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Thesis Summary
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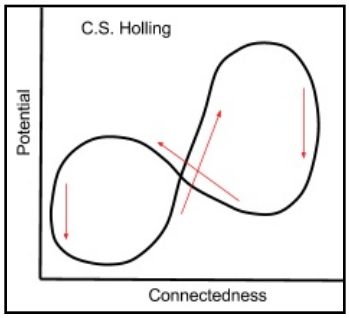
Fukushima Daiichi: Japan's Resilience to Nuclear Plant Meltdown

Background

At the most basic level, resilience refers to a system's capacity to undergo change while still maintaining function, including the ability to reorganize and learn moving forward (Benson and Craig 2014). This concept has grown to be applicable in multiple contexts, and the definition itself adapts with changing conditions. Beyond the branch of the most general definition of resilience, each specific set of conditions within psychological, ecological, and social resilience, to name just a few, fall under some category of change and recovery in one way or another (Kulig et. al. 2013). The theory can be applied specific events and scales as well, such as through disaster, or across individual and community levels.

While the growth of the resilience concept is demonstrated through the evolution of each definition, it is still a fairly new theory and has room for more critique. One such critique is the abstract nature of the concept, often used without "a direction or goal…without reference to its subjects" (Bahadur and Tanner 2014), and used as "a rhetorical device with little influence on actual decision making" (Benson and Craig 2014). Judith Kulig and others have made similar references, more specifically acknowledging the difficulties in recognizing the connecting interactions on an individual and community level (2013).

Interactions between different systems, such as the social and ecological (Kulig et. al. 2013), and within the same system, such as the consequences of vulnerability in social systems (Wisner et. al. 2011) both complicate how an event like a disaster is to be reckoned with. As such, different models have been used to help understand how disasters better. In the context of 'rapid onset events' in particular, the primary time for "change or modification in behaviors or practice" is before and after the event itself (Cutter et al. 2008). C. S. Holling's development of the 'panarchy' theory, and the Protective Action Decision Model (PADM) (Lindell and Perry 2012) are two models through which to interrogate resilience in potential and action before and after disaster events. The panarchy could be considered an alternative to resilience that Holling uses to explain "complex adaptive systems" through what are noted as the stages of growth, accumulation, restructuring, and renewal (2001). The stages appear in a figure-eight shape, highlighting the connectivity of each stage.



A second notable model that specifically works with the implications of disasters in a system is PADM, which includes different stages of decision making such as the exposure to and absorption of different cues and messages, perceived threats, and situational impediments, to name a few (Lindell and Perry 2012). How well individuals and communities are able to follow the steps through the PADM model can help articulate the relationships between place-, people-, and system-specific vulnerabilities and resilience (Cutter et. al. 2008).

That being said, new types of disasters due to changing technology and development mean that our understanding of what a disaster entails must change as well. One such example is the potential for disasters at nuclear power plants (NPP) and other types of radiation disasters. So what makes a disaster at a nuclear power plant different from other disasters? The primary difference are the unique characteristics that radiation creates pre-, during-, and post-disaster.

Radiation is not visible, and not well understood by the public (Coleman et. al. 2013), making it both impossible for people to recognize environmental cues, and intrusive in psychological well-being (Lindell and Perry 2012). Though fear of radiation is highly intrusive, the differences between "short-term and long-term health effects" are often not well articulated

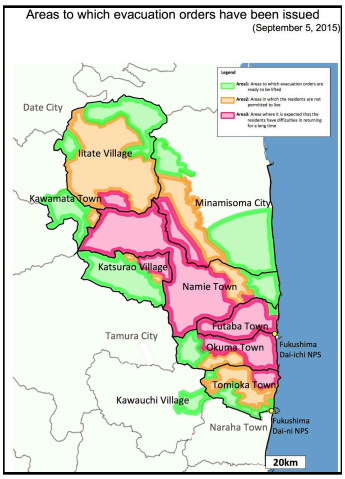
(Coleman et. al. 2013). In fact, Norman Coleman and others have acknowledged the unique role that radiation plays in actual and perceived health, fear and risk, “polarization of opinion regarding nuclear power” and the “sensationalism by the media” (2013).

Radiation-contaminated resources like milk, food and land (Yamashita and Takamura 2015) create a link between the capacity of an individual and the responsibility of governmental bodies. Capacity and vulnerability link disaster events and a system’s resilience, in which the capacity refers to the resources “that people possess to resist, cope with and recover from disaster shocks they experience” (Wisner et. al. 2011). While vulnerability refers to the “susceptibility to harm from exposure to stress” (Adger 2006), it is important to remember that vulnerable parts of a system are not without capacity, but rather operate with a different capacity limit (Wisner et. al. 2011).

Understanding the potential and limitations between individual and community resilience as it relates to NPP disasters in our modern age is the dilemma that has led me to *investigate the extent to which a country can be resilient to nuclear plant disasters.* All in all, resilience to disasters in the context of nuclear energy must be reframed and reimagined base on how they manifest in scales of time and space. Japan's experience with the Fukushima Daiichi Nuclear Plant meltdown presents a case study of how NPP disasters affect post-disaster evacuation, prolonged rehabilitation, heightened stress on mental and physical health, as well as the economic and political implications of the nuclear industry.

<u>Situated Context</u>

In March of 2011, Japan experienced a 9+ magnitude earthquake just off the northeast Tohoku coastline. The area is home to the Fukushima Nuclear Power Plant, which did well structurally during the earthquake. Though the plant was switched to backup generators, the subsequent tsunami breached the nearby seawall and knocked out the backup power (Wang et. al. 2013), without which kickstarted the meltdown of Fukushima Daiichi reactors 1, 2, and 3. Within the following months, the reactors were put into ‘cold shutdown’ for permanent decommission (WNA 2017a), but not before the meltdown caused a large swath of the nearby Fukushima prefecture to evacuate due to the release of radioactive material (Hayano and Adachi 2013) (Zhang et. al. 2014).



The accident spurred concerns, including the impacts on nearby residents and land, economy and energy, resources, public opinion, and more. In the days following the earthquake, between 100,000-150,000 people were evacuated from their homes (WNA 2017a) (Zhang et. al. 2014), with only ~2,000 people within the evacuation zone when the radiation levels were highest (Hayano and Adachi 2013). Since the disaster, some evacuation orders have been lifted, but evacuation maps demonstrate that much of the area was still uninhabitable as of 2015.

Following the shutdown of Fukushima, the rest of Japan’s 50 plant industry also shut down temporarily (WNA 2017b). Japan is considered a resource poor country (FEPC), so nuclear power has often been framed as a ‘quasi-domestic’ resource to increase energy security (WNA 2017b). Before the accident, nuclear energy accounted for 30% of energy production, which was lost as the industry shut down for safety inspections (Koyama 2013). As a result, the market switched back to liquid natural gas (LNG), which increased both the country’s greenhouse gas emissions and the total trade deficit (Koyama 2013).

Evacuees from Fukushima prefecture were arguably those most intimately affected but the accident, but the implications on public opinion of both nuclear energy and the Japanese government spread throughout the rest of the population. For years, pro-nuclear discourse stemming from soft-power sources like Godzilla and Astro-boy (Szasz and Takechi 2007) combined with articulations like the ‘safety-myth’, ‘green and clean’, and energy independence

(Kinefuchi 2015) had disseminated through all stages of Japanese life. Now, the public is left with anxiety and fear, and a strong sense of distrust.

These key sectors are important in considering whether Japan has been able to resiliently respond to the meltdown because they represent the intersecting systems and scales that are referred to by resilience theorists. In particular, by looking at the different aspects of the response, the extent to which each part relies on the other is more applicable. Kulig et. al. has recognized the "synergistic relationship" between the individual and the community that must be examined (2013). These system and scale interactions are the reason that the question of resilience must for now be studied under the 'extent' of resilience rather than just the presence of it.

Methods

Benson and Craig (2014), Kulig et. al. (2013), and Cutter et. al. (2008), to name a few, all reinforce the ambiguity of resilience definitions, particularly in the ways it can be measured. On top of that, the concept has been applied to many types of disasters (e.g. Cutter et. al. 2008), yet the introduction of new technologies into our world presents another layer of complexity to the equation. Because of this, I intend to use the experiences at Fukushima to better understand how resilience can be understood in the context of NPP disasters by studying the question, *to what extent has Japan demonstrated resilience to the Fukushima Nuclear Plant meltdown?*

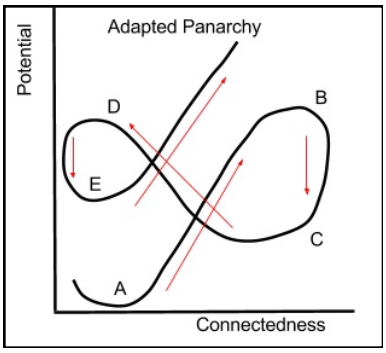
In order to unpack this question, I am using different case studies within the Fukushima context that have been put together over the past seven years, combined with extensive and anecdotal evidence, to justify an adapted panarchy theory to that of C.S. Holling (2001). I am using the realities of the post-Fukushima experience to propose a partial un-winding of the figure-eight model that Holling uses in his work.

Following the application of each piece of evidence into the adapted panarchy, I also graph each on a sliding scale of resilience (the middle of which represents potential for resilience), and scale (from individual to community).

Both of these approaches are not meant to decisively measure the resilience of any individual or community action (or inaction). Rather, they are to help conceptualize the changes to the resilience theory that countries using nuclear energy must make in order to adapt, if possible, to radiation disasters.

Results

C.S. Holling's panarchy theory primarily operates off of a model that is a cyclical figure-eight style progression. I would like to propose an alternative model that works within the unique characteristics of disasters that involve radiation, using the scope of nuclear power plant disasters. This adapted panarchy theory operates primarily with the goal of suggesting that, if resilience to such a disaster is possible, it must present itself in a different way; the time and and scope of damage is such that the stages of growth, accumulation, restructuring, and renewal (Holling 2001) cannot restart at the previous levels. Instead, they must unwind somewhat in order to look something like the figure to the right.



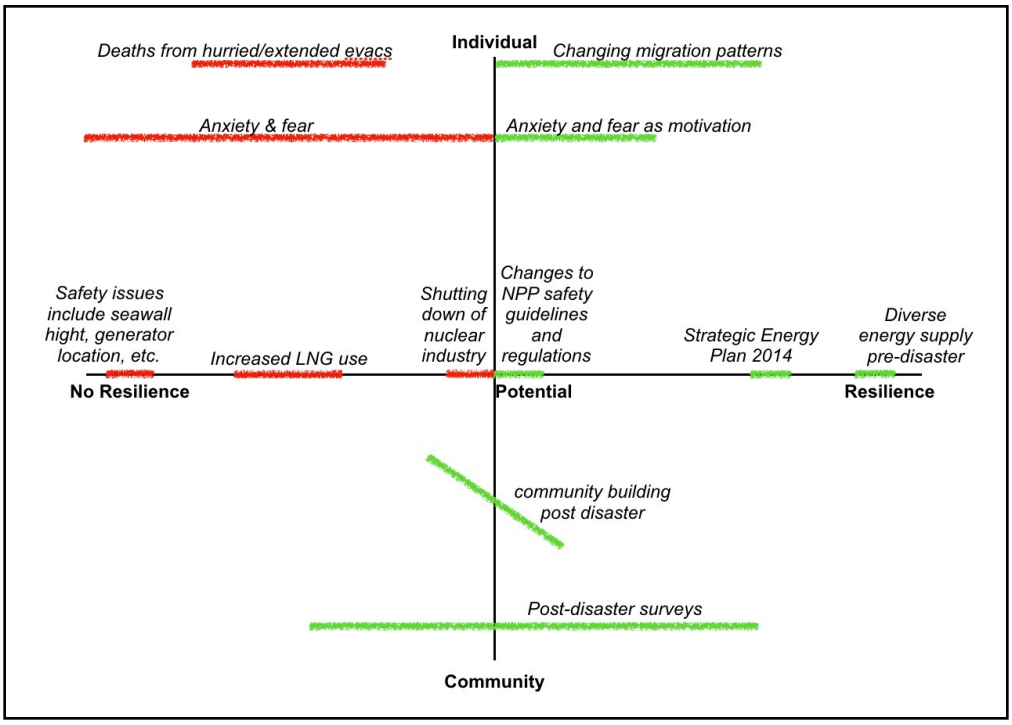
The most significant part about this adapted panarchy is that the adapted panarchy 'begins' at point A and 'ends' at point E. Like Holling's model, this one can also continue on in a cyclical way as new changes are introduced and reimagined at new levels of the model. While the axis of Holling's version are potential and connectedness, it is unclear as of yet if these should be the axis of this adapted model, which will likely be up for debate in the coming months.

In order to apply Fukushima to this adapted panarchy, I have distinguished five points at which to organize the cases, realities, and responses of individuals, communities, and the

government. The following chart displays some of the notable aspects of the disaster, though not all:

Point A	Diversified energy sources	beginning of nuclear power industry
Point B	Fukushima meltdown, poor safety planning at nuclear plant	up to 1000 deaths from evacuations
Point C	shutting down of all 50 nuclear plants for inspection, increased use of fossil fuels	anxiety and fear; prolonged temporary evacuation
Poing D	role of fear and memory in relocation decision-making caused different migration patterns	Japan's new Strategic Energy Plan
Point E	Fukushima plant + surrounding areas unusable don't retain original function, are now used as research	lost trust in government regarding compensation; loss of international trust in nuclear energy; continued relocation for certain communities; role of fear in rehabilitated communities

Graphing the chart is another necessary step to understanding Fukushima because it can help visualize how parts within each system, whether political, ecological, or otherwise, can still relate in ways that fit together. For the sake of this summary, the graph included is one way that the disaster does or does not express resilience on different scales. In a more complete picture of the results, another graph that would help conceptualize this information would represent the points over time and space.



The studies that have contributed to this snapshot of results (or are not seen here but will be in more detailed results in the coming months) include aspects of the Fukushima Health Management Survey (Yasamura et. al. 2012) (Nagai et. al. 2017) (Murakami et. la. 2017), GPS snapshot of evacutation (Hayano and Apache 2013), surveys regarding social capital in

Fukushima towns (Iwasaki et. al. 2017), and more. These sources and their application in the results are an important consideration for the extent of resilience because they note that it cannot be captured with a single set of data or a specific study of a town, but rather an all-encompassing understanding, highlighting that no one part is the most important for resilience.

Comparison and Generalization

The snapshot of the Fukushima disaster that I hoped to create in the previous section makes the point that in order to understand the whole picture, each individual part must be considered on its own, and then again in the larger context. This same principal can also go beyond the Fukushima meltdown and be applied to both the potential for similar disasters in other countries and for other types of disasters that have similar characteristics. Already, the implications of the meltdown have spread to other countries, including the phase-out of nuclear energy in countries like Germany and Switzerland (Wang et. al. 2013), and changes in risk perception of nuclear power plants in places like China, which rose from "limited risk" to "great risk" in surveys done pre- and post-Fukushima (Huang et. al. 2013).

In order for a country to be resilient to a nuclear plant disaster, they must recognize some of the individual characteristics that happened as a result of Fukushima, and begin restructuring themselves. While the resilience of most disasters is contained within the context of the disaster, the disseminating effects of Fukushima throughout the world tell us that the scales of resilience to NPP disasters must also be extended to wider-reaching scales.

Next steps and Further Research

As I delve deeper into contextualizing resilience in the Fukushima meltdown, it is important to note that this summary does not represent all of the necessary ties between theory and the event itself. In order to create a more robust understanding, more explicit connections should be made, and should be explained through the chart and graphs. In particular, next steps for this thesis would include using the Protective Action Decision-making Model (PADM) to study the possible impediments to resilience and should be implemented more thoroughly into the methodology.

The larger purpose of this study has been to understand the extent to which resilience can be attained. If this were to be continued beyond the scope of my research, the question of measurement would be a helpful direction for the resilience community to head in. Perhaps the most important direction, however would be to focus this study on the difference between NPP disasters that stem from natural disasters, and those that do not. While I think this topic would be vital to my research, but as it currently stands, the inclusion of this would create too wide of a scope for the direction of my methodology.

Resources

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