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Interconnected Risks, Cascading Disasters and Disaster Management Policy: A Gap Analysis

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Abstract – Today it is increasingly recognized that disasters are "cascading" in nature i.e. the impact within one network/area of a disaster may impact several related networks resulting in what is a "network of networks" disaster. For the near future, the world will need to consider an even more complex and interconnected next generation of disasters i.e. "global network" disasters resulting from the coupling of different kinds of systems. So far, governments, disaster management organizations, communities, business and civil society have made significant advances in improving preparedness, early warning, response, recovery programs and in the adoption and implementation of Disaster Risk Reduction (DRR) policies and programs. However, the decadal trends and the best available science all clearly indicate that geophysical, meteorological, biological, technological and human induced disasters are increasing in intensity (also many in frequency), complexity (interconnected, synergistic and cascading), uncertainty (future new events). Further, these multiplying risk factors are interacting with an ever more complex set of physical, social, economic and environmental vulnerabilities at rates that nations, societies and commerce are ill- prepared to deal with in terms of "gaps" in existing governance and institutional capacities. To narrow the gaps, the paper provide comparative analysis of the Tohoku and Katrina disasters highlighting specific issues that arose, their resulting impacts and the adequacy of the response/s in terms of existing governance, policy and institutional structures.

Keywords – *Interconnected Risks, Cascading Disatters, Disaster Management Policy*

1. Introduction

The 2003-2013 decade began with the 2003 European heat wave, which claimed the lives of over 40,000 individuals and ended with the 2013 Hurricane Haiyan (Yolanda) in the Philippines with the loss of over 6,300 lives (with more than 1,000 still missing). The intervening years saw Hurricane Katrina in the US and the Indian Ocean Tsunami in 2004; the Kashmir earthquake in 2005; Hurricane Nargis in Myanmar and the Sichuan earthquake in 2008; the H1N1 Global Pandemic in 2008-2010; the massive floods of Pakistan in 2010 and the tri-partite Tohoku disaster (earthquake, tsunami, nuclear) of Japan in 2011 (hereinafter Tohoku Disaster) and Super-Typhoon Haiyan (Yolanda) in the Philippines in 2013.

Occurring during this same period were a number of somewhat smaller, but similar disasters, including massive flooding in Australia, Europe and Asia, wildfires in Australia and the US; mudslides in Brazil and the Philippines; drought in China, the US and Africa; volcanic eruptions in Iceland (Eyjafjallajökull) and Indonesia (Mount Merapi) and a rapidly increasing number of technological and human induced disasters.

Disasters during the period 2000-2012 resulted in over 1.1 Million deaths, over 2.7 Billion affected people and resulted in US$1.3 Trillion in damages (UNISDR, 2013)[1]. This continued a 30 year (1980-2012) upward trend that has resulted in more than 2.5 million deaths and over US$3.5 trillion in economic losses globally. The World Bank (2012) reported that during this decade 2011 was the most costly year on record for natural disasters with estimated losses of US$380 billion.

To respond to and meet the challenges of the above "decade of disasters" governments, disaster management organizations, communities, business and civil society have made, and continue to make, significant advances in improving preparedness, early warning, response, recovery programs and in the adoption and implementation of Disaster Risk Reduction (DRR) policies and programs. However, the above decadal trends and the best available

[1] `http://www.preventionweb.net/files/31737_20130312disaster20002012copy.pdf` (accessed on January 2, 2014)

science all clearly indicate that geophysical, meteorological, biological, technological and human induced disasters are increasing in intensity (also many in frequency), complexity (interconnected, synergistic and cascading), uncertainty (future new events). Further, these multiplying risk factors are interacting with an ever more complex set of physical, social, economic and environmental vulnerabilities and at rates that nations, societies and commerce are ill- prepared to deal with in terms of "gaps" in existing governance and institutional capacities.

To a significant degree the "gaps" in existing governance, policies and procedures are attributable to an overarching weakness in disaster management and disaster risk reduction capacities e.g. the lack of integrated multisectoral risk assessments that provide a common actionable base of information and knowledge within and across selected impacted sectors. Equally important is the lack of a clear recognition of the spatial and temporal components of disasters across sectors. To address this deficiency there is a need to (a) better understand what constitutes the "new generation" of inter-linked disasters, (b) how such disasters are evolving, transforming and impacting societies in complex and uncertain ways and (c) what new modes of governance, disaster management and public-private cooperation will be required to address these gaps for the future. To address these issues this paper presents a background analysis of the changing structure of disasters, a policy based comparative analysis of (1) the 2011 tri-partite (earthquake, tsunami, nuclear) Tohoku disaster in Japan and (2) the 2005 Hurricane Katrina that struck the southern coastal area (New Orleans area) of the United States and the formulations of new paradigms of policy, governance and management of disaster impacts across individual and inter-linked sectors.

2. The Changing Structure of Disasters

The concept and understanding of what characterizes a disaster, is constantly changing. Historically disasters were characterized in terms of a "site" specific expected probability of occurrence and an assessment of the most likely individual impacts. This characterization was in large part responsible for the mantra that "all disasters are local". Subsequently it was recognized that disasters were far more "systemic" in nature i.e. they have a much greater impact over a much broader area through an interrelated complex of factors i.e. a "network" of events and impacts.

Today it is increasingly recognized that disasters are "cascading" in nature i.e. their impact within one network/area of a disaster may impact on several related networks resulting in what is a "network of networks" disaster. A special case of "network of network" disasters are the low probability but high economic and social impact "Black Swan" (Nassim Taleb, 2010)[2] events. An excellent example of the "network of network" concept of a Black Swan disaster, involving physical networks, would be the 2003 electrical grid failure in the eastern United States (caused by a software bug in the alarm system at an electrical company control room in Ohio) that ultimately directly impacted transportation, communication and commercial networks throughout the eastern US and southeast Canada and indirectly globally though the worlds interconnected stock markets.

For the near future, the world will need to consider an even more complex and interconnected next generation of disasters i.e. "global network" disasters resulting from the coupling of different kinds of systems – such as through the increasing interdependency of the world's food, water, energy, economic, communications and financial systems (Crutzen and Stoermer, 2000)[3].

3. Interconnected Risks and Cascading Disasters

First, the classification of disasters and associated risks has been dramatically changing. Historically the majority of disasters have been rather readily classified in terms of their underlying cause (i.e. natural, human induced and technological cause). However, this classification is rapidly proving to be highly problematic as a basis for policy formulation and effective disaster management. The principal reasons for this are (1) the rapidly changing "scalar" structure of disasters, in terms of rate, intensity, complexity, uncertainty, and (2) the "transformative" drivers (i.e. population, globalization, urbanization and climate change/variability) which exacerbate the complexity and impact of disasters. These factors require that future policy makers and disaster managers address disasters in the context of whether they are traditional, modern or synergistic disasters (Table 1).

- Traditional disasters are those that are (a) widespread globally, (b) recurring, (c) most numerous in type, (d) best understood in terms of impact and (e) have been/are the primary focus of most disaster management activities today.
- Modern disasters are increasingly complex and rapidly evolving forms of both traditional and new types of disasters for which the risks are inadequately known e.g. the risks and impacts of disasters associated with climate change and climate variability are incompletely understood at the global level, progressively less well understood at the regional and national levels, and least well understood at the local (urban) level.

Second, the challenges of interconnected risks and the resulting cascading disasters are dramatically changing in scope, severity and impact. These changes are driven by a combination of global risks (globalization, urbanization and climate vulnerability) and social and economic risks (aging, larger gap between the rich and the poor, disaggregation of infrastructure especially in urban areas, and gaps in education and medical accesses).

Third, increasing interconnected risks lead to larger and more complex disasters such as Katrina and of the tripartite (earthquake, tsunami, and nuclear disruptions) of

[2]Taleb, Nassim, 2007, THe Black Swan: The impact of the highly improbable, Random House Publishing, New York, 444p.

[3]`http://www.weforum.org/issues/global-risks` (accessed on January 2, 2014)

Table 1: Traditional, Modern and Synergistic Disasters

Traditional Disasters	
Geophysical and Meteorological: -Typhoons/Hurricanes -Flooding/storm surge -Earthquakes -Tsunamis -Landslides -Volcanoes -Heat/Cold Waves	**Biological**: -HIV/AIDS -Vector Borne Diseases (dengue, influenza, Malaria, -West Nile and Lassa Fevers) -Hepatitis -Cholera -Diphtheria
Human Induced: -Terrorism (Chemical, Biological, Nuclear and Radiological) -Fires	**Technological**: -Transportation -Toxic spills -Dam breaks
Modern Disasters	
Cimatic: -Climate Change -ENSO Effects -Climate Variability -Drought	**Biological**: -Avian Influenza/SARS -Ebola -Severe Acute Respiratory Syndrome -Mad Cow Disease
Human Induced: -Trans-boundary pollution (air/water) -Waste disposal -Terrorism	**Technological**: -Nuclear power plants -Cascading Infrastructure failures
Synergistic Disasters	
-Risk Overlap (Traditional + Modern risk) -Risk Compounding (Traditional + modern + interactions)	

Clark, A.L., 2010

the Tohoku Disaster, that seriously challenge the existing capabilities of traditional governance, policy and institutional structures for effective disaster management.

Fourth, the impacts of modern cascading and synergistic disasters are most often the result of unanticipated and/or unappreciated global to local risks and systems linkages that occur for a variety of reasons:.

- Inaction - The potential for cascading disasters are often identified early on in the planning and development stages of many projects such as the Fukushima Diaichi nuclear plant in Japan and the New Orleans levees of New Orleans that are the basis of the following comparative analysis. In both cases the existing infrastructures were allowed to run to failure before serious corrective action was taken.
- Resources - On the other hand, there is an evolving need to manage both more uncertainty and more complex disasters with often limited resources. Possible pathways to the challenge include adopting a more inclusive, balanced, and systematic approach with the more focus on linkages of sectors, institutions, process, people, and knowledge, which is relevant to operational aspects of "resilience".
- Uncertainty - The high level of uncertainty with respect to future risks requires a process for continual learning, improved decision making capacities and a high level of adaptability to changes.

The following comparative analysis of the Tohoku and Katrina disasters highlight specific issues that arose, their resulting impacts and the adequacy of the response/s in terms of existing governance, policy and institutional structures.

4. A Comparative Analysis of Tohoku and Katrina

The Tohoku and Katrina disasters were chosen for this comparative analysis for the following reasons:

1. First and foremost both disasters occurred in nations (Japan and the United States) that were widely regarded as "disaster resilient" with well-developed state-to-local governance, policy, institutions and organizations (state to local) for disaster management.
2. Both disasters have been extensively studied, albeit for differing time periods, in terms of (a) phases of preparedness, response, recovery and reconstruction and (b) in the context of governance (national-to-local), policy and disaster management organizations.

3. In both countries sufficient information was available to (a) evaluate the relative efficacy of the national disaster management system in terms of its overall response to the Katrina (US) and Tohoku (Japan) disasters and (b) to document the changes made in disaster management governance, policy, institutions.

The focus of the following discussion is on assessing the efficacy of existing national disaster management governance, policy and organizations to meet the short-to-long term impacts of interconnected risks and cascading disasters associated with a major disaster. The assessment focuses on issues of interconnected 1) public policies, 2) infrastructures, 3) economies, production and supply chains and 4), risks and uncertainties.

Following a brief background of each disaster, an assessment of the above issues is presented and a summary of the experiences and lessons learned is provided. Based on these analyses a gap analyses, based on how well existing governance, policy, institutions and existing practices and policies met the challenges of each disaster, will be articulated.

Tohoku Disaster

The Tohoku Disaster on March 11th 2011 articulated the interconnected interaction of risks through tripartite (earthquake, tsunami, and nuclear power plant disruptions) disaster, which caused not only human (approximately 16,000 death tolls and 3,300 missing) and physical but also social and economic impacts in short to long terms.

Central to understanding the efficacy of governance, policy and institutions during the Tohoku Disaster is recognition that during the Tohoku Disaster, major public or government buildings in more than 14 cities, towns, or villages were significantly damaged or destroyed (Sankei News, 2011). For example, in Minamisanriku-cho in Miyagi prefecture the city center was completely destroyed by the tsunami and about 40 of town's government staff were killed. In Otsuchi-cho in Iwate prefecture, the government building was swept away by the tsunami and approximately a quarter of the town's government, including the mayor, were killed. The disaster not only caused human and physical impacts at the time of the disaster, but continues to have ongoing social and economic impacts. These examples serve to reinforce the reality that complex, large-scale disasters cannot be addressed only through community capacities but require outside resources, including human, financial logistical, and administrative support — delivered in an effective and timely manner (Shimizu, 2012).

Hurricane Katrina

After first making landfall in Florida as a Category 1 hurricane on August 25, 2005, Hurricane Katrina crossed the Gulf of Mexico, grew in intensity, and made a second landfall near New Orleans, Louisiana as a strong Category 3 hurricane on August 29, 2005. During the Hurricane the New Orleans' levee system sustained several breaches, failed, and submerged much of the city under water, exacerbating what was already a major disaster.

Hurricane Katrina's damage was of catastrophic proportions along the Gulf Coast with major disaster declarations covering over 90,000 square miles of the area. Overall Hurricane Katrina caused 1,326 deaths (1,096 in Louisiana, 228 in Mississippi, and Alabama): more than 273,000 people were displaced and evacuated to shelters in total more than 700,000 people were displaced from the Gulf Coast region as a result of Hurricane Katrina. An estimated 300,000 homes were destroyed, or received major or minor damage in Mississippi alone, 780 homes and 413 mobile homes were reported destroyed; 6,482 homes and 808 mobile homes sustained major damage; and 42,444 homes and 18,243 mobile homes had minor damage as of September 17, 2005. The hardest hit communities lost all infrastructure: electricity; water and sewer; roads and bridges; communication systems including telephone lines, cell phone towers, radio capabilities, and many satellite antennae and, in some instances, basic governmental operations including law enforcement. As in Tohoku many local first responders were also victims.

The federal government, in particular the Federal Emergency Management Agency (FEMA), of the US Department of Homeland Security (DHS), received widespread, and justifiable, criticism for a slow and ineffective response to Hurricane Katrina. Although FEMA and other federal, state, and local entities had prestaged commodities and personnel in and around the region to respond to Hurricane Katrina, the magnitude of the storm and its catastrophic effects completely overwhelmed FEMA's disaster response system and resources, and those of state and local governments. A major contributor to the inadequate national government response was differences in disaster response and emergency management capabilities across states which resulted in varied levels of response success.

Issue 1: Interconnected Critical Infrastructures

Issue: In modern societies critical infrastructures are interconnected in complex ways. As a result a disruption in one critical infrastructure sector may lead to disruptions in other critical infrastructures, often interfering with the functions of disaster management. Therefore it is critical to both articulate the interdependencies of critical infrastructures before the Disaster and to develop a plan of action to minimize the risks of disruptions. Central to a successful plan of action is (a) the establishment and testing of coordination schemes for different stakeholders, in the public and private sectors and that (b) extend beyond the traditional boundaries of geographic regions and expertise.

Tohoku Case: Reviewing the Tohoku Disaster, three major relevant experiences can be seen:

1. Immediately after the disaster, because a major airport in Sendai city in Miyagi prefecture and other public transportations were severely damaged, the devas-

tated areas could be accessed only by ground transportation. In that situation, local municipal officers and volunteers in the private sector at different locations nationwide attempted to deliver food, water, and other critical commodities by trucks and cars. However, because of the shortage of gasoline at local gasoline stations, smooth delivery of goods was suspended, which led to food and water shortages in the devastated areas

2. Disruptions of power, phone, and internet connections caused by the earthquake and tsunami severely impacted critical communications between national and local governments, and between governments and first responders who were working at the affected nuclear power sites or medical sites in the devastated areas. The disruption of communications led to confusion in critical information dissemination and delays in appropriate response to urgent situations.
3. During the response phase, although stakeholders at different sectors such as communications and Information Technology worked very hard in recovering individual critical infrastructures, there were very few specific coordinated actions by the public sector to address those disruptions of critical infrastructures. This was partly because few mechanisms existed for coordinating stakeholders, an issue which should have been addressed before the disaster.

On the other hand, some good practices were seen in the coordination at the local and the private sector level. For example, commercial helicopter pilots across Japan recognized the delay in government-ordered deliveries of food, water, medicines, and supplies. Through the private Helicopter Conference of Japan (HCJ), pilots collected donations to cover fuel costs and used helicopters based in Miyagi to distribute supplies to shelters in the area. The pilots also identified other communities with severe water shortages, some of them having to boil and filter pool water for drinking. By June 2011, the HCJ had completed over 300 missions, delivering more than 40 tons of supplies.

Another example was that Tono City in Iwate Prefecture had paid specific attention to Tono's unique location an hour away from the Pacific Ocean coast and since 2007 had initiated and promoted the coordination of logistical support to prepare for earthquakes affecting nearby coastal cities in north-eastern Honshu. As a result, immediately after the Disaster, Tono City and an non-profit organization known as the Tono-Magokoro Network played a critical role in acting as a focal point to coordinate logistics for response and recovery efforts in devastated coastal regions nearby. The city collected and delivered more than 250 shipments of food and commodities from different cities to the region during the response phase.

Katrina Case: In virtually all cases the communities hardest hit by Hurricane Katrina lost all access to critical infrastructure (electricity; water and sewer, transportation, roads and bridges) communication systems (telephone lines, cell phone towers, radio and TV and satellite antennae) capabilities and in some instances to basic governmental operations (fire„ police, health services).

Although the Federal Emergency Management Service (FEMA) of the US Department of Homeland Security (DHS) and other federal, state, and local entities had pre-staged commodities and personnel in and around the region to respond to Hurricane Katrina, the magnitude of the storm and its catastrophic effects completely overwhelmed FEMA's disaster response system and resources, and those of state and local governments. The initial lack of access to basic infrastructure and public services, in the Katrina impacted area, stands as one of the most outstanding deficiencies of the US disaster response system.

The U.S. House of representatives report[4] "A failure of Initiative" specifically highlighted that during and immediately after Hurricane Katrina Massive in-operability had the largest effect on communication, limiting command and control, situational awareness and federal, state and local officials ability to address the impacts of Hurricane Katrina. More specifically, one of the most glaring deficiencies of the emergency management system, in the Katrina impacted area, was the inability of local (police, fire, civil defence and military response recovery units) to effectively communicate. As a result, once the levees breached and New Orleans flooded, a chain of events was set in motion that caused a rapidly deteriorating situation as a result of:

- The failure of multiple levels of government to take the initiative to adequately respond to the disaster
- Flood-waters severely impacted effective responses from the national to the local levels.
- General loss of communications between the Emergency Operations Center (EOC) throughout the region compromising situational awareness and command and control operations.
- Public safety organizations suffered from personnel absences.
- Overall, impacts at virtually all levels were compounded by a lack of preparedness for what was a predictable and planned for event.[5]

Gap: Although critical infrastructure emergency

[4]U.S. House of Representatives, 2006. A Failure of Initiative: Final Report of the Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina, U.S. Government Printing Office, Washington, D.C. 379P

[5]This was particular true in the case of Hurricane Katrina where one of the key planning and preparedness steps many of the local, state, and federal officials involved in the response to Katrina in Louisiana took part in was the July 2004 exercise commonly known as "Hurricane Pam." FEMA funded and participated in this disaster simulation exercise in which a fictional, strong category three — with qualities of a category four — hurricane named Pam hit the New Orleans area. Emergency officials from 50 parish, state, federal, and Volunteer organizations faced this scenario during the five-day exercise held at the Louisiana State Emergency Operations Center in Baton Rouge. The South-east Louisiana Catastrophic Hurricane Plan was the product of these series of workshops. The Plan was "designed to be the first step toward producing a comprehensive hurricane response plan, jointly approved and implemented by federal, state, and city officials." by January 2005,to give the South-east Louisiana emergency management planners time to prepare for the 2005 hurricane season.

plans or policies had been developed by governments, the above issues demonstrated that such existing plans are not necessarily practical and actionable. Because of critical infrastructure interdependency a disruption in the function of one critical infrastructure e.g. communications may bring about cascading effects on functions of other critical infrastructure components e.g. command and control centres. It is critical for governments to review these issues and to develop specific actionable mechanisms for coordination that can accommodate interconnected risks and cascading effects of disasters by ensuring continuous collaborating within and between government, local communities and the private sector. These key capacities include abilities to:

- Inform federal response and prioritization decisions
- provide rapid assessment of the impact of a disaster on critical infrastructure
- provide needed goods and services during and immediately following emergencies
- strengthen capacity to conduct large-scale logistical operations that can supplement, and where necessary, replace State and local logistical systems.
- assure an integrated leveraging of resources within both the public sector and the private sector
- establish a modern, flexible and transparent logistics system, based on established contracts for stockpiling/distributing commodities to the local level, in response to emergencies
- support disaster resilient infrastructure restoration in order to save lives and mitigate the impact of the disaster on the Nation

Issue 2: Economies, production and supply chains

Issue: The globalization of production, optimization of supply chains and an increasing reliance on lower tier suppliers have increased systemic efficiencies in the global economy but correspondingly these activities have also increased the rapidity, scope and vulnerability of industries in the event of shocks. The recent Tohoku, Katrina and other large-scale disasters have shown that local shocks often have a subsequent "knock on" impact of business disruption with effects rippling throughout the global economy.

The direct and "knock on" business disruption effects are primary the result of supply chain interruptions and general deficiencies, in some cases a complete absence (particularly within the Small to Medium Enterprises sector), of adequate business continuity planning (BCP) for disasters. An overarching issue in both supply chain and BCP failures is an incomplete understanding and assessment of the structure and vulnerabilities inherent in the dependency on thousands of SME's, in particular second and third tier suppliers that make up the core of corporate supply chains[6].

Equally important to ensuring business continuity is an understanding of the implications of the "new normal" for natural disasters which includes planning for "cascading" risks, such as the direct and immediate wide spread downstream impacts resulting from the loss of energy from the Fukushima Daiichi Nuclear facility in Tohoku Disaster or the national and international impact of the loss of petroleum refining and shipping in the case of Katrina. In both cases the "lessons learned" were that longer term associated "synergistic" risks and their impacts may lead to dramatic longer term impacts such as changes in policy or shifts in production operations.

Tohoku Case: In the case of the Tohoku disaster, Honda's CFO Funihiko Ike noted that "when we heard the names of some small suppliers that were in trouble, we didn't even know what kind of parts they produced "and when we tried to paint a car with a certain color, we didn't realize it was produced only at one company in the Fukushima area". Similarly, the maker of the Camry sedan took four months to restore production to pre-quake levels, partly because it couldn't track down which of the estimated 1,500 factories that make up its entire supply chain needed to be replaced or helped. Toyota estimates the delay cost the Toyota City-based company about 160 billion yen.

Katrina Case: In Katrina Case, the short to long term economic and supply chain consequences of Hurricane Katrina were locally to internationally profound. From a broad perspective the US$50 billion of physical damage and the overall disruption of the economy and livelihoods is unto itself a clear indication of impact. However, it does not truly capture the extent regionally, nationally and internationally of the supply chain "ripple effect". The extent and complexity of the supply chain disruptions are briefly summarized in the following.

According to (James S. Granelli, 2005)[7] The Gulf of Mexico produces about a quarter of the US's oil and natural gas, and is home to several major gasoline refineries. Further the New Orleans port area is a key entryway for bulk commodities, such as coffee and steel, an outlet for grain exports from the nation's heartland and a major hub in the Gulf Coast's rail and highway network. New Orleans had been looking to the newly opened $100-million Napoleon Avenue Container Terminal to compete with Houston and other ports. The Port of New Orleans connects with many different forms of transport, including all six major U.S. railroads and barges operating on the Mississippi River. In Gulfport, Miss., warehouses and much of the pier structure has been destroyed. Additionally, Gulfport is a major point of export for fruit, and Chiquita Brands International Inc, one of the world's largest banana producers, said it suspended shipments because of damage to its facilities at Gulfport. Nearby Alabama lumber products firms could be hurt especially hard and the company said it would divert those shipments to facilities in South Florida and Texas until the Mississippi facilities were repaired. Steel imported at New Orleans was diverted to Houston, Texas where inland transport could

[6]The supply chain for any major company normally consists of a number of Tier 1 (large and well known), Tier 2 (smaller and less-well known) and Tier 3 (normally very small and often highly specialized) companies

[7]`http://economistsview.typepad.com/economistsview/2005/08/the_economic_co.html`

cost four times as much.

Gap: Although issues associated with supply chain and BCP are well known to both major corporations and Government agencies there remains a need to put in place more robust and proactive "Supply Chain Management" programs based on "continuity partnerships" that prioritize suppliers in terms of their "criticality" to the organizations primary needs.

Issue 3: Interconnected Policy Issues

Issue: Large scale, complex and cascading disasters such as Tohoku and Katrina have a broad impact across virtually all sectors of national to local activity and de facto across all policy sectors. For the majority of "simple disasters" existing agency, industry and local response, recovery and reconstruction policies and activities are adequate to deal with the crises. However the more complex the disaster, and in particular those with cascading effects, require first closer cooperation with both more clearly defined specific policies that govern cooperation and support: increasingly such policies and procedures need to include the private sector if they are to be effective.

Tohoku Case: Tohoku Disaster caused by tripartite (earthquake, tsunami, and nuclear disruptions) disaster brought wide ranging short to long term social and economic effects and has impacted at least six major policy domains: disaster management, environment (removal of tons of debris), energy, public health, local economy and industry (e.g., fisheries, agriculture), and international relations (e.g., radioactive contamination of sea and air). Since each problem is linked with different policy domains beyond individual sectors, these different issues has been intricately linked in extremely complex ways, which in turn bring about uncertainties for solutions not only for short term but also mid and long term basis.

Katrina Case: As was the case with the Tohoku disaster Hurricane Katrina had large spatial, temporal and sectoral impacts (outlined above in Issue 2). Overall FEMA's efforts to support state emergency management and to prepare for federal response and recovery in natural disasters were insufficient for an event of Hurricane Katrina's magnitude. Difficulties experienced during the response directly correlate with weaknesses in FEMA's grant programs, staffing, training, catastrophic planning, and remediation of issues identified during previous disasters and exercises.

The above challenges require systematizing multidisciplinary, multi-sectoral policy and continuous research on risks and their complex effects. Systematizing this research requires long term policy analysis carried out by multiple institutions, engaged in comprehensive policy analysis and evaluation, which are linked with a diverse stakeholder community. The need for such a multidisciplinary approach was clearly demonstrated by specific national to local policy deficiencies during Katrina, in particular in terms of dealing with cascading disasters in the following areas (Table 2).

Gap: The above areas of challenge require systematizing multidisciplinary and multi-sectoral policy research on risks and their complex effects on a continuous basis. The systematic study of these risks requires a mix of institutions, linked with a diverse community of stakeholders, to (a) undertake the required policy analyses and evaluations and (b) to work effectively to implement these studies in national to local policy.

Issue 4: Interconnected Effects on Multi-Sectors

Issue: Initial preparedness operations pre-disaster and search and rescue and rescue operations post disaster, focused on the most vulnerable populations, are recognized as both extremely complex and difficult tasks and as of critical life-saving importance. Major challenges include (a) the development of pre/post "tracking and identification" of vulnerable populations; (b) maintaining up-to-date "capacity" information on public and private emergency and health care institutions and (c) interactive logistical data bases, available to emergency workers, that provide a basis for transport and treatment decisions. The importance of multi- sector information and coordination in the search, rescue and treatment of those impacted by a disaster, with particular attention to the most vulnerable and critically injured populations, often determines who lives and who dies.

Tohoku Case: Although search and rescue operations based on initial assessment is critical immediately after disasters, it often occurs that because fire fighters, police and self-defence forces engage in their own activities, based on their individual policies and planning, that in turn were determined by other considerations. As an example during the Tohoku disasters search and rescue operations were made on the basis of requests from specific

Table 2: Hurricane Katrina Policy Areas of Policy Concern (Department of Homeland Security, 2006)

-National Preparedness	-Public Communications
-Integrated Use of Military Capabilities	-Critical Infrastructure and Impact Assessment
-Communications	-Environmental Hazards and Debris Removal
-Logistics and Evacuations	-Foreign Assistance
-Search and Rescue	-Non-Governmental Aid
-Public Safety and Security	-Training, Exercises, and Lessons Learned
-Public Health and Medical Support	-Homeland Security Professional Development and Education
-Human Services	-Citizen and Community Preparedness
-Mass Care and Housing	

hospitals or medical institutions (Uehara, 2012). However, for the request to be made and initial assessment by the medical institutions, which they could not make, was required and therefore response was often delayed. In the case of Shizugawa Hospital, in Miyagi, 150 patients and staff were isolated in the damaged building and were only rescued by the Defence Forces on March 12 and 13. During the time between the disaster and rescue seven patients passed away b; in the Ishinomaki City Hospital, 152 patients and 200 people had to wait for rescue for over 3 days until they were evacuated.

In response to the lack of a direct linkage between medical health institutions, and their initial assessments, and search and rescue operation the 17th Conference of the Japanese Association of Disaster Medicine (on February 2012) issued an urgent appeal statement to prepare for a large-scale disaster, which includes increasing a capacity for search and rescue for health/medical institutions as well as that for rapid assessment in emergencies.

Katrina Case: As with the Tohoku disaster a major component of the assessment of the response to Katrina focused on the inadequacy of the preparedness, evacuation and search and rescue operations with respect to assisting the most vulnerable populations. This assessment showed that the initial preparation for evacuation were woefully inadequate and contributed greatly to the disaster – among the most critical deficiencies were:

- Preparedness: The lack of preparedness on the part or government (national to local), communities and individuals to the impact of Hurricane Katrina is perhaps the most striking and least understandable component of the disaster. Although it is argued by all responsible that the impact was unanticipated in magnitude and therefore overwhelmed capacity available information indicates just the opposite.
  - In 2004, before the onset of the 2004 hurricane season, FEMA contracted to support catastrophic planning for South-east Louisiana in the event of a major hurricane (Project Pam)[8]. The goal of the project was to develop a functional, scenario-based exercise that would drive incident Action Plans for catastrophic hurricane response and build the foundation for Functional Plans. Ultimately, these plans would serve as a "bridging document" between local and state plans and the National Response Plan (NRP).
  - The initial eight-day exercise in July 2004 involved more than 300 participants from
    - 13 parishes; more than 15 federal departments and agencies; more than 20 state
    - agencies; FEMA Headquarters; FEMA Regions I, II, IV, V, and VI; the Louisiana Office of Homeland Security and Emergency Preparedness (now the Governor's Office of Homeland Security and Emergency Preparedness, or GOHSEP); the States of
    - Mississippi and Arkansas; and numerous volunteer agencies.
  - Subsequently, in 2005 funding for the follow on meeting cut for the follow-on disaster exercise meant to prepare government agencies for a major hurricane in New Orleans.
  - The exercise that was to develop a plan to fix such unresolved problems as evacuating sick and injured people from the Superdome and housing tens of thousands of displaced residents.

- Evacuation and Transportation
  - The delay in issuing a mandatory evacuation order until just before the Hurricane struck was a critical issue in placing lives at risk. More importantly, there was no existing plan for identifying and evacuating the most vulnerable portions of the populace.
  - The delay in issuing the evacuation order meant that alternative methods of evacuation were not put in place. As a result the majority of evacuating citizens were unable to find adequate gasoline as (a) service stations had not been given prior warning to "stock up" and (b) the vast majority used a single freeway creating a major traffic jam.
  - There was an inadequate provision of alternative transportation, in particular buses, and expanded public transportation capacity.

- Public Health and Medical Support: Related to issues 1 and 2 above it was widely recognize from Katrina there was a critical need to:
  - Create an operational, functional and integrated knowledge base of public health resources,
  - Develop specific operational plans and options for care of the needy
  - Provide additional investment in deployable operational resources, and
  - Accelerate initiatives to foster the widespread use of interoperable electronic health records systems.

Issue 5: Interconnected Policy, Risks and Uncertainties

Issue: The ever-increasing interconnectivity of risks and the complexity of cascading disasters, with their resulting diverse impacts, require a higher degree, from the national to local levels. of integrated multi-sectoral policy formulation and coordination. Central to the new policy formulation is the need to (a) transition from traditional "stove piped" specialized agencies to broader-based approach based on intra-agency cooperation, (b) move from vertical "top-down" disaster management to a combined "top down-bottom up" and "horizontal" (across disciplines)" form of management and (c) expand the skill and com-

[8] http://www.iem.com/case-studies/hurricane-pam

petency of existing organization to meet the emerging challenges of the new normal of interconnected risks and complex cascading disasters. For the future, there will be an ever-increasing need for government, disaster management and the communities to be "adaptive" to the unexpected consequences of future disasters.

Tohoku Case: The complexity of emerging interconnected disaster risks and the associated uncertainty of their multi-sectoral impacts requires that technical experts and other groups in society generate new knowledge and technologies together (co-knowledge production system) as inputs for policy analysis and evaluation.

The Tohoku disaster has shown, even when critical information and problems were identified by someone or some organizations, many of them were addressed separately in terms of overall disaster management and public policy. For example, in Minami-Soma city in Fukushima prefecture, where people were confined to their homes because of the crippled nuclear power plants, there was a significant shortage of food, water, medical supplies, and gasoline. Mayor Katsunobu Sakurai stated through the news media that even weeks after the disaster the city had still not had any contact with, or received any information directly from, the central government, including the status at the crippled power plant, and that as a result he had to depend on news media reports. This was not the only case. Many local mayors, including Namie-cho, Fukushima Prefecture Mayor Tamotsu Baba, as a witness of a public meeting in National Diet of Japan, Fukushima Nuclear Accident Independent Investigation Commission on 21st April 2012, emphasized that he did not receive any information from the Government.

Regarding critical data, the most typical case was seen in the national government's mishandling of radiation forecasts from the computer system known as the System for Prediction of Environmental Emergency Dose Information (SPEEDI). Although SPEEDI provided data on radioactive releases from the Fukushima Daiichi nuclear plant during the continuing disaster, the information was not communicated appropriately within the central government.

Katrina Case: A retrospective review of Hurricane Katrina demonstrates that the interconnected risks and uncertainties associated with complex and cascading disasters often negatively impact 5 major areas:

- Responding to the Disaster – As would be expected, but is rarely appreciated and/or planned for, is that cascading disasters are often self-perpetuating in terms of their impacts. Therefore many of the impacts are not adequately anticipated. Therefore it is essential that governments, disaster management agencies, communities and individuals adopt an overarching philosophy of "adaptive response".
- Who is in charge – the overlapping jurisdictional responsibilities of individual agencies, resulting from the complexity of issue related to major disasters immediately exposes the need for coordinated and integrated action within an an priori defined framework. In particular the framework must provide for both vertical and horizontal chains of command within government and with communities and the private sector.
- Lessons Learned - throughout the Federal, State and local governments specific requirements and programs for training, exercise, and lessons learned programs, within a comprehensive system and common supporting methodology, should be developed and. all entities be made accountable for the timely implementation of remedial actions in response to lessons learned.
- Environmental Data - Governments, agencies and communities should collectively improve their capacity to quickly gather environmental data and to provide the public and emergency responders the most accurate information available, to determine whether it is safe to operate in a disaster environment or to return after evacuation.

Gap: The Tohoku and Katrina case has demonstrated, to address uncertain and complex issues effectively require far more systemic co-knowledge production matrix (see Figure 1) than is normally required for conventional disasters. The co-knowledge production process includes systemically accumulating, synthesizing and integrating key information, experience, data and lessons learned, beyond conventional expertise, organizational, or geographical boundaries, to produce "actionable policies" (Shimizu, 2012). Furthermore, the co-knowledge production systems will be enabled by pluralizing and systematizing basic knowledge production systems beyond demarcations of expertise and interests. The knowledge production systems include systemic analysis and evaluation (not just on-time assessment or evaluation but integrating different assessments for continual evaluations for actions) to produce operational information, and diverse dissemination mechanisms for conveying the knowledge to end users in the formulation of "actionable polices".

5. Why Do Cascading Disasters Continue to Occur

Disasters continue to occur, and if not an exact copy of the previous event, they are sufficiently similar to suggest that the underlying issues have not been addressed. There are many reasons for this but a major element appears to be the assumption that "well designed" systems are inherently safe and causes for failure must, therefore, lie outside the system itself. In a management climate that rewards efficiency and speed of operation, there is little incentive to adopt approaches that may take longer and cost more to achieve a measure of safely that is difficult to measure and hence hard to achieve. We usually know whether a system has failed or not. We rarely know how close and how frequently it approaches a failure point. As a result, organizations and the bodies that regulates them tend to assume a level of safety that may or may not exist. When failure does not occur, these assumptions are reinforced with the result that safety margins are often reduced on no other basis than the system has not failed. The incentive of measurable financial benefits from reduced safety precautions (inspections, testing, maintenance, etc.) against

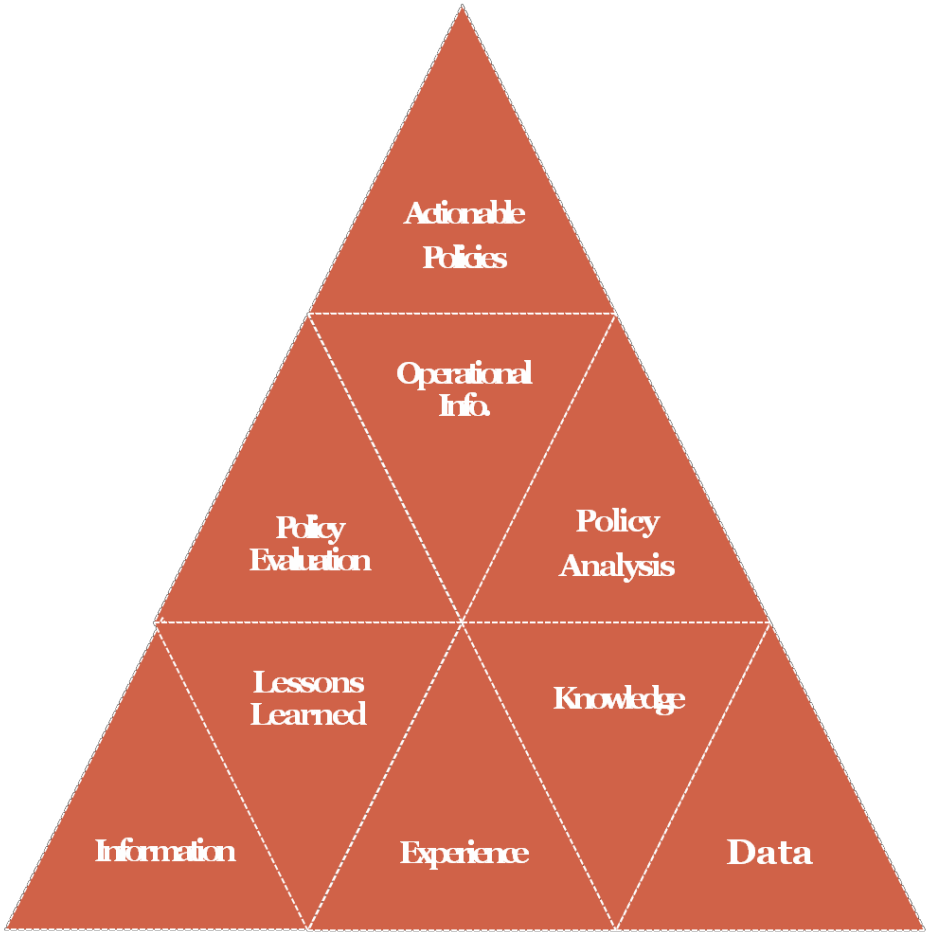

Figure 1: The Co-Knowledge Production Matrix (Shimizu, 2012)

an immeasurable (or at least unmeasured) level of safety usually drives decision- making. When this behavior becomes ingrained in organizational culture it is very difficult to implement alternative courses of action.

The major lesson that should be taken from this effort is that complex infrastructure systems are not inherently safe, no matter how well designed. The reason for this is that the systems are designed first and foremost to produce a service, be it electric power or flood defence, and not to be safe on their own accord. These two events are not unique recurrence of the same institutional and human factors as underlying root causes suggests that a new paradigm for addressing the risks of high-consequence infrastructure failures is called for. Rather than seeking an optimal design solution based on an expected maximum probable demand or hazard event, a more effective way of addressing these risks may be to assume that a failed condition is actually the stable configuration of the system. If high entropy governs system behaviour, then continuous inputs of financial and intellectual capital would be required (and expected) to keep the system in an unstable, lower entropy and "safe" condition. By recasting the problem as one of achieving safety rather than preventing failure, such investments take on a wholly different meaning and can no longer be viewed as optional. Without on-going analysis, assessment, planning, testing, maintenance, and repair, the system will revert to its most stable configuration, i.e., failure.

This story is not all bleak. Institutional behaviour in some nations is progressive on this issue. More must be done however, to develop and incentivize organizational culture that values and rewards actions to reduce the risk of infrastructure failure and its accompanying cascading effects.

6. Implications for the HFA and the Successor Framework to the HFA

The "Yokohama Strategy for a Safer World" specifically identified gaps and challenges in five issues to be addressed as Part of the Hyogo Framework for Action (HFA):

a Governance: organizational, legal and policy frameworks
b Risk identification, assessment, monitoring and early warning;
c Knowledge management and education
d Reducing underlying risk factors;
e Preparedness for effective response and recovery.

The preceding analysis of the Tohoku and Katrina disasters clearly demonstrated that a multitude of inadequacies, in terms of addressing the "Yokohama Strategy" in the context of the HFA still exist even in the most ad-

vanced nations in the world. The present comparative study shows that, although the disasters differed in structure and impact, existing disaster management policies and programs were regrettable deficient in most areas. The inadequacy of existing polices and disaster management is clearly largely attributable to an, inability to define and adapt to, a "new normal" of interconnected risks, cascading disasters and unexpected consequences. Therefore there is a need for the successor framework to the HFA to more fully incorporate and addresses the following critical points: to address interconnected risks and cascading disasters:

- There is an overarching need to more fully define and understand complex interconnected risks and the structure and diverse impacts of resulting cascading disasters. To accomplish this requires a new paradigm, based on a "whole of the system" approach, for risk and vulnerability assessments. This is particularly true for large complex developments, such as the Tohoku and Katrina areas, of communities, industries and critical infrastructure.
- For the future policy and disaster management activities should be "resilience based" and designed to ensure that resilience is "operational" and "sustainable" based with a co-generation of information and knowledge. Especially continual learning and co- knowledge production process is critical to address a high level of complex and uncertain challenges.
- Ensuring operational continuity, by linking resources (financial, human and knowledge) and complimenting or strengthening each entity's weakness throughout the continuum is an overarching requirement.
- Systemic coordination and linkages between national and local entities and among different sectors (particularly the private sector) should be more examined and specific mechanisms for operational coordination should be developed.

References

Clark, A. L. 2013. "21st Century Paradigm Shifts in the Governance and Management of Disasters," Conference Paper, East-West Center, Hawaii, United States.

Crutzen, P. J., and E. F. Stoermer. 2000. "The 'Anthropocene'". Global Change Newsletter 41: 17–18.

Department of Homeland Security. 2006. The Federal Response to Hurricane Katrina: Lessons learned. U. S. Government Printing Office, Washington, D.C.

Shimizu, M. 2012. "December, Resilience in Disaster Management and Public Policy: A Case Study of the Tohoku Disaster" in Risk, Hazards and Crisis in Public Policy, Volume 3, Issue 4, pp 40–59.

Taleb, N.N. 2007. The Black Swan. Random House. United Kingdom.

Uehara, N. 2012. "Daikibosaigai ni taisuru hoken iryou no sonae (Preparation in Medical Health for Large-Scale Disasters" in Higashinihon Daisaigaini Okeru Hokeniryou Kyugo Katsudou no Kiroku to Kyoukun (Records of Medical Health Rescue Activities in Tohoku Disaster and Its Lessons) Jihou (in Japanese), Japan.

World Economic Forum. 2012 and 2013. Global Risks 2012 and 2013.

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