

Community Resilience: demonstrating the socioeconomic value of Earth Science data
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Introduction

Resilience is the ability of a system to absorb shocks or disturbances, and to re-establish critical functions within some threshold period. Resilience is a concept that is gaining prominence across both the natural and social sciences, resilience is increasingly used to help frame and guide decision making from the local to the global scale (Wilson, 2012).

Place-based community resilience has emerged as a U.S. national priority with the expectation that it can improve human livelihoods, address environmental change, and prepare communities and households to cope with hazards, risks, and disasters (Cutter et al. 2013; NSTC 2014; PCAST 2011). It is well-recognized that increased application of Earth Science data for urban and place-based community decision-making can help inform and enhance social and infrastructural resilience to environmental events and climate change. However, there are still obstacles that prevent the effective translation of Earth Science data to support such local-level decision-making. Most notably, the highly complex nature of Earth Science data makes it difficult to use without the assistance of experts, the coarseness of Earth Science data makes it challenging to apply on the local level, and the focus of Earth Science data on collecting baseline information or monitoring problems can make it challenging to identify solutions.

In an effort to identify ways that Earth Science data, and the Earth Science Information Partners (ESIP) community could contribute to enhancing place-based community resilience, we held a session entitled, “Community Resilience: Demonstrating the socioeconomic value of Earth Science data” on Jan 9th, 2018 at the ESIP winter meeting in Bethesda, MD. We focused on the case of small- to medium-sized US towns that have city planning staff. A total of 13 ESIP meeting participants attended the session (not including the co-organizers), and their affiliations ranged from federal agency (eg., NASA, EPA, BOEM), private industry, interagency entities (e.g., USGCRP, STPI), NGOs, and academia.

The session built on previous work conducted at ESIP on community resilience (summer 2015) and integration of multidisciplinary, socio-environmental datasets (winter 2017), and current work conducted by the co-organizers on city resilience planning and community

development, climate resilience decision-making (from within the Data to Decisions for Climate Resilience ESIP cluster), and capacity-building for stakeholders of city resilience.

For the first portion of the session, the co-organizers briefly presented on both the data challenges that have been identified in specific U.S. towns that address community resilience issues in their city planning (e.g., Boulder, CO and Westminster, CO) and the architecture, engineering and construction companies that tactically work on the digital infrastructure aspects of city planning. Then, the co-organizers introduced some examples of how these challenges can be addressed (e.g., reproducible, traceable, data-driven analytical approaches for integrating societal values and biogeophysical models; emerging technologies for monitoring the environment; indicator datasets; development of templates). The co-organizers offered thoughts on how society could realize the value of, as well as the cost of not having, earth science data, data services, and planning in place to support community resilience.

The remaining half of the session consisted of facilitated discussions with two break out groups. The discussions were focused around the questions: 1) What are potential linkages between data-driven community resilience and other ESIP work, as well as with the overall Earth Science data community? 2) What are specific ways that ESIP can contribute specifically to place-based community resilience?

Findings

_____Through the session, we identified a number of ways that the ESIP community could contribute to developing and identifying data solutions for community resilience, which we summarized along three main pathways.

1. Help communities access the right tools and information for place-based community resilience.

This could be done in a number of ways including:

A. Identifying the right data products by understanding what the community needs and wants

Place-based communities (including such entities as residents, planners, disaster relief organizations) are often not interested in data. Instead, they seek information which they can use to make decisions. Typically, they want very simple data or information products, while having less interest in the science behind the data.

Such behavior suggests that data practitioners working in the resilience field must first gain an understanding of the entire end-to-end process of resilience planning before developing data products. To do this, data practitioners can study examples of communities that have implemented resilience activities

based on credible resilience frameworks (see Section 3). In addition, data practitioners must document the end-to-end process, keeping in mind to preserve all products (including not just scientific products, but meeting minutes, decisions, applicable policies that drive decisions, etc.), so that the focal community can re-visit the decision provenance of the underlying data and information that drove their decisions. Such actions can help to build trust in the process, allowing stakeholders' concerns to then evolve to matters like the credibility behind the data, and the science behind the data.

It is notable that a "community" is often made up of smaller sub-groups (e.g., based on different culture, language, values), so this social diversity must be taken into consideration when assessing the needs of the community in order to develop the specific products to translate data and information appropriately. How relationships are built within these community networks (e.g., how the sub-groups interact) must also be considered. To elicit information about resilience, it is important that champions of different stakeholder groups be identified and engaged early in the decision-making process.

In regards to place-based community resilience, we must understand their environmental and social concerns. The US EPA "Triple Values Framework" for sustainability has been used to analyze the environmental, social, and economic needs for focal communities (e.g. [Narragansett Bay, RI](#)). The US EPA and the European Environment Agency both also adopt the [DPSIR framework](#) to describe the interactions between society and the environment. Such frameworks helps one assess the scope of socio-ecological data that are required to inform a resilience solution. A systems approach is also the basis for resilience. First, a strong community foundation is needed. Then city governance is layered in, and finally partnerships with different entities (such as data practitioners).

The following are some examples of how data products have been tailored to meet the needs of the community: NASA has developed different levels of data products to try to enhance how people can use data; NSIDC's [Arctic Sea Ice News and Analysis](#) website and associated [Sea Ice Index](#) data product specifically target the general public; [an NCAR study](#) on what information people needed to decide when they must leave their house under threat of storm surge resulted in pictures of the water line in relation to their house; and images of what offshore wind turbines would really look like in the ocean help communities, such as in [Ocean City, MD](#), to decide how to proceed with offshore wind farms.

B. Developing a community of practice

To develop data solutions for place-based community resilience, it is necessary to foster a community of practice that can engage on this topic. This community should be a blend of both data scientists and resilience practitioners, who have expertise in such areas as algorithms & templates, community building,

networking, etc. Overall, addressing resilience challenges require both inter- and transdisciplinary approaches.

Community cohesion (in the community of practice) is a major factor in being able to find data solutions for community resilience - successful data collection, curation, use, data, algorithms and frameworks is not enough to make decisions about place-based community resilience. Considerable communication, visioning, and visualization is needed to understand “What are the options”, “What does resilience look like?”, “What are the trade-offs?” and “How are decisions made?”.

C. Developing communication mechanisms for community resilience end users

The right communication mechanisms between data scientists and resilience practitioners are needed to develop successful data/information flows that result in products that communities can use to make decisions. First, it is important to well-define and align goals among the different stakeholders (e.g., adaptation, resilience, mitigation).

A translator or intermediary between the different stakeholders in the information pathway can help to streamline this communication, such as by helping communities find or know what they should ask for in regards to planning for resilience.

One way for data scientists to connect to resilience practitioners is to contact Resilience or Sustainability Officers, which many towns often have today. There are also many conferences around this topic (e.g., World Urban Forum). Resilience is being implemented both through grassroots movement (BoCoStrong in Boulder, CO) and top-down programs (e.g., Rockefeller 100 Cities), so there are different ways for data scientists to connect to resilience efforts.

D. Supporting Capacity Building and Education

The community can be empowered to use data and information for decision-making through capacity building and education initiatives. There are different age groups and career moments when people can be reached. For example, specific individuals on city planning teams, like information specialists, can be offered training on earth science data and use. People’s formative years (e.g., junior high/high school; ESIP Educators / Coding for Kids) is another key time to offer educational programs to help them understand how data is really useful. In addition, there are current knowledge workers who are retraining for career transitions.

To move this topic forward within ESIP: we could connect with **ESIP’s partner**

- **the CLEAN Network & Education**, which works with citizen science, connections and phenologies, and climate education. In addition, **ESIP's Data Stewardship cluster** works with education & training, data archives, management training.

2. Document use cases of place-based community resilience to help enable the development of useful data products and tools.

Use cases and scenario building can be helpful for identifying what communities really need by exploring such questions as, “How do you analyze your vulnerability?” “What are tools that would be useful for you?” and “What do you need to restore your community?”. ESIP could provide use cases of some success stories to help motivate communities to work with groups like ESIP by demonstrating to communities what their return on investment might be by working with ESIP. Another purpose of collecting use cases is to contribute towards develop an informatics oriented framework for data useful for resilience planning. ESIP is a founding partner of the Partnership for Resilience and Preparedness (PREP) which is jointly coordinated by the USGCRP and the World Resources Institute. PREP aims to “to facilitate the process for planners, investors, resource managers, and others to routinely incorporate climate risks into their decisions, by enhancing access to relevant data and facilitating collective learning“. PREP was launched February 7, 2018.

Capturing case studies, and the subsequent encoding and editing of the case studies into a format amenable for the US Climate Resilience Toolkit, has been successfully undertaken for at least one agriculture-based resilience challenge. This recent (2017) undertaking was conducted out of the ESIP Agriculture and Climate cluster, which is working with LuAnn Dahlman (NOAA).

To move this topic forward within ESIP: we can leverage **ESIP Agriculture and Climate cluster's** work with the Climate Resilience Toolkit, **Disaster Life Cycle cluster's** interest in collecting case studies (e.g., for hurricane response), and the **D2D cluster's** potential interest in working with a new case study.

3. Develop and share conceptual and technology tools for enabling transdisciplinary collaboration and community resilience.

There is a large community of practitioners that may be described as “resilience practitioners”. Such practitioners span the gamut of academia and government officials tasked with fulfilling national preparedness goals, county

and city planners who are required to make communities climate-ready, community-based organizations and NGOs that seek to push forward grassroots resilience efforts, and scientific and informatics professionals that push forward the theory and development of the field itself. Many of these professionals work and specialize in different fields, and the challenge is how to bring these diverse people together in way that meets the transdisciplinary needs of community resilience. This challenge is not limited to individuals: ESIP, as an organization, would also benefit from implementing collaborative processes that could effectively leverage the capabilities that already exist, particularly among the community of practicing resilience practitioners.

There is palpable recognition that large-scale environmental challenges unfolding across the tightly-weaved matrix of human-natural systems requires transdisciplinary approaches. Relevant to our work here, transdisciplinarity can be defined as *“integration that extends beyond disciplinary perspectives to incorporate knowledge outside of academia”* (Pennington et al 2013), such as by including the involvement of city planners and natural resource managers in co-development of scientific knowledge. Transdisciplinary teams, such as those including domain scientists, data scientists, and resilience practitioners, *“work jointly to grasp the complexity of problems from diverse scientific and societal perspectives, integrate natural and social science disciplines, alter discipline-specific approaches, and focus on problem solving for what is perceived to be the common good”* (Yates et al 2015). Below, we propose three tools that may be useful for fostering transdisciplinary collaborations. These tools also help answer questions like: What are the pathways for achieving resilience? How do you assemble a team to address resilience challenges, and what are their respective roles? How do you make resilience strategies that are hosted on a community repository (distributed or otherwise) discoverable and re-usable by other communities?

A. Use an existing resilience framework developed by resilience practitioners that includes a role for ESIP constituents

Many resilience frameworks have been formulated and promulgated by academic, government, and consultant working groups that work extensively with communities. Such frameworks are useful for adopting a common vocabulary to share best practices that can subsequently be adopted by others. They are used by community resilience practitioners to assess the potential shocks and stresses that face a community, the scope of social and infrastructural assets available to a community, and the potential for the community to recover from and adapt to disturbances. This information is used to determine ways that resilience may be enhanced in the community.

The authors have examined the literature for community resilience, and we present two conceptual and assessment frameworks by Tango 2013 (Figure 1

& 2) that can serve as communication pieces to connect ESIP resilience efforts with communities seeking to enhance their resilience through the improved use of data and information. Figure 1 demonstrates a "process flow", which the ESIP community might use to determine where their individual roles might be (e.g. "shocks and stressors" data). Figure 2 expounds further on some of the elements in Figure 1, such as by listing some of the data products that are useful to characterize shocks and stressors that the ESIP community might contribute to (e.g., SEDAC @ Columbia produces global-coarse scale socio-economic data products). Figure 2 demonstrates the importance of a collaboration between external experts (e.g., data practitioners and scientists) and local decision-makers to achieve resilience goals, as some areas of the framework would be better addressed by one stakeholder versus the other.

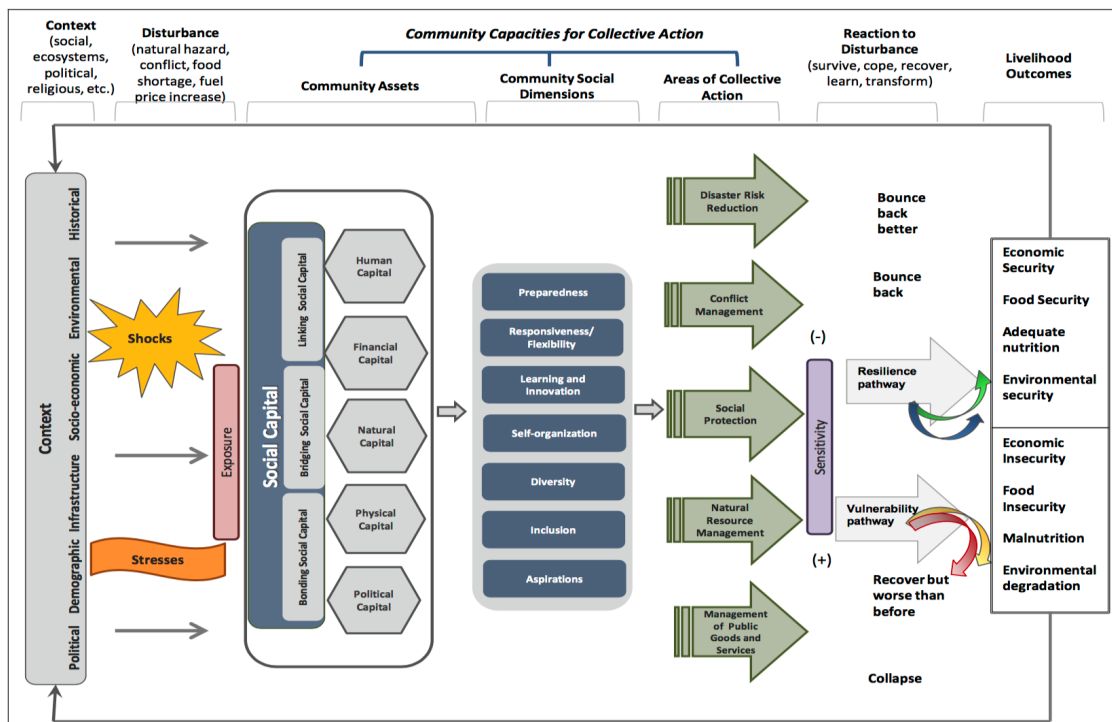


Figure 1. Conceptual framework for community resilience (Tango 2013).

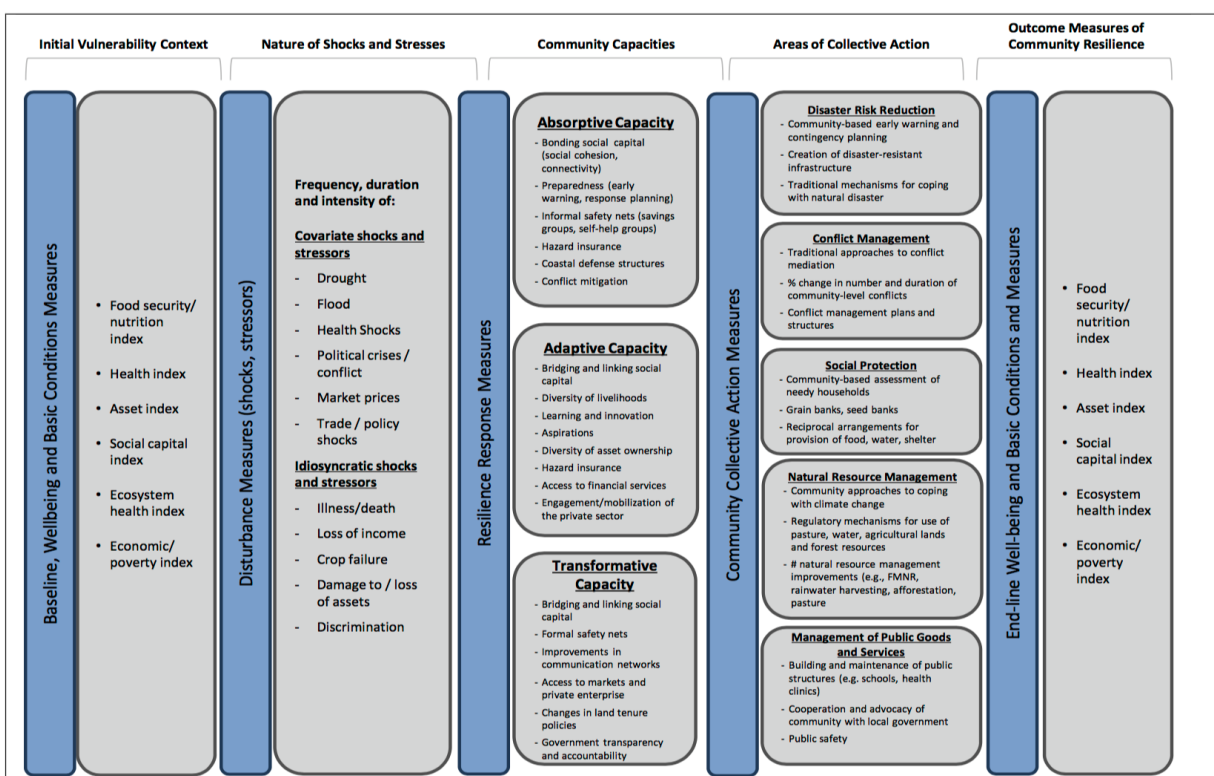


Figure 2. Assessment framework for community resilience (Tango 2013).

B. Use existing sets of indicators that have been developed for different sectors and scales of governance

Different sets of indicators of resilience are being used by agencies and international organizations, and these indicators are often developed to address different social and governance scales (e.g., individual, household, city, region). For example, EPA indicators are often on a national scale (e.g., Average air quality), while town and cities often develop and use their own local-level indicators. While local-level indicators can often offer the most relevant type of information that communities are looking for, there is also a risk that they may only address things that they *know* about. There is an opportunity to make communities aware of other indicators that they could or should be considering.

As an example from the EPA of how developing a set of indicators might work, in a series of [workshops that were held in 2014](#), a big spreadsheet of 50 communities was made to keep track of the indicators and ways the communities used to plan resilience. With this process, they sought to “pattern” resilience in order to share what other communities are doing to inspire other communities to

act.

The ESIP community can help educate practitioners in regards to how different types of information can be linked together more efficiently. For example, provenance metadata can be used to document how high-level indicators can be computed using "lower-level" observation data, and algorithms can be developed to facilitate the computation of that data.

C. Understand and communicate the role of semantic resources in identifying and defining concepts of resilience.

Semantic technology can help disambiguate different concepts that may be expressed in identical terms but encapsulate different meanings to different communities.

An adequately curated ontology that has been developed with the input of stakeholders and thoroughly reviewed enables search engines to discover related data products that may be useful for a given context. Adequately documented data products (that are described with machine-parsable metadata) contributes to both the machine-mediated discovery of those products (through ontologies), as well as the human understanding of how those products were used for a specific context, and how they may be re-used for a different context. Ontologies also facilitate the serendipitous discovery of data that may be unexpectedly useful for a given problem. Likewise, provenance of the data product contributes to the human understanding of the context of those data products. The ability to better discover and understand data products ultimately informs a decision-maker as to who might have the data, tools (e.g. models, frameworks, community sanctioned indicators), and information (e.g. publications, assessments) that may be applicable for a focal climate resilience challenge.

Different communities have their own specific needs and ways. Adopting existing ontologies but creating specialized ontologies that are conceptually more constrained to the local context helps to connect those local community needs to other climate resilience challenges that manifest at possibly larger geographical (and potentially temporal) scales. This synergy is enabled if communities demonstrate a tendency to utilize an existing framework for resilience planning (Section 1A). In doing so, the terms and concepts embedded in digital artifacts and stored in community resilience repository as use cases (such as the US Climate Resilience Toolkit (Section 2)) can be related to other resilience use cases that utilize identical, or similar, terms and concepts.

To move this topic forward within ESIP: we can connect with the **Semantic cluster of ESIP**

Conclusion

We propose that supporting the Earth Science data needs for place-based community resilience and sustainability may be an appropriate space for ESIP to direct attention, and thereby further emphasizing the socioeconomic impact of these data. We have identified specific areas that the ESIP community could contribute to the field of community resilience. In particular, ESIP clusters and committees, such as: Agriculture & Climate, Disaster Life Cycle, Data Stewardship, Semantic Technologies Committee, Education committee, and D2D, may be appropriate partners to further this work.

Concrete examples of how to move forward include:

- Create a framework to connect with city end users; ESRI has local government meetup that could help make these connections.
- Form an ESIP Cluster to enable next steps such as partnering with other clusters to host a data-specific community resilience session, documenting community resilience use cases by obtaining input from agencies or other stakeholders as to how data is being used (e.g. ESIP “Ideas scale” account getting input from agencies on how data is used - “27 unique ideas captured” etc).
- Create a blog post or 1-page white paper that could link to an extended paper that we can circulate either in person or post on Slack for other clusters to see or contact them directly. Use this to solicit feedback on what the ESIP community wants to do with this information and how they may want to collaborate..
- Capture the process of our workflow (from raw data to information synthesis) on open source site to potentially serve as a template or launching pad for broader place-based community resilience and data community collaborations.

After May 1st, 2018, this working paper will be archived on Figshare. Any individuals who add comments and contributions to this paper will be acknowledged.

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