Sustainability for whom? Sustainability how? *The Politics of the Urban*

Sustainability Concept. David Wilson (Ed.), Common Ground Publishing.

https://doi.org/10.18848/978-1-61229-800-9/CGP

Myslivy, R. (2019, November 4). Healthy + Resilient Kansas: Mapping the Connections

[Lecture]. University of Kansas Edwards Campus.

National Academies of Sciences, Engineering, and Medicine. (2019). *Building and Measuring*

Community Resilience: Actions for Communities and the Gulf Research Program.

Washington, DC: The National Academies Press. https://doi.org/10.17226/25383.

Patel, S. S., Rogers, M. B., Amlôt, R., & Rubin G. J. (2017). What do we mean by 'community

resilience'? A systematic literature review of how it is defined in the literature. *PLOS*

Currents Disasters. Feb 1. Edition 1.

10.1371/currents.dis.db775aff25efc5ac4f0660ad9c9f7db2

Pfefferbaum, R. L., Pfefferbaum, B., Van Horn, R. L., Klomp, R. W., Norris, F. H. & Reissman, D.

B. (2013). *The Communities Advancing Resilience Toolkit (CART): An Intervention to*

Build Community Resilience to Disasters. Published in *J Public Health Management*

Practice,19(3), 250–258. Wolters Kluwer Health | Lippincott Williams & Wilkins.

https://doi.org/10.1097/PHH.0b013e318268aed8

Resilient Cities Network. (2019). What is urban resilience?

https://resilientcitiesnetwork.org/urban-resilience/

Sandifer, P. A., Sutton-Grier, A. E. & Ward, B. P. (2015). Exploring connections among nature,

biodiversity, ecosystem services, and human health and well-being: Opportunities to

enhance health and biodiversity conservation. *Ecosystem Services*, Volume 12, 2015,

   Pages 1-15, ISSN 2212-0416, https://doi.org/10.1016/j.ecoser.2014.12.007

Seccombe, K. (2004). "*Breathing the odds*" versus "*changing the odds*": Poverty, resilience, and

   family policy. Journal of Marriage and Family, 64(2), 384-394.

Schweinberg, A. (2019, October 6), Ponca City resilience [case study]. University of Kansas

   Edwards Campus.

Summers, J.K., Harwell, L. C., Buck, K. D., Smith, L. M., Vivian, D. N., Bousquin, J. J., Harvey,

   J. E., Hafner, S. F. & McLaughlin, M.D. (2017, October). *Development of a climate

   resilience screening index (CRSI): An assessment of resilience to acute meteorological

   events and selected natural hazards* (Report No. EPA600/R-17/238). US Environmental

   Protection Agency.

   https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NHEERL&dirEntryId=337914

VanDerslice, J. (2011). Drinking water infrastructure and environmental disparities: Evidence

   and methodological considerations*. American Journal of Public Health*. 101, S109-S114.

   https://doi.org/10.2105/AJPH.2011.300189

Vogel-Leutung, R. (2019, December 2). Frames for Understanding and Engaging People in

   Complex Issues [Lecture]. University of Kansas Edwards Campus.

Zurich Flood Resilience Alliance. 2019. *The Flood Resilience Measurement for Communities

   (FRMC)*. www.floodresilience.net

Appendix

Table A1

Example of Resilience Screening Results by CRAFT Framework

	Financial Capital Source (B-)		Human Capital Source (C+)		Natural Capital Source (C+)		Physical Capital Source (C)		Political Capital Source (C+)		Social Capital Source (B)	
R1* **(C+)**	Income & Per Capita payments	B	Overall Health & Access to Care	A	Natural Resource Management	C	Wastewater Treatment	C	Potawatomi Nation Collaboration	A	Healthy and Equitable Food Sources	C
	Agricultural Production	C	Tribal Mitigation Plan	B	Surface Water Quality	C	Drinking Water Supply	B	Tribal Government and Sovereignty	B	Vulnerable Populations	C
	Lack of Gov. Debt	A	Culture, TEK^ and Language	A	Agricultural Resource Mgmt. Plan	B	Surface Waters and Floodplains	B	Coop. with External Governments	B	Shab-eh-nay and Traditional Lands	B
	Taxes & Revenue	C					Government Buildings and Casino	B			Health Care system	A
	Diverse Housing & Affordability	B					Roads and Transportation	C			Tribal Sovereignty and Regulations	A
	Tribal Gov. Budgets	B					Current Housing	B				
	Healthcare Affordability	A										
	Casino, Resort and Prairie Band LLC	B										
R2* **(C+)**	Emergency Funds	B	Disaster Communication	C	Floodplains and Floodways	B	Infrastructure Recovery Time	C	Public, Health and Community Services	A	Peacemaker circle	A
			Emergency Responders	B	Riparian Forested Land	B	Emergency Shelters	C	Pub. Safety and Infrast. Services	C	Disaster Planning and Participation	B
					Natural Resource Recovery/Resilience	B						
R3* **(C+)**	Sources of Income	C	Mutual Aid Agreement	C	Natural Land Cover Types	B	Health Centers	A	Other Tribal Assist. and Supports	B	Housing Programs & Availability	A
	Sheb-eh-nay Gaming Potential	B	Schools and Education	B	Water Supply Sources	C	Energy Distribution	B	Federal Mitigation & Recovery Supports	B	Comm. & Health Services Avail.	A
							Emergency Food	C	State Mitigation & Recovery Supports	C		
									Local Mitigation & Recovery Supports	D		
R4* **(B-)**	Burial Fund	A	Food Distribution Program	C	Natural Land Cover Extent	B	Restoration Supp. and Equip.	B	Disaster Planning and Mitigation	C	Potawatomi Nation Connection	A
	Donations & External Aid	B	Resource and Recovery Potential	B	Watershed Health and Connectivity	B					Donations and External Supports	B
	Community Dev. Investments	B			Hunting and Fishing	A						

*R1 - Resourcefulness; R2 - Robustness; R3 - Rapidity; R4 - Redundancy,

^TEK = Traditional Ecological Knowledge

NOTE: Sources of resilience have been shortened or paraphrased to save space.

NOTE: From Fannin-Hughes 2019

Table A2

Example of Adaptive Grading Rubric for Sources of Resilience

Capital Stock / Resilience Property	Source of Resilience	Grade	Rubric
Social / Robustness	Tribal Sovereignty	A	A = Tribal sovereignty is robust and fairly unchallenged B = Tribal sovereignty is robust but challenged by local entities C = Tribal sovereignty is robust, but challenged by local and state entities D = Tribal sovereignty is limited or challenged by federal entities
Natural / Rapidity	Riparian Forested Land	B	A = Riparian forest exists along 100% of surface waters and extends to a traditional width across floodplains. B = Riparian forest exists along 80-100% of surface waters and extends to a limited width due to land use in floodplains. C = Riparian forest exists in no greater than 80% of surface waters and is disconnected due to land use in floodplains. D = Riparian forest exists in less than 50% of surface waters and is severely disconnected and limited in width due to land uses in the floodplains
Human / Resourcefulness	Food Distribution Program	C	A = Food distribution program that supports vulnerable populations and the entire Reservation's needs during a disaster and recovery B = Food distribution program that supports vulnerable populations and could support some of the Reservation's needs during a disaster and recovery C = Food distribution program that does not fully support vulnerable populations and fulfills limited Reservation needs during a disaster and recovery D = Food distribution program that does not fully support vulnerable populations and cannot fulfill Reservation needs during a disaster and recovery
Political / Resourcefulness	Climate Action	D	A = Climate Action Plan created and accepted by the Tribal Council. Resilience screening completed for Reservation. Actionable goals created to ensure climate resilience B = Climate Action Plan created, and aspects of a resilience screening completed. C = No Climate Action Plan, but other efforts made to increase capacity for climate action. Resilience screening in process of completion D = No Climate Action Plan and no efforts made to address climate change. No resilience screening attempted

*Adapted from Fannin-Hughes (2020)