

THE TOHOKU DISASTERS: CHIEF LESSONS CONCERNING THE POST DISASTER HUMANITARIAN LOGISTICS RESPONSE AND POLICY IMPLICATIONS

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ABSTRACT

This paper describes the findings of the research conducted by the authors on the humanitarian logistic efforts after the cascading disasters that impacted the Tohoku region after the Great East Japan Earthquake of March 11th, 2011. Using a combination of in depth interviews with participants in the relief efforts and meta analyses of news accounts, the authors identified lessons learned by the participants, and the corresponding policy implications and suggestions for improvement of future response efforts.

1. INTRODUCTION

The extreme nature of disasters poses significant challenges to the individuals and organizations involved in the delivery of critical supplies to assist the people in need. This is because: (1) the social networks that orchestrate the array of technical activities concerning logistics are severely disrupted or destroyed; (2) the infrastructure and communication systems that support such socio-technical process of logistics may have been impacted and unable to fully function; (3) there is a great deal of uncertainty about infrastructure conditions; (4) large (and dynamic) volumes of critical supplies must be transported; (5) there is a short timeframe to respond and prevent loss of lives and property; (6) there is a huge amount of uncertainty about what is actually needed, where is it needed, and what is available at the site; (7) the ability of the local leaders, civil society, and private sector to organize an effective response may have been compromised by the event itself; (8) large proportions of critical local assets (e.g., trucks, supplies) may have been destroyed, thus preventing their use as a first wave of relief aid; and, (9) the event generates a huge flow of donations with large proportions of supplies that are not needed at the site, which complicates the response tremendously as handling these goods detract resources from other more important tasks (Holguín-Veras et al., 2007; Holguín-Veras et al., 2012b). These characteristics set post-disaster humanitarian logistics (PD-HL) apart from both commercial logistics and the various forms of longer term humanitarian logistic endeavors—termed regular humanitarian logistics in Holguín-Veras et al. (2012b)—such as distribution of medicine and/or food in crisis regions, that take place in less chaotic environments. In this context, PD-HL is very different than its commercial and the regular humanitarian logistic counterpart, in terms of: (1) objectives pursued; (2) nature and origination of the commodity flows transported, (3) knowledge of demand, (4) decision making structure, (5) periodicity / volume of logistic activities, and (6) state of the supporting systems, e.g., transportation and communications, (Holguín-Veras et al., 2010; Holguín-Veras et al., 2012b).

A major issue that hampers research, development, and implementation of more effective PD-HL systems is that the realities of actual operations are poorly understood. The reasons for this situation are three-fold: (1) the relatively low occurrence of large disasters and catastrophic events; (2) the small size of the professional and research PD-HL communities; and, (3) the transient involvement of responders and the dynamic nature of the operations and data. To start with, large scale disasters are rare events that, even in disaster-prone countries like Japan, happen many years apart and typically impact different jurisdictions. As a result, only a relatively small number of individuals get involved in more than one large disaster, which prevents the accumulation of experiences that is central to knowledge creation. In Japan, for instance, the last major disaster before the one of March 11th, 2011 was the 1995 Kobe earthquake. After the sixteen years that elapsed between the Kobe and Tohoku disasters, it is likely that the bulk of the individuals involved in the Kobe response either moved to other pursuits, or retired. Not surprisingly, none of the about 60 individuals interviewed for the paper had disaster response experience.

A second important reason is the minuscule number of individuals involved in PD-HL on a regular basis. In contrast to other disciplines (e.g., medical response, search and rescue) in which tens and even hundreds of thousands of individuals perform and train on these duties on a daily basis, the number of people routinely working on PD-HL is very small. The reason is that only large disasters and catastrophic events—which as said are few and far between—require sophisticated PD-HL operations (Holguín-Veras et al., 2012b). It is entirely possible that less than five hundred individuals, worldwide, work full time on PD-HL. Complicating the matter, these highly qualified professionals are not inclined to write

publications that could help create a knowledge base on PD-HL. If and when they write documents discussing PD-HL, these are typically internal (agency) reports of restricted circulation.

The third reason is the ephemeral nature of the data. Disaster response is a transient and highly dynamic activity with markedly different phases, ranging from a chaotic initial phase in which the main goal is to assess conditions and define a path for the stabilization of the crisis; to much calmer phases of expansion and consolidation during which the focus is on how to meet the needs in an efficient manner. The dynamic nature of the activity, together with the fast rotation of the staff and volunteers involved in the work, poses a major challenge for characterizing and understanding PD-HL operations. International relief agencies, for instance, typically send their top staffers at the onset of the crisis so that they, on account of their experience, stabilize the situation. Once this is achieved, the top teams are rotated out to give them some rest, and are replaced by follow up teams that take care of the process for another period of time (at some point these teams are also rotated out.) Similarly, volunteers and local responders tend to switch out of the response as time passes on as they have to return to their regular activities, or simply need time to recover. The net result is that the individuals doing PD-HL weeks after the disaster are not likely to be the same ones that responded in the initial days and, for that reason, cannot provide full accounts of what transpired at the beginning of the crisis. Thus, there is a very limited amount of time to identify and interview the individuals involved in the crucial initial phases, and gather the data they could share about it. If the researchers fail to arrive soon enough, or if they do not manage to get access to the proper individual(s), or if they are not allowed to observe the operations, the opportunity to characterize and collect data about the initial stages gets increasingly difficult as time passes on. At some point it is no longer possible to document the operations as memories fade, data are lost, and the ability to identify and find the individuals involved evaporates. These factors lead to a situation in which the level of knowledge about PD-HL possessed by outsiders to the response is very small. Not surprisingly, only a handful of the PD-HL cases have been systematically studied (e.g., Katrina, Haiti), and only a couple of publications (Holguín-Veras et al., 2007; Holguín-Veras et al., 2012a) discuss PD-HL based on direct observations. The research community is only starting to scratch the surface of such complex subject.

This paper is important because it provides evidence-based insight into actual PD-HL practices, and the lessons that ought to be learned to improve plans and response procedures. Since solid knowledge of PD-HL practices is a requirement for the development of policies, decision support tools, and analytical models aimed at improve PD-HL, field research like the one reported here is key to develop new paradigms of PD-HL able to deal with the real life complexity of the operations. In essence, it is difficult to improve the operations of a system that is poorly understood. This topic has long been identified as a key priority by the Federal Emergency Management Agency (FEMA), that stressed the need to "...improve the distribution of critical assets and goods in a catastrophic event..." (Picciano, 2002). The paper builds on (Holguín Veras et al., 2011).

The fundamental objectives of this paper are to: (1) discuss how the unique nature of the cascading disasters in the Tohoku region impacted the PD-HL response; (2) describe the PD-HL operations implemented to respond to the Tohoku disasters; (3) identify how the persistent nuclear threat impacted the overall PD-HL effort; (4) document lessons learned, both positive and negative; and (5) identify a set of policy recommendations to improve future disaster response. Understanding the importance of publicly available accounts of PD-HL efforts, the authors describe the operations of the key players in as much detail as possible to provide documentary evidence of benefit to both researchers and practitioners. In identifying the lessons learned, the authors are fully aware that in disaster response, particularly after

catastrophic events, it is not realistic to expect perfection as these operations take place in chaotic conditions. Rather than identifying blame, the main emphasis is on extracting lessons that could help future disaster response efforts.

The paper summarizes the work of an international team that, with funding from the National Science Foundation (NSF) and the Japanese Science and Technology Agency (JST), visited the Tohoku region. The data were collected using a multi-prong approach based on in depth interviews with participants in the relief efforts, assembly of a comprehensive database of news articles and reports, and the creation of a timeline of relevant events. The interviews, conducted during several trips to the area, were with the Tohoku Regional Bureau of the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT); the prefectures of Miyagi, Iwate, and Fukushima; the cities of Ishinomaki and Kesenuma, and three large private companies (i.e., Yamato, Sagawa, and AEON), that were involved in the response. In all cases, the authors met with numerous staff members. To ensure anonymity, the names of the individuals that provided the information are not disclosed. Triangulation of the responses was used to mitigate the limitations inherent in relying on accounts and information provided by individuals that, for the most part, only had a partial view of the operations.

Throughout the paper, the supplies that arrived to the disaster area are classified using the levels of priority defined by the Pan-American Health Organization, PAHO, (Pan American Health Organization, 2001). This classification system divides supplies in three groups: high-priority, which are goods urgently needed at the site; low-priority, which are those that could be needed later on and must be stored for future use; and, non-priority items that are those that are not needed, not appropriate to the needs, or that could do harm if distributed to the survivors. Throughout the paper, metric units are used.

The paper has six sections in addition to this introduction. Section 2 discusses the cascading disasters that precipitated the humanitarian crisis in Tohoku. Section 3 provides a system-level overview of disaster preparation and PD-HL response efforts. Section 4 describes the PD-HL operations enacted by the different private and public sector actors interviewed by the authors. Section 5 analyzes the lessons learned by the interviewees. Section 6 identifies policy implications and a set of recommendations to improve future disaster response efforts. Section 7 conducts a comparative analysis of the contrasting performances of the construction work and PD-HL. Section 8 summarizes the chief findings of the work.

2. THE CASCADING DISASTERS

On March 11th, 2011 a 9.0 earthquake struck 130 km East of the city of Sendai in the East Coast of the Island of Honshu, Japan. Lasting about five minutes, the earthquake—referred to as the “Great East Japan Earthquake”—produced a violent shaking and unusual duration that damaged an untold number of roads and buildings. Providing testimony of Japan’s seismic design and construction practices, physical damage was kept to a minimum; and loss of lives by the earthquake was relatively low considering its intensity. However, the earthquake led to the temporary shutdown of ports, airports, subways, and rail systems throughout Japan (Journal of Commerce, 2011d).

Immediately after the earthquake, tsunami alerts were issued throughout the Japanese East coast. The warnings predicted waves of 6-7 m height which, in most cases, would have been within the design range of the tsunami protection infrastructure. Scores of local citizens, well trained after years of emergency drills, moved to higher ground following pre-established tsunami evacuation routes. Regrettably, anecdotal evidence suggests that many individuals—with fresh memories of the false alarms of February

22nd and March 9th, 2011 (with a magnitude of 7.3) earthquakes—ignored the warnings. As expected, the waves struck the Eastern seaboard of Japan. Unfortunately, the waves were much higher than anticipated as tens of cities and villages, and hundreds of small communities were hit by waves towering in excess of 12-16 m, with a reported maximum of 39 m in Northern Japan (NHK World News, 2011b). There was also confusion about the arrival time of the tsunami waves, which may have led people to believe that the danger had passed when in fact, the tsunami was still on its way (NHK World News, 2011b).

The Japanese people had been preparing for such a scenario for decades. Local governments had organized tens of thousands of evacuation drills throughout the country and invested heavily on seismic resistant structures and tsunami protection infrastructure and systems. The latter includes a huge network of tidal gauges to collect real time wave height data, sophisticated information technology systems that process the wave height data and issue automatic warnings in case of danger, and an estimated 8,800 miles of seawalls and breakwaters to protect life and property (New York Times, 2011a).

In the Tohoku region—the one closest to the epicenter and the one most heavily impacted—the most critical pieces of infrastructure are the: Sendai Airport, Iwate-Hanamaki Airport, Port of Sendai-Shiogama, Port of Onahama, Tohoku Motorway, Joban Motorway, Sanriku Motorway, Routes 4, 6, and 45, the East-West arterials connecting the Tohoku Motorway to the coastal areas, the Tohoku Shinkansen (high-speed railway), the Fukushima Daiichi Nuclear Plant, and the Onagawa Nuclear Plant (Journal of Commerce, 2011). In addition, there are hundreds of miles of populated areas where agriculture, industrial activity, and human habitation takes place. Figure 1 shows the key infrastructure in Tohoku.

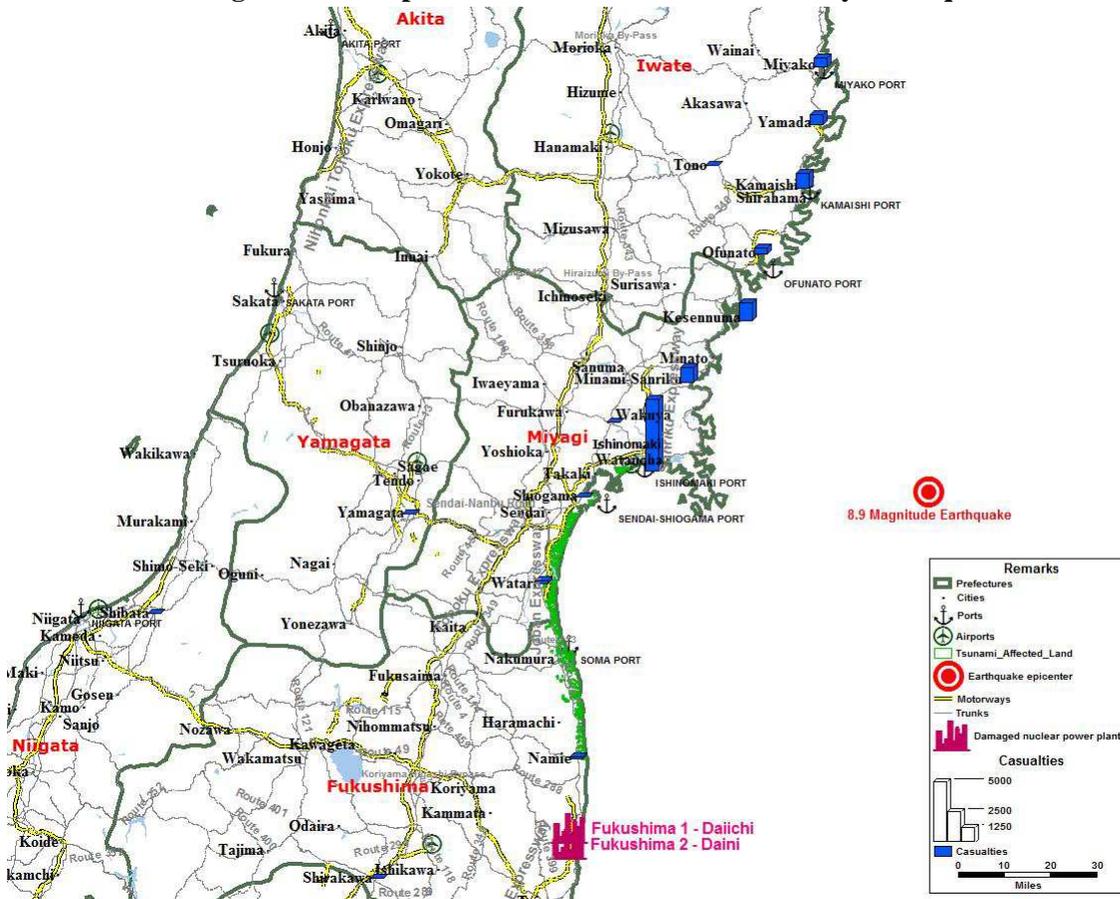
Overall, the level of protection against tsunamis was uneven. In most of the populated areas, seawalls—not as effective as breakwaters and certainly much less effective than tsunami breakwaters—were the main form of protection. The airport at Sendai, located about one km from the coast behind a 4 m seawall, was deemed to be in a safe area (NHK World News, 2011b). The Fukushima Daiichi Nuclear complex had a double layer of protection as the reactors had been located at the top of a 6 m bluff facing the sea, and a small two-wing breakwater protected the facilities. In contrast, the Port of Sendai has two sets of breakwaters including a massive deep water tsunami breakwater located 3 km from the port.

These critical facilities experienced different levels of damage. The airport, though flooded, did not experience irreparable damage, and was back in operation six days after the disaster (Washington Post, 2011c). The port was in acceptable shape, though hundreds of containers were piled up by the waves requiring significant clean-up. More importantly, the piers were not damaged though gantry (ship) cranes needed repairs (a very different situation than what happened in Port au Prince, where both piers and cranes were completely destroyed by the earthquake, thus removing a crucial component of the logistic system). The port was opened to receive relief supplies on March 18th (Journal of Commerce, 2011r), to commercial domestic traffic on March 29th (Journal of Commerce, 2011), and to international containers on June 9th, 2011 (Journal of Commerce, 2011c).

Farther away from the epicenter, the Fukushima Daiichi nuclear complex did survive the earthquake, and went into the automatic shutdown established in emergency procedures. Unfortunately, the tsunami waves overtopped both the breakwater and the bluff, flooding the emergency generators that provided the electricity to run the water pumps needed to cool the nuclear reactors. The crisis that followed—that culminated with the release of radioactive material—impacted the response in rather dramatic ways as it deterred the convergence of volunteers and materials to the disaster site. As a result, local responders had to undertake the response without the assistance of the massive help that typically comes from the outside

bringing manpower, equipment, supplies, and expertise. The deterrent effect that the nuclear crisis had on both people and material convergence sets the Tohoku disasters apart from the most recent events (one would need to go back to Chernobyl to find a precedent); as in most disasters once the physical phenomenon that produced them fades away, the response can start in earnest.

Figure 1: Transportation Infrastructure Affected by Earthquake



Note: After MLIT (2011b)

Three specific features make the Tohoku disaster an event without precedents in recorded disaster history: (1) severity and pervasiveness of the danger, (2) geographic coverage with both widespread and localized damage, and (3) persistence over time. In terms of severity, the earthquake and tsunami are among the strongest on record, while the nuclear crisis is only topped by Chernobyl. Adding to the complexity, the pervasiveness of the (invisible) nuclear threat—and the fact that it conjures images from Hiroshima, Nagasaki, and Chernobyl—sent a powerful deterring signal to potential responders outside the area. The disasters also impacted a large geographic area: the tsunami wiped out hundreds of square kilometers of coastal communities, while the nuclear crisis threatened the health of individuals and impacted environmental conditions within a large radius from the nuclear plants. A unique feature of the disasters was that the damage was both widespread and localized. It was widespread because it impacted large continuous urban areas, e.g., Ishinomaki, and it was localized as it destroyed numerous isolated communities leaving untouched communities nearby that were not on the path of the tsunami. Finally, the time-persistence of the nuclear crisis—which lasted months—and its impacts on the response may

ultimately be the defining factor as it profoundly altered the flows of goods and the very essence of the PD-HL process, particularly in the Fukushima Prefecture.

Important to the purposes of this paper is that for some communities (e.g., Ishinomaki, Minami Sanriku) the Tohoku disaster was a catastrophic event, because: "...most or all of the community built structure is heavily impacted... [and] facilities and operational bases of most emergency organizations are themselves usually hit..."; "...local officials are unable to undertake their usual work role..."; "...help from nearby communities cannot be provided..."; "...most, if not all, of the everyday community functions are sharply and concurrently interrupted..."; "...the mass media system especially in recent times socially constructs catastrophes even more than they do disasters..."; "...mass out-migrations for protracted periods of time..."; and, because of the previous processes "..., the political arena becomes even more important..." (Quarantelli, 2006; Wachtendorf et al., 2010). As discussed in Holguín-Veras et al. (2012b), the catastrophic nature of the event has a profound and dramatic impact on PD-HL because of a number of interrelated effects. First and foremost, logistic activity is a socio-technical process in which a social network of individuals (e.g., shippers, carriers, receivers) organize technical activities such as routing and distribution, using supporting systems, e.g., transportation and communications. In this context, events that impact any of these components could produce massive disruption in this socio-technical process. Second, large portions (and, in some cases, all) of the inventories of supplies held by households and businesses in the impacted area are destroyed, which deprives the local communities of what otherwise would be readily available critical supplies. Third, the private sector supply chains that—in normal conditions bring all the supplies needed by the community—are severely disrupted (taking them weeks to recover) or completely destroyed. Fourth, the demand for supplies at the disaster area increases tremendously due to the combined needs of: survivors, the response process itself, and local stores that perceiving a business opportunity due to precautionary/opportunistic buying on the part of individual (mostly from the outside of the disaster area) increase the size of their purchases above and beyond what is actually needed under normal conditions. The combined impacts on supply and demand leads to a situation in which the only practical alternative is to bring the supplies from the outside. This stands in contrast with smaller disasters where local inventories and the existing private sector supply chains are able to satisfy most of the immediate needs of survivors. The failure to recognize this crucial difference, and prepare for it, had major impacts on the response as discussed next.

3. OVERVIEW OF PREPARATION AND RESPONSE EFFORTS

This section provides a general overview of both disaster preparation and the response, without discussing in great detail the efforts of specific agencies, local governments, and companies as this is the main focus of Section 4. In all cases, the discussions center on the PD-HL effort as other important aspects (e.g., search and rescue, medical logistics) are outside the scope of the paper.

3.1 Overview of disaster preparation efforts

The public sector interviewees reported having taken numerous steps to enhance disaster response as prefectures and cities had response plans that outlined the actions they would take in case of a disaster. However, all them reported that these plans were not followed, for the simple reason that they only considered a small disaster and not a catastrophe as the one they faced. Moreover, the respondents indicated that—with perfect hindsight—PD-HL was not adequately discussed in the response plans: in some cases it was not mentioned at all; in another "...it was just one line in the plan..." (Iwate

Prefecture), and in three cases (Miyagi, Iwate, and Fukushima prefectures) was limited to identifying a handful of distribution centers or DCs, (Holguín-Veras et al., 2011d; 2011b; Taniguchi et al., 2011a; Taniguchi et al., 2011b; 2011c). Quite tellingly, none of the plans considered in adequate detail the local distribution, and how the manpower and assets required for the entire operation would be secured. In the words of a company staffer: "...they were assuming that 'somebody else' would take care of the distribution of relief supplies..." (Holguín-Veras et al., 2011a).

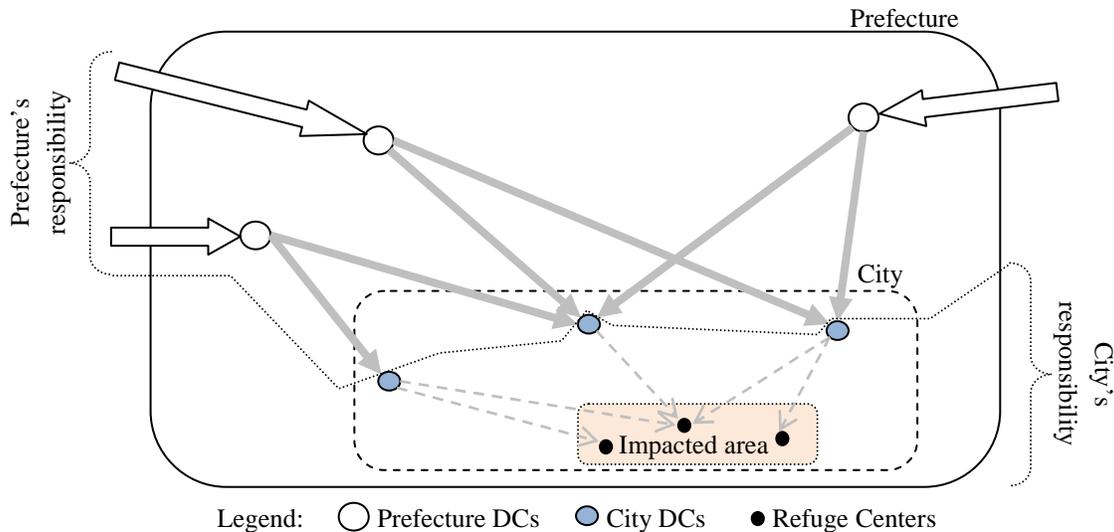
Not surprisingly, PD-HL did not figure prominently in the training exercises annually conducted by local governments. The respondents could only recall two cases (Fukushima Prefecture and Ishinomaki City) with a PD-HL component, albeit small ones. In one of them, the staff transported supplies from the outside of the region to a DC inside the area. The other involved transporting cargo from a shopping mall to a single Refuge Center (RC), which was deemed by participants as "...simplistic...". Reflecting on the experience that they went through, a staff member at Fukushima Prefecture indicated that "...a quality exercise would have been very helpful..." (Taniguchi et al., 2011c). The lack of complex and realistic exercises involving local distribution prevented the agencies from appreciating the complexity associated with the challenge they would face in March 11th, 2011.

In their favor, most of the agencies and local governments had signed cooperation agreements with potential private sector partners. In the case of the MLIT, the agreements were with construction companies for debris removal and construction work (Taniguchi et al., 2011d). In the case of prefectures and cities, the typical agreement was with the Japanese Trucking Association (JTA) for the transportation of supplies from the outside of the disaster area to the DCs operated by these governments. In addition, some prefectures, e.g., Miyagi, had signed agreements with construction companies. Unanimously, the transportation agreements were deemed "...too general..." by interviewees (Holguín-Veras et al., 2011a; 2011d; Taniguchi et al., 2011a; Taniguchi et al., 2011c) as they did not specify crucial details such as who would organize the local population, who will be the public sector person in charge of PD-HL, where the RCs would be located, how many people would be expected at each RC, who would be in charge of the local distribution of the relief aid, how much and what type of cargo would be transported, among other key operational details. Not recognizing the complexity and magnitude of the challenge associated with local distribution would have dramatic consequences. Moreover, the lack of established relationships between government authorities and transport and logistics companies—particularly local ones—hindered an efficient response. Only the Fukushima Prefecture had an agreement with a local trucking organization (Taniguchi et al., 2011c), which seems to have worked well as the local truckers assumed from the start (though it was not explicit in the agreement) that they would take care of the local distribution. This agreement with local truckers provided the prefecture with speedy access to local assets and knowhow where, and when, relief supplies were needed the most.

In terms of the structure of the PD-HL networks, the disaster plans typically defined a three echelon network with the DCs managed by the prefectures at the top, a middle layer with DCs operated by the cities, and Refuge Centers (RCs) at the bottom (see Figure 2). Implicit in this structure was the assumption that the cities would be able to undertake the PD-HL work at their DCs and RCs; and that, as a result, the role of the prefectures would be to ensure a suitable flow of supplies from their DCs to the DCs operated by the cities. Unfortunately, such assumption was wrong as the ability of the cities (which have been destroyed by the tsunami) to man, organize, and orchestrate the operations at DCs and RCs was severely compromised. This, in turn, forced the prefectures to undertake major components of the local distribution, which was a task for which they were not prepared, nor they had the physical resources

required to do a good job. In the chaos that ensued, supplies went directly to improvised DCs and in some cases to the RCs, making difficult to coordinate deliveries and conduct any form of centralized management and control. Over time, the system evolved towards a structure in which some of the DCs operated as warehouses of non/low-priority supplies; while others operated as DCs. Thus, depending on their cargo the vehicles were sent to one or the other. In other cases, non/low-priority supplies were allowed to unload at the busiest DCs complicating operations there as these locations were already congested, and had limited manpower to unload, sort, store, and manage such cargo.

Figure 2: Schematic of Flow of Supplies as Defined in Disaster Plans



All the prefectures (i.e., Miyagi, Iwate, and Fukushima) and one city (Ishinomaki) indicated that they had prepositioned critical supplies (e.g., blankets, meals ready to eat, water) (Holguín-Veras et al., 2011d; Taniguchi et al., 2011b) though all considered the prepositioned amounts "...were not enough...". This would come to haunt them. The companies interviewed had inventories of food, water, and other supplies—intended for their normal business operations—which were used during the immediate response (Holguín-Veras et al., 2011a). The companies also had contingency plans to deal with minor emergencies and interruptions, such as a blackout of limited duration.

3.2 Overview of the disaster response

This section discusses the most salient events concerning the PD-HL response to the Tohoku disasters. To facilitate understanding of the complex response that followed, a timeline with milestones is shown in Table 1. The most striking aspects of the table are the breadth of the impacts on all modes of transportation both in and outside the disaster area; and the time persistent effects produced by the nuclear crisis, which hampered the response for an extended period of time.

Table 1: Timeline of events concerning PD-HL

<u>Date</u>	<u>Description</u>	<u>Source</u>
3/11/2011	Great East Japan Earthquake and tsunami	(Journal of Commerce, 2011d)
	Ports, airports, highways shutdown	(Journal of Commerce, 2011d)
	Container shipping traffic stopped	(Journal of Commerce, 2011m)
	Train service suspended in Tokyo	(NHK World News, 2011a)
3/12/2011	Tokyo trains to resume service	(NHK World News, 2011c)

	Japanese government sends aircraft and ships	(Washington Post, 2011b)
	11 out 16 East-West arterials opened	(MLIT, 2011a)
	Prefectures start receiving supplies	(Taniguchi et al., 2011a)
3/13/2011	SDF ready to mobilize 50,000 troops	(Kyodo News, 2011b)
	Nine expressways close, hundreds of flights canceled	(Kyodo News, 2011b)
3/14/2011	Ports of Tokyo, Yokohama; Tokyo airports open	(Journal of Commerce, 2011j)
3/15/2011	Lack of relief supplies reported	(Washington Post, 2011a)
	Shipping companies announce efforts to help	(Journal of Commerce, 2011s)
	Yamato starts bringing supplies on volunteer basis	(Holguín-Veras et al., 2011a)
3/16/2011	Express carriers restore service (UPS, FedEx, DHL)	(Journal of Commerce, 2011a)
	Passenger airlines cancel flights to Tokyo	(Journal of Commerce, 2011a)
	Shortages of critical supplies reported	(New York Times, 2011b)
	Destruction of production bases described	(Daily Yumiuri, 2011b)
3/17/2011	Shipping lines start to cut down service due to nuclear crisis	(Journal of Commerce, 2011n)
	Shift to air transportation noticed	(Journal of Commerce, 2011h)
	Hardships in shelters described	(New York Times, 2011c)
	Yamato approaches government to offer help	(Holguín-Veras et al., 2011a)
	Sendai airport opens	(Washington Post, 2011c)
3/18/2011	Port of Sendai opens to relief supplies	(Journal of Commerce, 2011r)
	Ships advised to stay clear of Fukushima	(Journal of Commerce, 2011r)
	Ocean carriers cancel some services	(Journal of Commerce, 2011p)
	Humanitarian crisis increases, only a trickle of supplies	(Washington Post, 2011c)
	Government criticized for lack of help	(Daily Yumiuri, 2011a)
	SDF announces that will distribute supplies	(Daily Yumiuri, 2011a)
	Trucking associations offer help, refused for lack of fuel	(Daily Yumiuri, 2011a)
	Sagawa approaches government to offer help	(Holguín-Veras et al., 2011a)
3/19/2011	South Korea donates 6,000 blankets	(Kyodo News, 2011c)
	Volunteers start work	(Daily Yumiuri, 2011c)
	Sagawa starts operations in Ishinomaki and Onagawa	(Holguín-Veras et al., 2011a)
3/21/2011	110,000 blankets donated so far	(Japan Times, 2011a)
	Yamato resumes operations DC to DC	(Holguín-Veras et al., 2011a)
3/22/2011	Oil tankers arrive at Port of Sendai	(Journal of Commerce, 2011q)
	Carrier offers free transport	(Journal of Commerce, 2011o)
3/23/2011	Oil tanker arrives at Port of Hachinobe	(Journal of Commerce, 2011e)
	Sagawa starts operations in Higashi Matsushima	(Holguín-Veras et al., 2011a)
3/24/2011	All ports and airports open	(Journal of Commerce, 2011k)
	Yamato starts operations in Minami Sanriku and Kesenuma	(Holguín-Veras et al., 2011a)
	Tohoku Motorway opens access to Fukushima Prefecture	(Taniguchi et al., 2011c)
3/25/2011	Carrier suspends calls to Tokyo and Yokohama	(Journal of Commerce, 2011f)
	Carrier resumes service to Nagoya	(Journal of Commerce, 2011g)
	Yamato resumes business/home deliveries outside disaster area	(Holguín-Veras et al., 2011a)
3/29/2011	Carrier turned away from China	(Journal of Commerce, 2011b)
	91% of infrastructure related requests fulfilled	(MLIT, 2011a)
	Port of Sendai opens to commercial domestic traffic	(Journal of Commerce, 2011l)
4/6/2011	Supplies reported no matching the needs of survivors	(Japan Times, 2011b)
4/9/2011	Yamato and Sagawa start getting paid	(Holguín-Veras et al., 2011a)
4/12/2011	Trucks able to travel to Fukushima (air lift ends)	(Taniguchi et al., 2011c)
Mid-April	Private sector supply chains reestablished in Kesenuma	(Holguín-Veras et al., 2011b)

Note: SDF refers to Self Defense Force.

As expected in catastrophic events, all participants reported major impacts on their operations (Holguín-Veras et al., 2011b; 2011d; Taniguchi et al., 2011a; Taniguchi et al., 2011c; 2011b; 2011d). In some cases, public sector staff were killed, injured or missing, and key components of the response system were destroyed. Topping this list is the hospital at Minami-Sanriku, which was hit by tsunami waves so high that only the individuals that made it to the roof of the four story building survived. In all cases, the disaster led to the collapse of power and communication systems, major interruptions of private sector supply chains, and extreme shortages of fuel (in some cases there was no fuel at all, in others there was no power to extract fuel from underground tanks). In contrast with Haiti—where the earthquake killed or injured the local leadership expected to lead the response (Holguín-Veras et al., 2012a)—in most of the cases the local leadership survived, led the response, and provided visible links to the outside help. There were exceptions such as the city of Otsushi, where town leaders gathered to coordinate the response, and died when the waves overtopped the seawall; and Minami Sanriku, where the senior leaders were killed by the massive tsunami waves that destroyed the town (Holguín-Veras et al., 2011a).

The companies interviewed were also impacted. In the case of the logistic companies 6 out of 69 DCs in Miyagi Prefecture (Yamato), and 3 out of 43 DCs in the entire Tohoku region (Sagawa) were damaged or destroyed (Holguín-Veras et al., 2011a). Two DCs and a shopping mall operated by AEON were damaged, and its main DC in Tohoku was without power for a week (Holguín-Veras et al., 2011c). AEON reported a surge in demand—double than in normal conditions—for food and water, which was attributed to precautionary/opportunistic buying as people—particularly in areas that had not suffered major damage—rushed to purchase critical supplies (Holguín-Veras et al., 2011c). In response, numerous retail stores—sensing a business opportunity—increased the sizes of their orders to take advantage of the situation. This proved to be a major challenge as the main DC in Tohoku was working at 75% of capacity, and the staff had no experience on how to deal with this unforeseen situation.

As soon as they organized themselves, the agencies, prefectures, and cities tried to assess the impacts on their jurisdictions. The MLIT and Miyagi Prefecture used helicopters and planes to inspect roads and critical infrastructure (Holguín-Veras et al., 2011d; Taniguchi et al., 2011d). The MLIT reported making good use of the 1,800 Closed Circuit Television Cameras (CCTVs) part of their state of the art Disaster Control Room (DCR) in Sendai City. The DCR has a disaster mode feature—automatically engaged when a warning is received from the national government—that focuses the CCTVs on pre-defined critical infrastructure (e.g., bridges, tunnels), and enabled the MLIT staff to assess infrastructure conditions at key locations. The DCR is also a multi-agency coordination hub, e.g., it has a permanent representative of the Self Defense Force (SDF), and it is designed to be self-sufficient as it is equipped with emergency generators, food, fuel, and water for a week.

One of the cities (Ishinomaki), could not use the helicopters and planes operated by a local detachment of the SDF because they were destroyed by the tsunami waves (the pilots did not take off once tsunami warnings were issued as established in disaster protocols) (Taniguchi et al., 2011b). In contrast to the MLIT and Miyagi Prefecture—which were able to do air inspections—most agencies did not have an idea about the extent of the impacts on the infrastructure and the population. In some cases, the subsidence of the ground—up to 1.0 m—led to flooding in high tide reduced the effectiveness of air inspections, which had to be repeated (Holguín-Veras et al., 2011b).

Following established procedures, the SDF controlled access to the disaster area (none of the interviewees were directly involved in access control). The interviewees reported that in the first phase, only emergency vehicles were allowed to enter; in the second phase, delivery trucks were granted access;

and that finally, all restrictions were lifted. Some respondents indicated that unscrupulous individuals falsely reported transporting supplies to gain entrance to the area and/or to avoid paying the tolls at the Tohoku Motorway, which had waived the tolls for vehicles involved in relief efforts.

Not widely reported in the media is that the PD-HL operations had a very inauspicious start. To start with, prefectures and cities—which had not even identified PD-HL as a critical function in their disaster plans—made no provisions for it. Most likely influenced by their experience with small disasters in which PD-HL is of secondary importance, disaster response planners failed to recognize that catastrophic events require complex PD-HL operations in which most of the relief supplies have to be transported from the outside. Moreover, with hundreds of thousands of individuals needing critical supplies PD-HL became a monumental challenge for which cities, prefectures, as well as the national government, were not ready. As a result, for at least the first six days of the crisis hundreds of thousands of survivors did not receive relief supplies (Daily Yumiuri, 2011a; Sakurai, 2011). This prompted heavy criticism of the official response, which was accused of ignoring the plight of the survivors: a member of the Democratic Party of Japan said, “...The prime minister and Mr. Edano [Chief Cabinet Secretary] are focusing too much on the accidents at the nuclear reactors, and not caring enough about the evacuees...” (Daily Yumiuri, 2011a). In response to the heavy criticism—in day seven of the crisis—the SDF announced that it will distribute relief supplies to the individuals that survived the disaster (Daily Yumiuri, 2011a). The crisis would have been much worse, if not by the admirable community spirit of the Japanese that led them to share the supplies they had with their neighbors, as corroborated by the first author in Higashi-Matsushima (Holguín-Veras, 2011). In spite of that, the human suffering due to the lack of critical supplies was significant, though it did not lead to widespread riots. However, the interviewees reported that warehouses in the Watanoha district of Ishinomaki were broken into to get supplies, and that 40 million Yens were stolen from a bank (Holguín-Veras et al., 2011a). At this critical juncture, everything seemed to indicate that—with the SDF strained to the limit—and the normal private sector supply chains severed, that a huge humanitarian crisis was unavoidable.

Fortunately, fate intervened in the form of a handful of trucking/distribution companies (e.g., Yamato, Sagawa, Nittsu, and Akabo) that—because of their role in the food and retail sectors—were in a position to know that the private sector supply chains had been severely disrupted, and that the public sector was not ready to fill the gap. They recognized that a huge humanitarian crisis was underway and that without their intervention things would get much worse. Independently of each other, they approached local officials during the period March 15th-19th and took the unprecedented step of volunteering to do local deliveries of relief aid (Holguín-Veras et al., 2011a). In the two cases interviewed for this paper (i.e., Yamato and Sagawa), the companies paid for the costs of the local distribution and the supplies that they distributed during the first week; and the costs (except fuel) of the hundreds of trucks and drivers that they volunteered for almost a month of PD-HL operations in entire cities (Holguín-Veras et al., 2011a). Without their timely intervention—and the assets, expertise, and supplies they brought with them—the situation in Tohoku would have taken the path of Haiti, where the lack of help from the local business class contributed to a crisis of huge proportions (Holguín-Veras et al., 2012a). Ironically, many other trucking associations and companies seemed to have volunteered their services, though their offers were rejected because the government could not guarantee the fuel for the return trips (Daily Yumiuri, 2011a). Although it is not the authors’ objective to second-guess decisions made in the midst of chaotic field conditions, it is important to highlight that using SDF’s assets to transport fuel to the disaster area would have enabled the government to accept the help from the private sector, thus expediting the relief effort.

This point was made by an anonymous source that told the Japanese media that "Giving these firms preferential access to fuel would be one way to help us get more aid on the road to Tohoku,"..."There isn't a lack of supplies." (Daily Yumiuri, 2011a).

These volunteer companies did not have an easy time as they faced numerous challenges, notwithstanding their high level of professionalism, experience, and the fact that at least one of them (Sagawa) stated that they "...learned from the 1995 Kobe earthquake experience...". In most cases it took the companies more than a week to start distributing supplies to the RCs, which began in earnest at the end of the period March 19th-25th, 2011. The staff reported being shocked and overwhelmed by the complexity and magnitude of the challenge. Unanimously, they complained about: not having a good idea about the actual needs at the RCs, not knowing the conditions of roads and bridges, the lack of a single person in command of the PD-HL effort, and above all, of the challenge of doing local deliveries in a disaster zone. In their own words: "...transporting to DCs was easy...", while "...transporting to RCs was very difficult..." (Holguín-Veras et al., 2011a). The experience of these world class companies clearly show that the local distribution of critical supplies cannot be taken for granted; and that the response plans for catastrophic events must seriously take into account, and prepare for, such challenging effort.

An even more challenging scenario was presented to the leaders of Fukushima Prefecture. To start with, the nuclear crisis deterred the flow of volunteers and supplies to areas within a large radius around the nuclear plants due to concerns of radiation exposure. Thus, local responders were left to their own devices and the help they could get from the overextended SDF. Although there are no hard data, there is substantial evidence that suggests a significant deterrence effect. For instance, in the days after the crisis started airlines canceled numerous flights to Northern Japan and Tokyo (Journal of Commerce, 2011a), major shipping companies rerouted their ship schedules to avoid nuclear contamination (Journal of Commerce, 2011n; 2011i; 2011f), and even the U.S. Navy ships pulled out of the area due to the radiation risk (Reuters, 2011). However, in contrast to other areas where infrastructure had been devastated, most roads were passable.

Thus, the Fukushima Prefecture had a very difficult time mounting the relief effort (Taniguchi et al., 2011c). The most significant of the impacts on the PD-HL effort was that countless truckers decided to stay away from the entire prefecture thus reducing the flow of supplies, similar to what was observed after Hurricane Katrina when truckers abandoned the relief effort upon hearing that a second hurricane was coming (Holguín-Veras et al., 2007). The staff indicated that "...a large number..." of truckers simply unloaded their cargo at the border of Fukushima Prefecture, at about 80 km from the city of Fukushima (e.g., at Koriyama and Azaka Kawamachi) or simply parked the trucks and left, even though their destinations were well outside the exclusion zone. Of great significance was the case of 36 fuel tankers that—at the height of the crisis—were left about 50 km from their destination, which required sending drivers to retrieve the trucks and their critical cargo (Taniguchi et al., 2011c).

Furthermore, the nuclear crisis led to a situation in which almost all supplies had to be transported by plane to the Fukushima Airport. This was because: (1) of the variability of travel times could lead to potentially long exposures (the closing of the Tohoku Motorway until March 24th led to great uncertainty about travel times in the network); and, (2) planes have relatively short exposure times as they could quickly enter and leave the area. At the beginning, only official planes were allowed to land as there were no resources to sort donations. Planes were the main form of transportation until April 12th, 2011 when all highways were finally opened.

The PD-HL operations were further complicated by the orders issued by the Japanese government to minimize nuclear exposure, which had different effects on the populations in the areas surrounding the nuclear plants. More specifically, large numbers of people had to relocate elsewhere, while others were asked to stay indoors (including those living in areas impacted by the earthquake and tsunami). The Fukushima prefecture staff reported that, in spite that the national government had instituted a 20 km exclusion zone with a mandatory evacuation, and another zone between 20-30 km where people could leave but not return, many individuals stayed on both. For that reason, the prefecture asked Tokyo Electric Power and SDF to distribute supplies on their behalf. The suffering of those that stayed behind is dramatically illustrated in the video uploaded to the Internet by the mayor of Minami-Soma (Sakurai, 2011). In the video, he explains how the nuclear crisis both forced the survivors indoor, and prevented the arrival of the volunteers and supplies they needed. Specifically, he asked help from volunteers willing to "...act at their own risk..." that "...could bring in petrol (so that they could leave)...". He implied that large numbers of residents, that stayed indoors to avoid nuclear contamination, could not leave because of lack of fuel and vehicles and the impassable roads, and were not receiving the supplies needed.

The Tohoku experience yet again demonstrated the problems caused by excessive donations of non/low priority goods. This phenomenon, i.e., material convergence (Fritz and Mathewson, 1956), has been identified in all large disasters and labeled as a "...second tier disaster..." (Newsweek, 2002). The convergence of non/low-priority goods is extremely problematic as it arrives in very large volumes and at a time at which the responders are busy with other more important activities, disrupting operations. The trucking companies interviewed—which were responsible for the operations of the DCs and had to deal with the problem—estimated that between 50% and 70% of the cargo handled was not needed at all and should not have been sent there (Holguín-Veras et al., 2011a). This is consistent with the literature on the subject that suggest 60% (Fritz and Mathewson, 1956), and with the observations of the first author on the Katrina and Haiti disasters (Holguín-Veras et al., 2007; Holguín-Veras et al., 2012a). The amount of resources required to manage this massive and uncoordinated flow of goods is significant. As an illustration, when the authors visited the Iwate Industry and Culture Convention Center in Iwate Prefecture, one third of the staff (20 out of 60 workers) were sorting the unnecessary clothing that had been donated that was occupying about 40%-50% of the floor space. The consensus was that blankets, clothing (both used and new), and water were the top three non/low priority supplies. The case of blankets is illustrative of the dynamic nature of priorities as during the first week of the response they were high-priority because of the prevailing cold weather. However, as the weather warmed up, blankets ceased to be high-priority and became a nuisance as hundreds of thousands of them—donated by other prefectures, and countries like Canada (25,000 blankets) and South Korea (6,000 blankets)—descended on Tohoku (Kyodo News, 2011a; 2011c) complicating the response. For instance, the Iwate Industry and Culture Convention Center had 100,000 blankets in excess of the 100,000 that were actually needed. Thus, at least 50% of the blankets that arrived at Iwate Prefecture were not used at all.

3.3 Summary statistics

The experience of prefectures and cities in setting up the PD-HL distribution network provides guidance for disaster planning purposes regarding how many DCs and RCs may be needed in similar operations. To this effect, this section analyzes the structure of the distribution network in relation to the number of internally displaced people (IDP) at the peak of the crisis. Table 2 shows the number of DCs, RCs, and IDPs for the prefectures and cities for which data were provided to the authors, together with the average number of IDPs per DC and RC. These estimates represent the average number of IDPs that ultimately

depended on a given DC or RC. In the case of the RCs, since many IDPs were staying in cars and abandoned buildings, the average number of IDPs/RC is not necessarily the same as the number of IDPs that stayed at the RC.

Table 2: Number of Distribution Centers, Refuge Centers, and Internally Displaced People

A) Prefectures			
Key statistics	Miyagi Prefecture	Iwate Prefecture	Fukushima Prefecture
Population Before Disaster	2,348,165	1,330,147	2,029,064
Distribution Centers (DCs)	20	13	22
Refugee Centers (RCs)	1,000	342	350
Internally Displaced People (IDPs)	440,000	100,000	30,000
Average Number of IDPs per DC	22,000	292	1,364
Average Number of IDPs per RC	440.00	292.40	85.71

B) Cities				
Key statistics	Ishinomaki	Kesennuma	Onagawa	Higashi Matsushima
Population Before Disaster	160,826	73,489	10,390	46,412
Distribution Centers (DCs)	19	3	1	2
Refugee Centers (RCs)	170	99	17	68
Internally Displaced People (IDPs)	71,000	17,000	5,500	13,712
Average Number of IDPs per DC	3,737	5,667	5,500	6,856
Average Number of IDPs per RC	710.00	171.72	323.53	201.65

The estimates show that, at the prefecture level, there was a wide range of conditions. Miyagi Prefecture had the highest average of IDPs/DC (22,000) and of IDPs/RC (440), while the Fukushima Prefecture had the lowest values. These results make sense as Miyagi Prefecture was the one that experienced the bulk of the physical damage, and the one with the largest population impacted by the disasters. The statistics for individual cities exhibit a narrower range. In terms of the average number of IDPs per DC, Higashi Matsushima had the highest value (6,856 IDPs/DC) and Ishinomaki the lowest (3,737 IDPs/DC). However, in terms of the number of IDPs per RCs, Ishinomaki had the highest value (710 IDPs/RC) reflecting the heavy damage that the city suffered.

Although the authors did not have access to the number of DCs and RCs that were specified in the disaster response plans, the information gathered for one of the cities indicate that the actual numbers were four times larger than the ones specified in the plan. This clearly illustrates the significant difference in the magnitude of needs between disasters and catastrophes.

4. DETAILS OF THE HUMANITARIAN LOGISTIC RESPONSE

This section provides additional information about the operations enacted by the agencies, local governments, and companies interviewed as part of this research. To the extent possible, the discussion in this section does not duplicate the information provided in Section 3.

4.1 Ministry of Land, Infrastructure, Transportation and Tourism

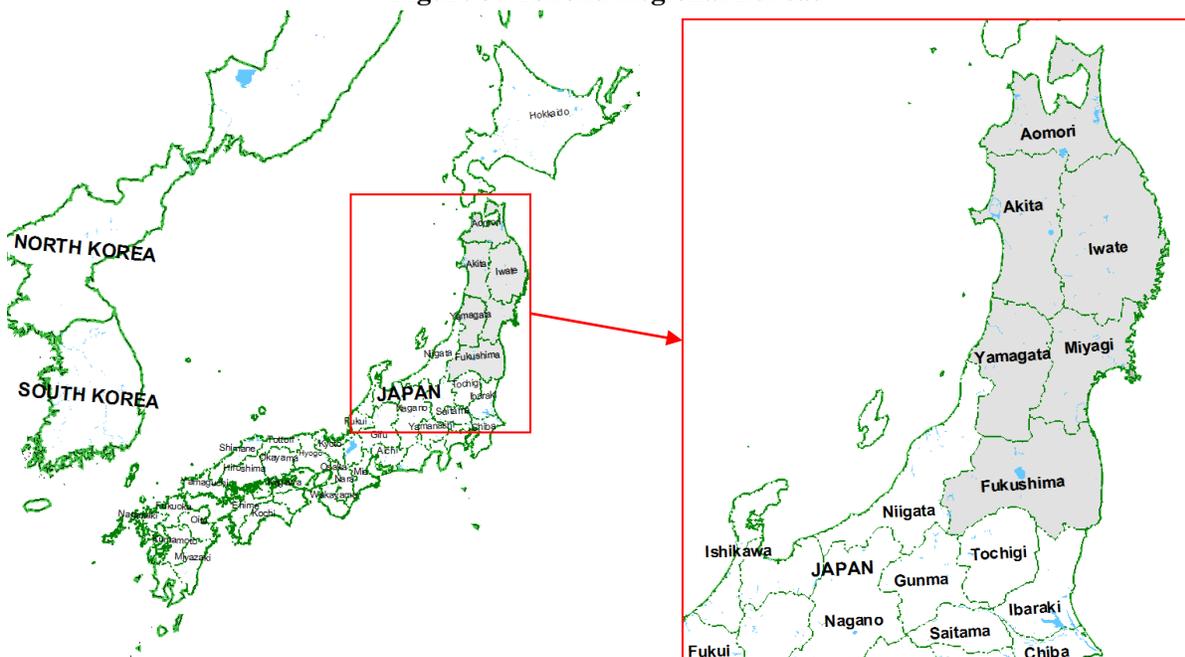
The Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) is the result of the integration in 2001 of four former ministries and agencies (MLIT, 2001). The MLIT overall functions are performed by a set of bureaus and departments, including: policy and planning, national and regional planning, city and regional development, housing, road transport, maritime, ports and harbors, civil aviation, nine regional bureaus, among others. The MLIT is in charge of regulating land use; operating and maintaining public infrastructure; developing and implementing transportation policy, and maintaining marine safety and security. Of significance to the response is that the MLIT includes the Japan Coast Guard, and the Japan Meteorological Agency (Government of Japan, 2008), which allowed the MLIT to get direct access to the resources of two agencies of critical importance to the response to a tsunami.

The MLIT—particularly its Tohoku Regional Bureau—played a key role in the response. These operations benefited from previous disaster preparation efforts—some of them based on the lessons from the 1995 Kobe earthquake—which included: the creation of a multi-agency Disaster Control Room (DCR), signing of contracts with construction companies, and coordinated use of vehicles specially designed to be field control stations at construction sites, which are equipped with satellite communications and video capabilities. Figure 3 shows the jurisdiction of the Tohoku Regional Bureau.

Immediately after the disaster, the MLIT used the helicopters stationed at the Sendai Airport—spared of damage because they took off when the tsunami warning was issued—to inspect the damage. The inspections clearly indicated that the most serious damage had been on the infrastructure close to the coastal areas, and on the inlets of water that allowed tsunami waves to penetrate inland. The Sendai East Motorway suffered major damage though, by virtue of being elevated 3-4 m above ground level acted like a dike that prevented further damage to the West. Thus, the Tohoku Motorway was spared of major damage though the earthquake produced numerous pavement undulations.

The state of the art DCR, located at the Sendai Headquarters of the Tohoku Regional Bureau, quickly became the hub of the regional response. The MLIT promptly decided that the main priority would be to open the East-West arterials that connect the Tohoku Motorway to the coastal areas to the East (hence the name “Comb Operation”). To this effect, the MLIT called on the construction companies under contract and charged them to clear the roads by pushing debris out of the way. By the next day (March 12th, 2011) 11 out of the 16 arterials roads connecting the Tohoku Motorway to the Sendai East Motorway had been re-opened. This operation, a joint effort with SDF, was successfully completed one week after the tsunami (MLIT, 2011a). Both MLIT and SDF brought temporary bridges and boats to expedite the response.

Figure 3: Tohoku Regional Bureau



To restore communications with the field, 180 field control vehicles were sent to the field within two days after the disaster. The bulk of these vehicles came from other bureaus as the Tohoku Bureau did not have enough of them. In addition, more than 250 staffers arrived from other regions to provide administrative support and expedite contracts. The MLIT provided the mayors of the impacted cities access to a webpage so that they could upload infrastructure related requests for assistance (though it is not clear how useful this was as the Internet was down for at least two weeks). According to the staff, 91% of the requests had been satisfied by March 31st, 2011. The consensus among interviewees is that the opening of roads and restoration of infrastructure was a major success.

4.2 Miyagi Prefecture

The Miyagi Prefecture—the most heavily impacted by the disasters—covers an area of approximately 7,285 km² and is home to more than 2.3 million people. The cities most affected were: Ishinomaki (160,385), Kesenuma (63,841 inhabitants), and Minami-Sanriku (16,294 inhabitants) (Vervaeck et al., 2011). The prefecture is located on the Pacific coast, 300 km northeast from Tokyo, in the central part of the Tohoku region. On the West and North-East is surrounded by three mountain ranges with a large central plain near the capital city of Sendai (Miyagi Prefectural Government, 2011). In total, the prefecture is comprised of 36 municipalities (13 cities, 22 towns, and one village). The city of Sendai (1,045,986 inhabitants), only 130 km West of the epicenter, was spared of major damage because it is located about 6 km inland where the tsunami did not reach (only the suburbs located in the coastal areas were impacted). Thus, the economic and political center of Tohoku—where the headquarters of public agencies and private companies are located—was able to play a key role in the response. A map showing the damaged areas is shown in Figure 4.

Figure 4: Areas Affected by the Earthquake in Miyagi Prefecture

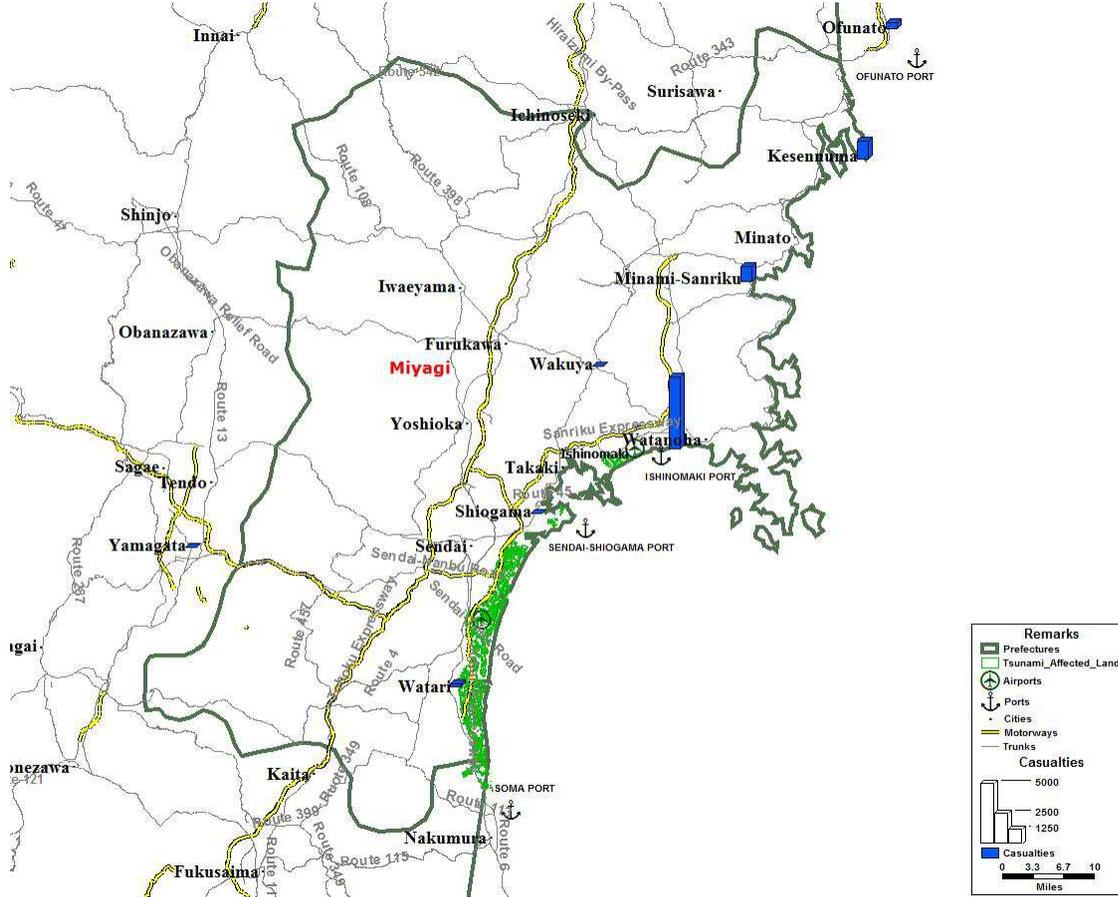


Table 3 shows population, fatalities, and IDPs in shelters for three different dates after the disaster for the five most impacted cities in the prefecture. As shown, some of the towns in the prefecture were heavily impacted, and the prefecture itself lost 3.11% of its population to the disaster. The city of Ishinomaki was the one that lost the largest number of individuals, while Minami-Sanriku lost the largest percent of its population with 7.40%.

Table 3: Fatalities and People in Shelters in Miyagi Prefecture

City	Population	Number of:			% Fatalities	IDPs in Shelters by:		
		Dead	Missing	Total		16-May	20-May	16-Jun
Ishinomaki	160,835	3,097	2,770	5,867	3.65%	20,993	8,776	6,030
Kesennuma	63,841	973	494	1,467	2.30%	12,656	4,402	2,812
Minami-Sanriku	16,294	541	664	1,205	7.40%	9,500	4,029	2,755
Higashimatsushima	35,522	1,039	142	1,181	3.32%	7,184	2,431	1,466
Natori	69,311	910	109	1,019	1.47%	1,781	880	13
Total	345,803	6,560	4,179	10,739	3.11%	32,274	20,518	13,076

Source: Adapted from Vervaeck et al. (2011)

The Miyagi Prefecture's response plan only considered a small disaster, identified a handful of DCs and RCs, and included a cooperation agreement with the JTA to bring supplies to the DCs operated by the

prefecture (they also had agreements with construction companies for debris removal and construction work). Neither the disaster plan, nor the agreement with JTA, specified who would deliver supplies to the RCs, or how the DCs and RCs would be manned.

Immediately after the disaster, the staff used the SDF helicopters at Sendai Airport to assess the damage. The inspections revealed that although most bridges had survived, many of their foundations had been scoured by the tsunami. As in the MLIT case, the agreements with construction companies helped expedite road openings and debris removal. However, the most immediate needs were power, fuel, and communications. The lack of power impacted the response as few activity centers had emergency power generators. Fuel was a major problem as access to the gas tanks that survived the disaster was blocked by damaged roads and debris, which forced the use of rail to transport the fuel though taking a longer route (from the Japan Sea to Morioka City, and then to Sendai). Communication was a challenge as Internet and phones were not working. Although battery operated satellite phones were distributed, the small number of them (1-2 per municipality) did not allow to get in touch with the RCs. When the batteries ran out of energy, they had to improvise mechanisms to charge them. At some point in the crisis, congestion in the satellite network produced additional problems.

The PD-HL network that emerged after the disaster was based on two complementary flows of goods: long-haul transport to the DCs in Miyagi Prefecture, and another flow from these DCs to RCs. Due to the chaos that ensued, some DCs were under the supervision of the cities, and others were under Miyagi Prefecture's. In most cases, these improvised DCs were public facilities (e.g., gyms, schools, parks) that were taken over as part of the response. Only some of them had been previously identified in the prefecture's and cities' disaster plans. Since the disaster plans had not made any provisions about how to staff DCs and RCs, they had to hastily assemble volunteers to meet the manpower needs. Thus, the workforce gathered did not have the technical expertise required for DC operations, leading to inefficient operations and waste of resources.

A total of about 20 DCs, and more than 1,000 RCs serving 440,000 IDPs, were in operation at the height of the crisis. Reflecting the size of the event, the number of DCs actually required was much higher than the one envisioned in the disaster plans, as additional DCs had to be brought in line to deal with the huge inflow of cargo. A major problem at the DCs was the lack of refrigeration capacity due to the Japanese diet that emphasizes the consumption of fresh perishable products. The staff indicated that, due to the damage at production sites in the Tokyo area, supplies had to be transported from the much farther away Kansai area. The longer long-haul distances increased delays to receive supplies. It took about one-two months for production sites in nearby areas to return to normality. With regards to prepositioning of supplies, the staff indicated that they had prepositioned some but that the amount was too small for a disaster of this magnitude. They also had agreements with local businesses to take over their commercial inventories in case of a disaster. Unfortunately, this did not work as many of these businesses were also heavily impacted or destroyed by the tsunami.

It is interesting to note that, when asked about non/low-priority donations, the respondents indicated that they "...were not a problem..." as TV ads discouraged private donations, and "...municipalities only accepted donations from companies, public agencies, and governments..." However, the information collected during the field research suggests that the campaign to discourage unsolicited donations was considerably less successful than these officials thought.

4.3 Iwate Prefecture

The Iwate Prefecture is located in the North-East region of Japan, North of Miyagi and East of Akita Prefecture (see Figure 5). With an estimated area of 15,278 km² is the second largest prefecture after Hokkaido. Iwate Prefecture is home to approximately 1.38 million individuals, with about 290,000 of them living in the capital Morioka, where the Prefectural Government is located. The prefecture has 13 other cities, 16 towns and 6 villages (Iwate Prefecture, 2012). Morioka is also home to a large number of semiconductors and communication devices industries. In addition, food and beverages, metal products, transportation and general machinery, and tools are the main industries in the prefecture (JETRO, 2012).

Table 4 shows fatalities and IDP for the five most affected cities in Iwate. The numbers show that, although Iwate Prefecture had fewer fatalities than Miyagi Prefecture, it lost a larger percent of its population (4.35% vs. 3.11%). Some of its cities suffered major damage. For instance, Rikuzentakata (21,262 inhabitants) and Otsuchi (13,811 inhabitants) were completely destroyed. The data show that by June 16th almost half of the population in Rikuzentakata, one of the towns most heavily damaged, was still in shelters. Moreover, the disaster destroyed 9,672 of the prefecture's fishing vessels, damaged 108 of 111 ports, wiped-out nearly all of the prefecture's fish processing centers, and caused ¥371.5 billion in damage to the prefecture's fishing industry (Fukada, 2011). The most affected cities and corresponding numbers of dead and missing (Vervaeck et al., 2011) were: Rikuzentakata (1,515 and 618), Otsuchi (779 and 827), Kamaishi (864 and 389), Yamada (578 and 267), and Miyako (417 and 355) (see Figure 5). In some cities the leadership was decimated, which posed major complications as the prefecture did not have pre-established contacts with the individuals that took over the response. For instance, in Rikuzentakata 30% of city employees died; and, in Otsuchi, city leaders were meeting close to the seawall when the tsunami struck (only the vice mayor survived). The prefecture faced numerous challenges including lack of information about road conditions as the only way they had to find out which roads were passable was to send staff from the prefecture's satellite offices to inspect the roads.

Table 4: Fatalities and People in Shelters in Iwate prefecture

City	Popu- lation	Number of:			% Fata- lities	IDPs in Shelters by:		
		Dead	Missing	Total		16-May	20-May	16-Jun
Rikuzentakata	21,262	1,515	618	2,133	10.03%	78	13,408	10,058
Otsuchi	13,811	779	827	1,606	11.63%	34	5,777	5,369
Kamaishi	41,360	864	389	1,253	3.03%	50	6,303	3,270
Yamada-machi	16,959	578	267	845	4.98%	32	4,532	2,581
Miyako	57,406	417	355	772	1.34%	26	5,372	2,423
Total	150,798	4,153	2,456	6,609	4.38%	220	35,392	23,701

Source: Adapted from Vervaeck et al. (2011)

Figure 5: Areas Affected by the Earthquake in Iwate Prefecture

financial responsibility for the relief operations without any assurances that the national government, or the cities themselves, would reimburse the expenses.

Iwate Prefecture started to receive emergency supplies on March 12th. Until March 13th, the supplies were stored at the Japan's Agriculture Association's warehouse which only had 3,600 m² of space and was quickly filled with water, blankets, and food. Because of the magnitude of the inflow, they were forced to set up a DC at the Iwate Industry and Culture Convention Center on March 14th with the support of ten JTA staffers paid by the prefecture. To cope with the increasing volume of cargo, the staff at the DC was increased to 50 staff on March 15th, which is when they put together a basic plan to manage the DC. However, on March 16th, the prefecture workers—who did not have any training on warehouse operations—were deemed ineffective and replaced with 30 workers from JTA that coordinated the work, 20 prefecture employees receiving and dispatching supplies, and 10 employees working on administrative matters. During the period March 11th-April 29th the DC operated 24 hours/day. After April 29th, 2012 it only worked 12 hours/day. The main DC delivered supplies to 12 DCs at various cities.

At its peak, 70 10t trucks arrived loaded with supplies every day. However, on average, only 40 trucks (a mix of 4t and 10t trucks) departed with supplies for the city DCs. This led to a rising inventory that forced the installation of eight large industrial tents in the parking lot of Iwate Industry and Culture Convention Center to store the non/low priority cargo (i.e., shoes, blankets, water, toilet paper, and facemasks). As an example of the large inventory: on May 17th, 2011 the DC had 700t of water (enough water to satisfy the needs of about 700,000 people for one day), and 100,000 blankets (in excess of the 100,000 they estimated were needed). The fact that neither were needed confirmed previous observations concerning non-priority donations after large scale disasters.

From the logistics perspective, the flows of goods were not organized as at first all donations went directly to the prefecture DCs causing significant problems as they overwhelmed responders. Then, the supplies were sent directly to the cities, which transferred the problem to cities with even lesser capacity to deal with the enormous inflow of cargo. Due to the lack of information, the staff did not know what/how much cargo was going to come which was a major problem for operational planning. In all cases, perishable foods were sent directly to the cities due to the short expiration times and urgent needs.

As in all other cases reported here, donations of non/low-priority items were a problem. In addition to the excess of waters and blankets, clothing was also a problem. Although initially there were no restrictions on clothing, they were quickly forced to announce at their website that clothing was no longer accepted. As stated earlier, 40-50% of the floor space at the Iwate Industry and Culture Convention Center was taken by the clothing donated by companies, which required the use of one third of its 60 workers for sorting (the staff indicated that another DC was handling the clothing donations made by individuals). In light of the experience in previous disasters indicates that the bulk of clothing donations are the work of individuals that typically collect them in donation drives, one could expect that the DC handling individual donations also had to manage a huge volume of clothing.

4.4 Fukushima Prefecture

The Fukushima Prefecture, located in the southern part of the Tohoku region, covers an area of about 13,783 km² with a population of 2.03 million people. Fukushima is the closest prefecture to Tokyo, and the entry point to the Tohoku region. The prefecture has ten cities and 80 townships and villages. The main cities are Fukushima, Koriyama, Shirakawa, Iwaki, and Aizu-Wakamatsu (see Figure 6). Due to its proximity and good access to Tokyo, the southern part of the prefecture is a popular place of residence for

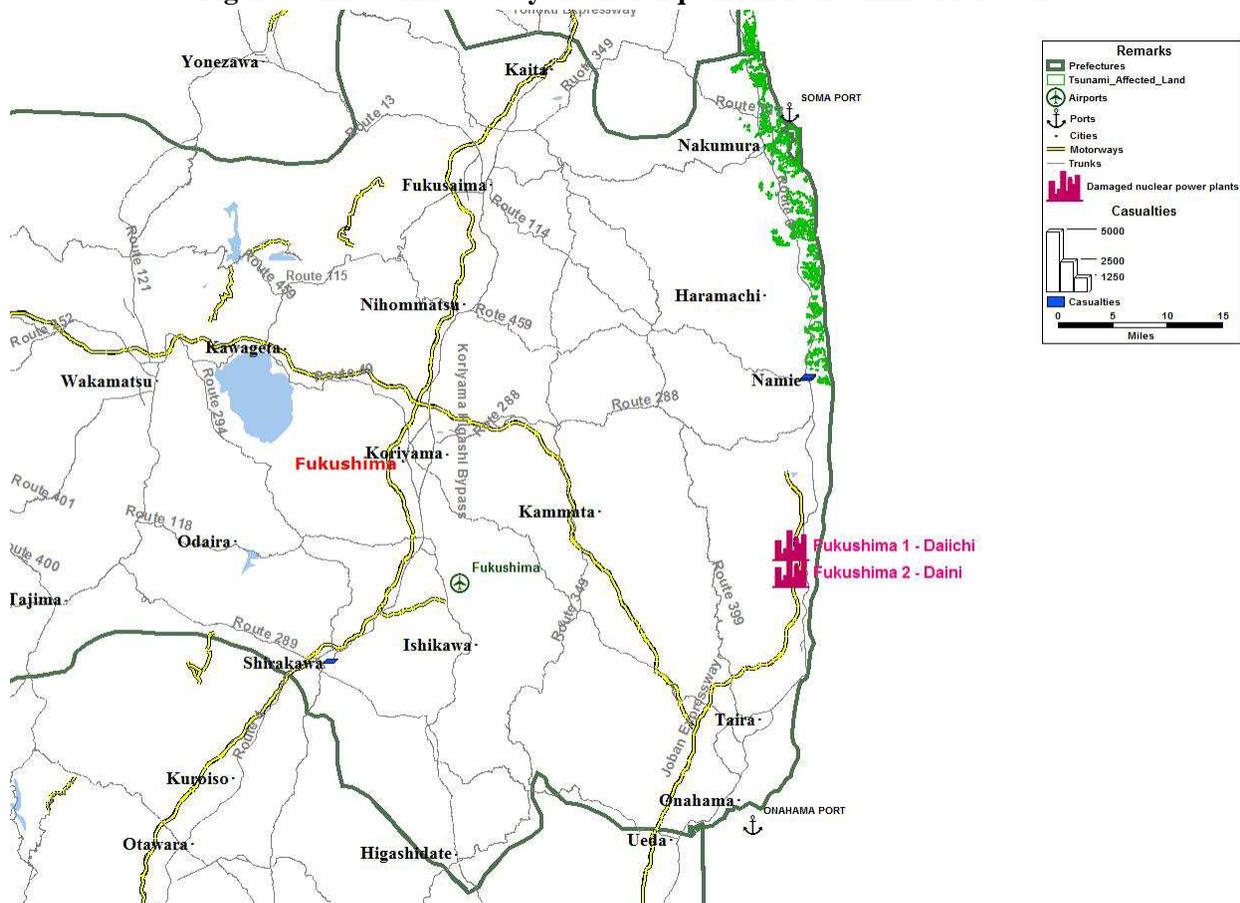
Tokyo workers (Government of the Prefecture of Fukushima, 2012). The prefecture’s economy is based on information and telecommunications, manufacturing of electronics, electrical machinery, chemicals, beverages, and fishing (JETRO, 2012). In addition, the prefecture is home to a large nuclear power generation industry, including the Fukushima Daiichi Nuclear Plants. Figure 6 shows the impacted area and Table 5 shows total fatalities and IDPs in shelters for the five most affected cities in Fukushima. Compared with both Miyagi and Iwate Prefectures, the number of fatalities in Fukushima is much smaller as the key challenge here was the nuclear crisis.

Table 5: Fatalities and People in Shelters in Fukushima

City	Popu-lation	Number of:			% Fata-lities	IDPs in Shelters by:		
		Dead	Missing	Total		16-May	20-May	16-Jun
Minamisoma	69,171	542	151	693	1.00%	5,713	2,627	2,627
Soma	37,843	432	27	459	1.21%	4,623	1,413	1,413
Iwaki	341,983	306	50	356	0.10%	4,332	2,979	2,979
Namie-machi	18,866	96	87	183	0.97%	17,793	4,092	4,092
Shinchi-machi	7,141	95	18	113	1.58%	787	583	583
Total	475,004	1,471	333	1,804	0.38%	33,248	11,694	11,694

Source: Adapted from Vervaeck et al. (2011)

Figure 6: Areas Affected by the Earthquake in Fukushima Prefecture



The earthquake and tsunami damaged Route 6 and the Yoban Motorway though the Tohoku Motorway was in relatively good shape and provided access to the prefecture. However, the most severe problems were produced by the nuclear crisis, which quickly became the main government's focus of attention, at the expense of the PD-HL effort. As expected, communications were a major problem as the regular phone service collapsed. During the crisis, they used five satellite phones and 50 priority cell phones (with preferential bandwidth), which had been purchased before the disaster and worked very well. Upon noticing how well these cell phones were working, they were collected and redistributed among the key staff overseeing the response.

As in the other localities the disaster plan was inadequate. First and foremost, in spite of the higher risk imposed by the presence of numerous nuclear power plants in a coastal area prone to tsunamis, the PD-HL disaster response plan was no different than the plans at the other prefectures. The plan was that the prefecture would arrange transport of supplies to the city DCs, and that from there somebody else would do the local deliveries to the RCs. The disaster plan was quickly abandoned. In terms of preparation, disaster exercises took place every year, though none of them included relief distribution at a large scale. The only exercise reported with a focus on PD-HL involved transportation of supplies from a shopping mall to a single RC. When asked if they thought that more realistic exercises would have helped, they answered "...yes, depending on the quality of the exercise, it could be helpful..." (Taniguchi et al., 2011c).

The complex crisis in Fukushima presented numerous and difficult challenges. To start with, the decisions made by the government to deal with the nuclear crisis segmented the population into numerous groups with significantly different needs. These decisions, though justified on safety grounds, added complexity to the already challenging PD-HL effort as each segment required a different approach. First there was the case of cities that were completely evacuated, which led to the challenge of relocating and supplying the IDPs at their new locations. In this case, the main responsibility of assisting the IDPs fell on the prefecture as the ability of the corresponding city leaders to help was hampered by the fact that they also became IDPs. The second case involved cities that were partially evacuated, in which the city and the prefecture collaborated in the effort. In this case, both the population that evacuated and the one that stayed behind needed supplies though for different reasons. In the case of the evacuees, they needed supplies because left behind their possessions. The residents that remained behind—even those in areas that had not suffer major physical damage—needed relief supplies because of the interruption of the regular flow of supplies produced by the refusal of untold number of truck drivers to enter the prefecture. The third case is the one of residents inside the exclusion zone that stayed indoors to avoid nuclear contamination, e.g., the case described by the Mayor of Minami Soma (Sakurai, 2011). In this case, the challenge was to find truckers willing to deliver supplies (or fuel, to enable the residents to leave the area) in spite of the nuclear risk. The fourth case included those cities outside the exclusion zone where no mandatory evacuation took place, which needed relief supplies because of the diminished flow of cargo via private sector supply chains that affected the prefecture.

The interviews highlighted that the risk (perceived and real) of nuclear contamination severely curtailed the flow of regular private sector supplies to the Eastern part of the prefecture—perceived to be the one most at risk of nuclear fallout—though it was most severe in areas closer to the nuclear plants where regular supplies completely ceased to arrive. The nuclear risk also negatively impacted the sales of the products manufactured and/or grown in the prefecture as potential buyers shied away from them. Soon

after, the prefecture entered an economic depression which was identified by the staff as another crisis they had to deal with.

The prefecture had agreements with both the Fukushima Trucking Association (FTA) to transport and distribute relief supplies, and with retailers to get the supplies needed in an emergency. Once the disaster struck, representatives of the trucking and warehouse associations became part of the command center. In contrast with the other cases discussed in the paper, the FTA assumed from the very beginning of the crisis that they will be in charge of the local distribution of the relief aid (though it was not clearly specified in the agreement), which according to the interviewees worked well.

The flow of relief supplies took shape in two forms. In the first one, the prefecture (or companies on behalf of) transported supplies to the DCs at the various cities, and from there the cities distributed to the RCs. Such strategy was used to supply small RCs. In other cases, the prefecture delivered supplies directly to the RCs, which was typically the case of fresh food deliveries, and shipments to large RCs. They felt that the quality of the requests received from cities and RCs was suspect, though they decided not to check the requests.

In spite of the dampening effect produced by the nuclear crisis, the Fukushima Prefecture received significant amounts of supplies. Due the large influx, the first warehouse became full by March 13th. Ultimately, 22 warehouses had to be put in service with ten of them dedicated to sorting, storage, and distribution, and the remaining twelve for storage only (of most likely non/low-priority supplies). Private operators tried to help by reducing the amount of business they did at the warehouses involved in the response. Due to difficulties in managing such complex logistics, the prefecture decided to specialize warehouses on one type of supply (e.g., clothing, food). They admitted being unprepared for the challenge as before the disaster, they "...did not have an idea about what a DC was..." In total, 30,000 internally displaced people (IDP) were housed at 350 RCs at the peak of the crisis. By May 12th 2011 these numbers were to 8,000 IDP at 142 RCs; and 16,000 IPDs living at 491 hotels.

Non/low-priority donations were also a problem. Used clothing was reported as the most problematic because it had to be washed before being distributed. They tried to refuse such donations to no avail as even other prefectures sent clothing. Other items donated in excess of needs include: facemasks, water, and blankets that had to be stored and were not used during the crisis.

4.5 *Ishinomaki City*

Ishinomaki City had a pre-disaster population of 163,517 inhabitants and an estimated area of 555.78 km² making it the second largest city in the Miyagi prefecture. It is located at the mouth of the Kitakami-gawa River, and its economy was based on fishing and seafood processing, shipbuilding, and paper and pulp industries (City of Ishinomaki, 2011). The industrial area of Kadowaki and other port areas were completely destroyed by the tsunami and subsequent fires. The downtown area was flooded and many shops, restaurants, and apartment building were severely damaged. Besides the economic and physical losses, more than 5,000 people were reported dead or missing (ADRC and IRP, 2011). The city was one of the most severely affected by the disaster.

As part of the original, and quickly abandoned, disaster response plan, the city had identified the locations for five different DCs. The city also had an agreement with JTA to transport supplies to the DCs in the city, though it did not guarantees delivery times, or considered local relief distribution. The city conducted disaster response drills every year. From time to time, these exercises included the

transportation of critical supplies, from the SDF base at the airport (which would be destroyed by the tsunami) to a DC in the city. However, none of these exercises considered the local distribution, which became the biggest challenge in the aftermath of the disaster.

As expected, the JTA agreement was activated during the response. However, as typical of catastrophic events, the local businesses could not help much because 87 out of 150 local transport companies were destroyed or severely impacted. Thus, the initial response fell on the shoulders of SDF, which was overwhelmed due to the vast disaster area (approximately 155 Km²). As part of the operations, a large DC was improvised at a public park near the city center with an area of about 142,000 m². In addition, due to the lack of prepositioned supplies city officials were forced to requisition supplies at two large AEON supermarkets to address the needs of IDPs. This provided an estimated "...one meal a day..." and required 20 trips of 2t trucks yielding about 40t of supplies. The staff estimated that the food obtained from the supermarkets and SDF was enough for 5,000 individuals though 80,000 survivors needed food and water. Two or three days after the tsunami, due to the lack of relief supplies, people broke into convenience stores and warehouses in the Watanoha area to get the supplies stored there. The staff at the emergency operations center reported not having anything to eat for three days. During the first week, the city did not receive supplies from the outside world as the only supplies available were the ones requisitioned from local businesses which, as said, were not enough to satisfy the needs of the population.

As in other areas, communication was a big problem. Emergency managers indicate that "...one out a thousand calls went through..." the normal phones. Three days into the crisis, the city received five satellite phones which they found difficult to use due to lack of training. A special phone line connected the prefecture, the city government, and the Red Cross hospital to share information and improve coordination. The staff indicated having major difficulties in getting information about special needs at the RCs, while assessing the needs for basic items (e.g., food, bread) were less of a problem.

In addition to the challenges in setting up the PD-HL network, city officials had to contend with fuel shortages and limited information about road conditions (which were being inspected by the SDF teams). Moreover, the arrival of truckers not familiar with the area complicated the response as they needed guides to be able to find the RCs. The staff mentioned the case of a convoy of three trucks that had to visit, as a convoy, their three different destinations because there was only one guide that could take them there. The formal distribution of relief supplies began on March 19th. A frequent problem that vast amounts of perishable products arrived past the expiration dates. In order to reduce spoilage of perishable food items, Sagawa was assigned the task of delivering them (i.e., food, bread, and onigiris or rice bowls), while the SDF distributed less urgent products. The requests for supplies were managed by the city council that informed Sagawa and SDF of the needs at the RCs.

Similarly to the other cases discussed here, the city had to manage a large amount of donations including significant amounts of non-priority items that arrived in all transportation modes and had to be stored by the SDF. Sprouted potatoes and expired foods were identified as the most outrageous donations. It was also reported that unscrupulous individuals, interested in seeing the disaster area, pretended to transport donations to avoid paying the toll (delivery trucks were waived tolls during the response).

4.6 Kesenuma City

Before the earthquake, Kesenuma City had 73,000 inhabitants, a vibrant fishing industry, and an area of 333.37 km². Located in the North Eastern part of Miyagi Prefecture, Kesenuma City was heavily hit by the tsunami and fires that lasted about four days and destroyed more than a third of the city buildings

(Davis, 2011; Thomson, 2011). According to measurements taken at the City Council building the city was hit by 10 m tsunami waves.

Soon after the disaster struck, the response plan was abandoned and the staff had to improvise DCs and RCs. For instance, the local gym that in the plan was supposed to be a DC was used to house IDPs; and, an old vegetable market was used as a DC as it had a good highway access that allowed the use of 10t trucks to serve it. In the initial days of the response, four companies (i.e., Yamato, Sagawa, Nittsu, and Akabo) volunteered to do relief distribution and assist with other tasks such as inventory control, and warehouse operations. During the response, the city had three DCs, operated by Yamato and SDF. Two additional DCs served two nearby towns. Overall, the SDF was in charge of receiving the goods, and Yamato of distributing to the more than 50 RCs spread all over the city. To facilitate sorting and distribution, high priority supplies were sent to the main DC, and non/low-priority donations to a secondary DC. The city staff indicated not having any kind of expertise on logistics and, particularly, on how to transport the relief supplies to the RCs or operate the DCs. For instance, when forklifts arrived to the DCs on mid April, the staff did not know how to operate them and had to request help from truckers which promptly helped them. The city had prepositioned supplies, though not enough.

Not surprisingly, the location and number of RCs did not follow any plan, as they were opened according to demand and availability of suitable buildings. At the peak, there were 17,000 IDPs in 99 RCs though by March 21st, 2011 the number had come down to 15,840. At the time of the authors' visit on May 17th, 2011 there were about 4,500 IDPs living at 48 RCs. Unlike Ishinomaki City where officials reported many people living in cars, in Kesennuma, many individuals stayed at the top floors of damaged buildings due to lack of space and poor conditions at RCs.

The staff reported that the lack of physical access to the RCs was the biggest obstacle to the operations. Since information about road conditions was not available at the beginning of the crisis, the operations were planned on the basis of the reports provided by truck drivers and the SDF. This produced problems as there was no uniformity on the assessment of road conditions. A complicating matter was that the subsidence of the ground (up to a 1 m) led to flooding in high tide, which hampered the effectiveness of road inspections by air. In the initial days of the crisis, the transportation of supplies took different forms. The SDF used helicopters with fishnets to transport supplies to isolated areas. These single blade units could transport either 6t of supplies or 20 people. The Japan Fishing Association dispatched four boats (50t capacity) that were used to transport supplies to coastal areas. Once roads were opened, bicycles were used to deliver supplies because the lack of fuel prevented the use of motorized vehicles.

Communications were a major challenge. Only after satellite phones arrived on March 12th, they were able to communicate with the RCs and the outside world. Later on, AEON donated 15 satellite phones which were a great help. In regards to other forms of communication, the internet was not available (fiber optic cables had been severed), there was no power, and normal phones were not working (service was restored on March 25th).

The city was taken by surprise, and its facilities overwhelmed, by the inflow of unsolicited supplies. Officials reported that more than half were unsolicited donations while the staff at the DCs indicated that non-priority supplies were a big problem. Donations of "...a lot of broken bikes..." and excessive volumes of clothing items were reported. At first, the staff at the DCs tried to refuse the donations which provoked angry reactions from the donors: "...people got offended when we tried to refused their donations..." and some said "...we are poor, we cannot donate more...". Then, the staff changed the

approach and told potential donors that donations would be “...postponed until further notice...” as they did not have space to store them. According to the staff, this approach worked fairly well. They also mentioned that after TV news indicated that blankets and food were needed, they were flooded with donations of these items which neutralized some of the progress made in discouraging people to donate unnecessary items. Out of respect for the donors, they did not discard anything. This decision produced major complications as it forced the staff to spend considerable resources trying to find a good use for supplies that should not have been sent there in the first place. Another problem was that they did not have any idea of what and when the cargo would arrive, which prevented making plans to deal with the supplies.

Regular shipments of supplies, from normal private sector channels, started to arrive on mid-April (a month after the event). Power and water systems were restored by the end of May while sewage was still not operational (something similar happened in Christchurch in 2011 (Ferreira et al., 2011)).

4.7 Yamato

Yamato Global Logistics Japan Co., Ltd. is the largest door-to-door parcel delivery company in Japan. The company offers trade logistics services and export factory services. The company operates from 32 offices throughout Japan and seven overseas locations (Yamato Global Logistics Japan Co. Ltd., 2008). The disaster had a major impact on Yamato’s operations as six out of the 69 DCs in Miyagi Prefecture were either damaged (five) or completely destroyed (one), though only one staff person died. As a result, business activities were suspended immediately after the disaster. Reflecting the challenge of recovering from a catastrophic event, it took them weeks to restart operations: on March 21st operations resumed for DC to DC flows, with business and home deliveries/pick-ups outside the disaster area resuming on March 25th. The expectation is that normal operations in the areas directly impacted by the tsunami would only resume—on account of the devastation—once the reconstruction starts in earnest.

The immediate reaction of Yamato staff was to assess the impacts on its workforce, facilities, and equipment. After the assessment was completed, they became increasingly involved in the response. In March 15th, 2011 they started to distribute relief supplies to survivors as a contribution to the community. Soon after, the SDF started to provide them with fuel. On March 17th, upon realizing that the local governments were not aware of the looming humanitarian crisis, they decided to volunteer its services and started to distribute relief supplies in earnest. In their words: “The cities did not think of using them. Humanitarian Logistics is not a priority.”

One of the immediate problems they found was that nobody seemed to know who was in charge of the relief effort, which delayed the start of operations. This was the result of the lack of planning for the PDHL effort and the impacts of the tsunami on the local leadership. For instance, at the city of Minami-Sanriku, half the city employees died, and a low level staff member was in charge of PD-HL. Similarly, they indicated that many government agencies (e.g., SDF, fire department) were operating without any kind of supervision or central command.

Reflecting the challenges of PD-HL operations, it took Yamato about a week to start the distribution (on March 24th). At first, they did not have any idea about where DCs and RCs were located. They indicated being overwhelmed by the challenge as: “...it was easy to get cargo in, but difficult to get cargo out to the people...” Furthermore, Yamato staff declared that “...last mile deliveries were a big problem... improving the flow from the DCs at the cities to the RCs was the key challenge...lack of information was a big problem...” as the requests for supplies were not always correct. Yamato managers indicated that

getting an accurate assessment of the needs at the RCs was extremely difficult. At first, they asked the staff of the municipalities to estimate the amount of supplies needed. This did not work well as city staffers did not know how to estimate the amounts of cargo needed at the RCs. Later on, they changed the approach and simply asked the city staff to report the number of people that needed a given product, leaving to Yamato the task of estimating the amounts of supplies needed. During the first week, the information was gathered by the drivers when they visited the RCs. In the second week, they started to use cell phones when communications were reestablished.

Yamato's main roles were to transport relief supplies from the prefecture DCs to the cities DCs, and from there to the RCs. Operating from four DCs in Sendai, on the typical day, they made 30 vehicle-trips (10t capacity) to deliver supplies to the DCs for a total of 1,200t/day. On March 19th, the Miyagi Prefecture arranged for 3-4 DCs (6.6 Ha of floor space) to supplement the original four DCs. The addition of these DCs doubled the amount of cargo distributed to 2,400t/day. The supplies came from Miyagi, prefectures, municipalities, and the SDF (which was in charge of delivering fuel to the DCs). At the peak of the operation, Yamato delivered supplies to 20,000-30,000 survivors located at 120 RCs. The operations in Miyagi Prefecture used 700 vehicles (about 530 2t trucks, and 170 3-axle 10t trucks used for long-haul). Since Yamato paid for the first week of supplies and the delivery costs (except the fuel supplied by SDF) until April 9th, when they were hired to distribute relief supplies, the expenses incurred likely reached tens of millions of dollars.

For the most part, Yamato used small trucks (2t capacity) to make local deliveries because they were the only ones that could maneuver the narrow local streets clogged with debris. The delivery operations depended on the size of the RC. In the case of large RCs the deliveries were made by convoys of small trucks. In other cases, a single truck was sent with a full load from the DC to some RCs (point to point delivery). Small shipments to small RCs were delivered in tours of 2-3 delivery stops.

In contrast to the opinions provided by government officials, Yamato managers indicated that non-priority donations were a major problem. They estimated that 70% of the cargo they handled at the DCs should not have been sent there at all, and that new/used clothing and blankets were the biggest problem. They started to receive a normal amount of fuel at the beginning of April when power was restored and fuel became available (though the fuel tanks in the area were not yet accessible).

4.8 Sagawa

Sagawa is a core operating company of the SG Holding Group. The company offers transportation and delivery related services, and has a significant presence in the door-to-door delivery market in Japan. The company has over 45,000 employees and 26,000 vehicles. The company headquarters are located in Kyoto with other 14 branches and offices distributed across Japan. The company has a large presence in the Tohoku region with more than 45 sales offices (Sagawa Express Co., 2012).

Sagawa's operations were directly impacted as three out of its 43 DCs in the Tohoku region were seriously damaged. To complicate things, the company was in the process of shifting their vehicular fleet to natural gas. Since the earthquake damaged the natural gas pipeline to their main terminal in Tohoku, all of the sudden 100 out of their 180 trucks in the region did not have the fuel they needed (SDF only transported gasoline and diesel to the disaster area). Fortunately, a second pipeline from Niigata became operational, and Sagawa was granted second priority (after hospitals).

Upon hearing the news of the disaster, Sagawa headquarters immediately dispatched 200 trucks (100 2t, and 100 4t trucks) from their Tokyo DC to Miyagi Prefecture to help with the relief effort, and sent one of its directors—who responded to the 1995 Kobe earthquake—to help manage the crisis. Soon after, Sagawa staff approached Miyagi Prefecture and offered to help with the response. The first delivery occurred on March 18th, though work began in earnest on March 19th on the cities of Ishinomaki (100 RCs) where they used 13 vehicles to serve the needs of 43,647 people; and Onagawa (1 DC, 17 RCs) with four vehicles (3t and 4t capacity) and 5,500 people. The city of Higashi Matsushima was added on March 23rd (2 DCs, 68 RCs) using 3t and 4t capacity trucks to serve 13,712 individuals. Eleven of the DCs were public facilities that were taken over for the effort.

Company staff reported that the number of people in RCs in Onagawa and Higashi Matsushima was relatively stable. In contrast, in Ishinomaki—where the RCs were in relatively small buildings—large numbers of survivors, that had to stay in cars because of the lack of proper conditions at RCs, were not included in the official count. For that reason, they believe that a more accurate number is on the range of 71,000 IDPs. The large number of IDPs living in cars complicated the effort as they moved from RC to RC in search of supplies. Thus, no one knew how many IDPs are actually staying at any given RC. The amount of cargo transported to Ishinomaki was very large. On average, during the height of the crisis, twenty vehicles made three delivery tours/day with 3t of supplies, i.e., 180t/day. Sagawa transported the fresh products typical of the Japanese diet, while the SDF took care of the non-perishables.

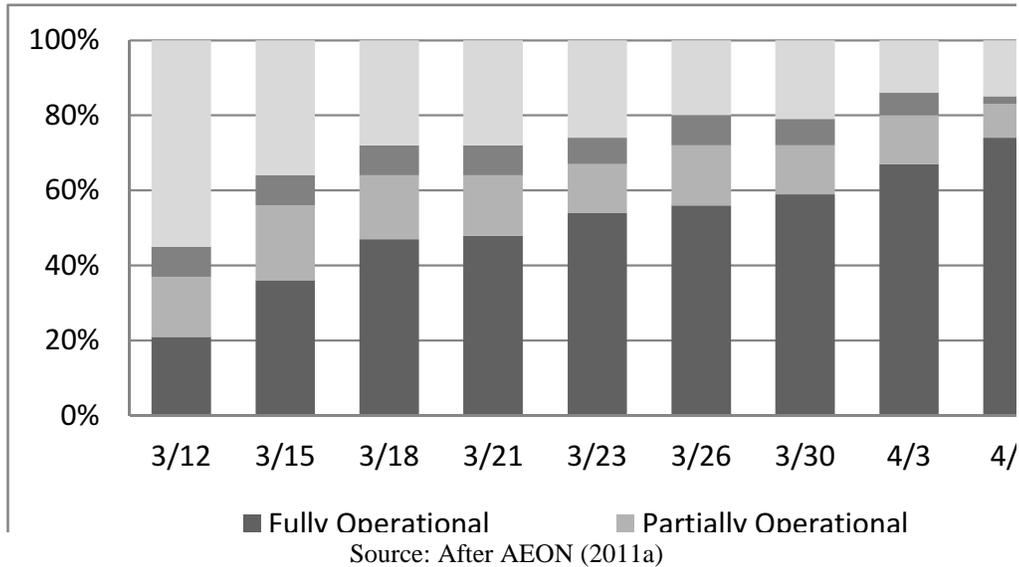
Sagawa staff complained about the quality of the information received about the needs. In one instance, ten days after the disaster, they were told that a section of the city had been evacuated. After an inspection, they found out 3,000 people living there. In most cases, the drivers asked RCs managers about the needs which were shared with SDF so that they could help meet the needs of IDPs.

Handling and sorting donations was a challenge. At Ishinomaki, the SDF was in charge of sorting the donated goods; while in Onagawa and Higashi Matsushima, the city staff took care of that activity. Non/low-priority goods were a major problem as about 50% of the goods received were not needed. The most problematic items were blankets, winter clothes, and portable toilets. In their opinion, by sending too many blankets, “...prefectures behaved as individuals...”. They indicated that the situation got worse when the roads were re-opened as the flow of unsolicited goods increased dramatically. Sagawa staff reported that 40 million Yen were stolen from a bank, and that warehouses located in the port areas in Ishinomaki were broken into by survivors in search of critical supplies.

4.9 AEON

AEON is a large retail group with 155 subsidiaries and 24 affiliates. The group operates retail and general merchandise stores, supermarkets, financial services, and amusement facilities. By February 2011, the AEON network had than 13,900 stores, with 11,800 in Japan (AEON, 2011b). The earthquake and tsunami had a major impact on AEON’s operations as a number of its facilities were impacted (AEON, 2011a): 65% of the 449 stores in Tohoku had to close, the Kesenuma shopping center was damaged, the DC in Iwanoma was hit by a 4 m wave that damaged 20 out of 85 trucks, the Kanto DC was operational though it took the staff a week to clear the debris, and the Ishinomaki Shopping Mall was occupied by 2,300-2,600 IDPs. As shown in Figure 7, one month after the disaster, about 16% of AEON stores in Tohoku had not yet re-opened.

Figure 7: Status of AEON stores in the Tohoku Region



Moreover, the Tohoku DC—that used to supply the entire Tohoku region—suddenly could not do so because part of the equipment and installations had been damaged by the earthquake. As a result, the Kansai DC took over the distribution of supplies to the West of the Tohoku region. Shortly after the disaster, 2,000 workers were deployed from Tokyo and Hokkaido to help restore the operations at the AEON locations impacted by the event. Fifty of these workers came to the Tohoku DC.

Lack of power significantly hampered operations as the equipment in the Tohoku DC uses electricity. They indicated being completely unprepared for such extended blackout (it lasted about a week) as their business contingency plan only considered a power outage of less than half a day, and the DC did not have emergency generators. The lack of power required the use of manual operations which significantly reduced productivity. The AEON staff reported being gladly surprised to find out that they could do the work as “...in the old days...” (Holguín-Veras et al., 2011c).

Communications were a major challenge. They only had one satellite phone, purchased before the disaster, that ran out of charge in a day. Then, they had to improvise a charging mechanism using a car engine to be able to use it. Phone land lines became operational on March 15th, and cell phones on March 25th. However, the Global Positioning System (GPS) used for vehicle routing—which has a dedicated Internet connection—did not suffer any interruptions enabling Tokyo headquarters to monitor the operations. Fuel was an issue though in a different way than what experienced by others. Although the AEON DC had both the trucks and all the fuel needed on account of the large fuel tanks on site, many of their truck drivers could not come to work because they did not have fuel to drive their cars to the DC.

AEON's response started about at 3pm on March 11th 2011. The two most immediate goals were to restore business operations, and provide relief support to cities and prefectures with whom AEON had contracts to provide supplies after a disaster. As expected, shortly after the tsunami, the prefectures of Miyagi, Iwate, and Fukushima, and 77 other municipalities invoked the agreements and asked AEON for help. Thus, they faced the dual challenge of recovering from the disaster and, at the same time, meeting their obligations with prefectures and cities. In total, about 2,000 employees in the Tohoku region

participated in the relief effort. Although AEON was not involved in local delivery of relief supplies, they noticed the problem others were having with the local distribution. At one point, the staff reported that 50% of the 10,000 onigiris (rice balls) that AEON delivered to a city DC went to waste because they could not be delivered on time. AEON also provided supplies to the SDF.

In order to meet the demands created by the needs of IDPs and increased purchases on the part of citizens and business in areas surrounding the disaster sites, AEON's supply chain was heavily supported by the Kansai Region DC. The AEON DC distributed supplies to major costumers, to cities' DCs, and to 30 RCs (three times a day). It is important to note that AEON's staff reported a major increase in demand—double than normal conditions—from customers outside the disaster area. In their opinion, store owners responded to increased demand by residents for food and water and rushed to order supplies. The surge in demand compounded the challenge as it took place when the capacity of the Tohoku DC had been reduced by 25%. The staff indicated having no experience on how to control such demand as their customers expected AEON to satisfy it in the midst of such a crisis. Something similar happened with fuel, though in this case AEON rationed fuel by setting a maximum purchase of 10 liters or 1,000 Yen.

The disaster led to the innovative use of the available transportation modes. Railways were used to transport supplies (e.g., water, milk) to Akita and Niigata; and from there trucks transported the supplies to the Tohoku DC. To improve coordination, a command center was created at the Akita DC to speed up deliveries. AEON staff mentioned the issues created by non-priority supplies, such as excessive blankets, which were at the top of the list of problem items, and that according to their estimates at least half were not needed.

5. LESSONS LEARNED

The interviews conducted with the participants in PD-HL efforts concluded with questions about the lessons they learned, what they advise others, and what they would do differently based on their experience. Their answers are summarized in Table 6, which shows that the responses are dominated by the perceived inadequacy of the disaster plans, and the importance of putting in place a number of steps to improve communication, coordination, and enhance efficiency of the overall response.

Table 6: Lessons Learned as Stated by the Interviewees

	Key lessons learned:	What to do differently, advise to others:
MLIT	Reality is more difficult than what described in the disaster plan. Planning for larger disasters is extremely important.	Communications with local MLIT offices should have been better.
Miyagi Prefecture	The response required resources that they did not have. Better communication equipment and helicopters were needed. The importance to have strong linkages between municipalities and prefecture. Biggest challenge: perishables and isolated towns.	To provide subsidies to municipalities so that they purchase satellite phones.

Iwate Prefecture	The importance of: (1) adjusting to conditions, e.g., allowing the person in charge of a DC to decide without consulting superiors worked well; (2) establishing a relationship with logistic companies before the disaster, (too difficult to do it after); (3) unified command at DCs, e.g., having two groups doing distribution and inventory management caused problems; and, (4) female teams to assess needs of female IDPs (men-only did not work well).	There should be only one person in charge of humanitarian logistics, with the power and financial resources to do what is needed. One important thing that the national government should do is to help pay for the expenses. Create female teams to assess the needs of women.
Fukushima Prefecture	The importance of: (1) using the right type of trucks (2t trucks are best); (2) providing psychological assistance to IDPs; (3) using helicopters for search and rescue, and transporting supplies to isolated places; and, (4) responding within 3-7 days. Google Earth and ITS-Japan helped with satellite pictures and information about road conditions.	Recognize the importance of evacuation and provision of information. Assess bridge conditions with inspectors. Take advantage of satellite imaging to assess infrastructure conditions. Try to get satellite pictures sooner.
Kesennuma City	“Everything.” Disaster plan did not work as it assumed that only part of the city would be damaged (the entire city was destroyed). The basic assumption was wrong. The importance of satellite phones. Did not have equipment, electricity, phones. Had to do basic things (e.g., receiving, storage, distribution by hand).	Emphasize humanitarian logistics, which is not considered in disaster planning.
Yamato	Gap between demand and supply dynamically changed. Government must have closed it sooner. Clothing donations were a problem (too difficult to match to survivors). The level of priority of supplies changes with time.	To prepare good response plans. To find ways to accurately estimate the needs based on lifestyle and community habits. Government should engage the private sector sooner.
Sagawa	Lack of planning for private-public work led to problems. Military forces collaborated really well. SDF did not collaborate well with cities, though it did a very good job delivering supplies to isolated places. The difficulty of local distribution: “...long haul was OK, but distribution from DC to RCs was very difficult, we need more planning and coordination...”	To put someone in control, “...nobody in control of who delivers to the people in need...” Improve agreements between prefectures and JTA so that they include local distribution. Need to reduce the excessive reliance on SDF which only delivers basic supplies and has a lot of problems because their vehicles (troop carriers) are not designed for logistic duties.
AEON	Importance of emergency generators. That they could work without computers, power, and technology. Gained experience with other modes. The importance of setting up a command center quickly, and prepare rations for IDPs.	They would try to have control on the total flow of cargo. Store owners ordered supplies without considering the entire picture. Install emergency generators.

Not included in Table 6 are the statements provided by some of the staff of the private companies interviewed, which were critical of some aspects of the official response. Due to the importance and sensitive nature of the comments, the authors decided to discuss them without attribution to any specific company. Central to their criticism is the lack of an adequate process to either phase out their involvement as volunteers, or transition their services to a for pay basis. As indicated before, the companies became involved as volunteers which they had not planned for. At some point in the response, when they told government officials that they could not continue paying for the costs of the distribution effort, they were advised to try to get contracts with the cities (which were in dire financial straits, had been directly impacted by the disaster, and did not have the administrative structures required to issue contracts). This puts the companies in a quandary as they could not keep absorbing the delivery costs indefinitely, nor they could risk their reputations and simply abandon the relief effort without a viable alternative to replace them. They deemed this decision "...very cruel...". After considerable wrangling, about a month after starting as volunteers, they were hired by the prefectures to distribute relief supplies. This experience, in which the companies felt were in lose-lose situation, taught them that they need to be careful when deciding to participate in future disaster efforts. In their opinion, a change in mindset is needed as the government "...expects volunteers to do the relief effort..." and companies could only do so much without getting paid. Needless to say, this is very unfortunate as it was the generous efforts of these companies what prevented a huge humanitarian crisis. In the opinion of the authors, these companies should be commended for their valiant efforts on behalf of the survivors.

The companies also reported to have problems dealing with what they deemed "...a bureaucratic mindset..." and the desire of some local governments that they distribute the supplies solely on their spheres of responsibility. The case of a hospital that needed relief supplies—but was not the responsibility of a local government—was mentioned. According to the staff, the hospital did not receive the supplies needed because that local government did not allow the company to supply the hospital (in spite of the protestations of the company staff that deemed the decision unsound). It is important to take steps to ensure that this does not happen in the future.

6. FACTORS THAT EXPLAIN THE CONTRASTING PERFORMANCES OF CONSTRUCTION AND PD-HL OPERATIONS

As established in the paper, the PD-HL operations faced numerous challenges stemming, in part, from the fact that the disaster response plans only consider small disasters and not a catastrophic event. In contrast, the construction operations (e.g., road opening, physical repairs) were conducted with extraordinary speed and efficiency, in spite of the fact that the corresponding response plan also considered a small disaster. In essence, two important response functions, PD-HL and constructions operations, exhibited radically different levels of performance: one did poorly (PD-HL), while the other performed magnificently (construction operations). Understanding the reasons that explain these differences could shed light into the factors that ought to be fostered by public policy.

In identifying these success factors, there are two main aspects to be considered: (1) the differences in nature and magnitude of the needs associated with the response to disaster and catastrophes; and, (2) the extent to which a response function, originally designed for a disaster, could be scaled up to respond to a catastrophe. The former aspect represents the demands that the response functions are supposed to fulfill, while the latter describes the supply that the response function delivers. To characterize these aspects, the authors identified the eight factors listed in Table 7, and provided a side by side comparison

between the MLIT and the typical situation in prefectures and cities. The factors are grouped in: needs (demand), technical capabilities of the performing units, and interfaces with other key stakeholders.

Table 7: Structural Factors Explaining Performance of Public-Private Joint Work

Factor:	MLITT (construction repairs, road opening, debris removal)	Prefectures and cities (post-disaster humanitarian logistics)
Needs		
Nature of the task to the performed in disasters vs catastrophes	Very similar nature, though in much larger amounts in catastrophes	Different: disasters do not require complex PD-HL, catastrophes do
Technical capabilities		
Public sector's level of technical familiarity with the task	High	Low/non
Jurisdiction of public sector agency	Regional	Local (prefectures or cities)
Private sector's level of technical familiarity with the task	High	High with commercial logistics, only a basic idea of PD-HL
Interfaces		
Nature of the cooperation agreements with private sector	Specific	Vague
Public sector's ability to integrate and coordinate outside help	High	Low/non
Linkages to the private sector and other sectors of the civic society	Many and strong (particularly with construction companies)	Few and weak (particularly with logistic companies)
Need for supporting social networks	None	High

The first key factor is the need that the activity is expected to fulfill. In the case of the MLIT, the nature of road openings and construction repairs—which was their main charge—is essentially the same in disasters and catastrophes, though the amount of work and criticality are much larger in the latter. For that reason, the response procedures designed with a disaster in mind translated well into the catastrophic case as increasing equipment and manpower accelerated the completion of the task. In contrast, the PD-HL operations required after the Tohoku disasters were very different from the ones for a small disaster. The reason is that in the latter, the local distribution of critical supplies does not require sophisticated planning and execution as in most cases only a handful of points of distribution, and a relatively small number of volunteers could cover the needs for the impacted area. Moreover, due to the relatively small impacted area, the best location for the points of distributions is relatively obvious. After a large catastrophe, however, where the PD-HL operations have to satisfy the needs of hundreds of thousands of individuals over relatively large areas, elaborate plans with hundreds of points of distribution and huge amounts of manpower are needed, as the case of Haiti demonstrated (Holguín-Veras et al., 2012a). Thus, scaling up the PD-HL operations designed for a small disaster only increases the flow of supplies to DCs, and does not solve the local distribution problem (as the disaster plans do not even consider it). The result is paralyzing congestion at the DCs and entry points to the disaster area—because the supplies arrive at the DCs and cannot be distributed forward—as it happened in Haiti (Holguín-Veras et al., 2012a). The chief insight is that the PD-HL operations did not scale up to the catastrophic case because the nature of the job was very different. This was promptly recognized by responders, which quickly abandoned the disaster plans.

In terms of the ability of the performing units to deliver the goods/services required, there are major differences. In the case of the MLIT, the technical staff (mostly engineers) is very familiar with construction operations as this is the main core of their work, which they perform on a daily basis. Moreover, since the MLIT staff have a lot of experience coordinating multiple contractors—which they do on a routine basis—the MLIT had a high capacity to integrate outside help during the response. They were also aided by the fact that construction repairs is a highly standardized activity with pre-established construction codes and procedures, which leads to a situation in which construction companies could be assigned to almost any job and be expected to deliver a quality result. This, together with contacts with numerous qualified contractors and established and strong internal relations across the MLIT structure, enabled the MLIT to allocate construction work to companies for maximum effectiveness of the overall effort. In addition, MLIT’s regional jurisdiction enabled it to have access to resources outside the disaster area, which increased their ability to effectively respond. Equally significant is that construction work is an almost self-contained activity that could take place with minimal help from outside groups, which reduces the need for coordination with other stakeholders.

In contrast, prefectures and cities do not have institutional expertise on PD-HL, have jurisdiction over much smaller areas with lesser resources than a region, do not have strong ties with the private sector companies that could help with the PD-HL effort, and had no experience conducting or coordinating PD-HL. Moreover, since PD-HL is not a routine activity for the private sector they need time to adapt before they are fully cognizant of the unique aspects of the work. Another important difference is that in order to conduct successful PD-HL operations, support from a local social network is needed to organize the population, split and distribute the rations. Faced with a multi-jurisdictional disaster that required a massive amount of coordination and knowhow, that they could not do on their own nor were able to get from outside partners, it should not come to a surprise that prefectures and cities did not do as well as the MLIT. In essence, prefectures and cities were structurally hampered to do an efficient PD-HL. Of great significance is that the situation faced by the Japanese prefectures and cities is no significantly different than the ones observed in other parts of the world. In fact, it could be argued that the Japanese are better prepared than most on account of the (limited) disaster drills and the agreements with construction and logistic companies (most cities in other parts of the world have not had undertaken such steps). It seems clear that addressing this structural deficiency is needed to ensure that the public sector could fulfill its PD-HL mission. How to accomplish this goal is the objective of Section 7.

7. POLICY IMPLICATIONS

The PD-HL response to the Tohoku disaster provides important lessons for disaster preparation and response. This section summarizes the key ones, and puts forward a set of policy recommendations. To facilitate the analyses, the key lessons have been summarized as follows:

- (i) The disaster plans failed to consider and prepare for worst case scenarios as they only focused on small events that could be handled by a given public sector agency.
- (ii) Not having disaster plans that, in detail, considered post-disaster humanitarian logistic (PD-HL) operations hampered public sector response as local officials had to confront the crisis without any guidance about how to proceed.
- (iii) The lack of designated local leaders with primary responsibility for PD-HL and with strong linkages to the logistic industry produced numerous problems. Companies and individuals

interested in supporting the PD-HL operations did not know whom to contact to offer help and coordinate efforts; neither the city leaders of the emergent PD-HL response knew whom to contact in the logistic industry to get the help so urgently needed.

- (iv) The private sector in the construction, transportation, and retail sectors played a key role as they brought to bear expertise and assets that benefited the response. However, the participation of transportation and logistic companies was improvised, unanticipated, and at times refused.
- (v) The most challenging part of the entire PD-HL process was, by far, the local distribution.
- (vi) The lack of training and realistic exercises on PD-HL significantly diminished the effectiveness of the response to the disaster. Among the 60 individuals that were interviewed, only about ten had experience in commercial logistics, and none had any previous exposure to PD-HL.
- (vii) The unavailability of technologies and systems to quickly assess the conditions of the transportation network and other critical infrastructures hampered the response.
- (viii) The availability of multi-modal transportation alternatives was successfully exploited to transport critical supplies to the disaster area.
- (ix) The lack of efficient communications with the field was a negative factor that diffculted the assessment of needs.
- (x) The bulk of the relief supplies had to be transported from the outside of the impacted area, as expected in the response to catastrophic events.
- (xi) Lack of fuel for the return trips prevented the volunteer participation of numerous trucking companies during the initial days of the crisis.
- (xii) The large flow of non/low priority donations created numerous problems as it consumed significant amounts of resources, were not needed, and arrived at a time at which there were more important activities to undertake.
- (xiii) Precautionary/opportunistic buying of critical supplies by individuals outside the disaster area aggravated the PD-HL challenge because it prevented the use of those supplies for the benefit of the survivors in the disaster area.
- (xiv) The lack of GPS devices in some of the delivery trucks delayed the response as it required the use of local guides that knew how to navigate the impacted area.

These findings provide the basis for a number of policy recommendations that, in the opinion of the authors, could play a key role in improving PD-HL response to future events. A central element of these recommendations is the goal of ensuring scalability of the PD-HL operations as this may be the only way to ensure robustness of the disaster response plans. These recommendations are discussed next.

Recommendation #1: Create a Logistic Committee to Integrate Civic Society in the Effort

As outlined in lessons (i) thru (vi), many of the problems encounters in the response were the result of the lack of familiarity with the unique demands that a catastrophic event imposes on PD-HL efforts, and the lack of resources needed to confront the crisis. This insight, together with the analyses of the factors that explain the performance of the construction sector response, suggests the convenience of integrating key representatives of the civic society and the logistic industry—and particularly those involved in the

distribution of food, water, medicines, and other supplies likely to become critical after a disaster—to help lead the local PD-HL effort. As part of this concept, a committee of representatives of disaster response agencies, key private sector companies, trade associations, community groups, churches, and any other group that could contribute a large social network, would be trained and certified as PD-HL leaders, and charged with orchestrating the effort in case of a disaster. In essence, these individuals would become part of a “reserve” of post-disaster logisticians that would be called into action if the need arise. This concept is similar to the standard practice in other areas, e.g., medical teams, in which the need to incorporate professional help from the outside has long been recognized. It is important for this committee to have a visible presence so that is evident to others outside the group that they are the coordinating hub of the PD-HL effort.

In this context, the incorporation of outside groups and expertise would complement the public sector effort in notable ways because it will: (1) enable logistic professionals with deep knowledge of local conditions to lead the effort; (2) provide access to regional private sector logistic networks that extend beyond the jurisdiction of the public sector agency; (3) contribute connections to the rest of the private sector expanding the potential pool of assets available; (4) provide the logistic effort with access to the social networks of volunteers that are likely to prove influential in community organizing efforts and local distribution of critical supplies. The latter will address one of the major challenges in PD-HL as organizing the population, splitting and distributing rations, and other related tasks require a significant amount of power (Holguín-Veras et al., 2012a). To this effect, the authors’ recommendation is to proactively engage local religious groups, community groups and the like so that they become the backbone of the local distribution effort (Holguín-Veras et al., 2012a). Achieving this could open the door to new paradigms of disaster response through better integration of efforts. Moreover, the incorporation of broad sections of the civil society as part of the disaster planning process would allow them to contribute ideas, and know what may be expected from them in the case of a large disaster.

To provide visible points of contacts, it is advisable that the logistic committee designate one or two individuals as the committee leaders. Moreover, in order to ensure both the physical/mental health of the committee leaders and maximize the effectiveness of the PD-HL efforts, it is important to rotate the leadership out of their duties to give them some rest. (The experience of SDF—where 1/3 of the force is always resting, while the other 2/3 work—clearly shows the benefits of planned periods of rest.) Such periods could also be used to provide participants with psychological counseling to help them cope the traumatic experience.

Recommendation #2: Design Plans for a Wide Range of Events

One of the key lessons from the Tohoku experience is that the scalability of a response function cannot be taken for granted. Thus, the key to robust design of disaster plans is to ensure that they are able to perform as expected in a wide range of conditions. To ensure that a given operation is scalable, disaster planners must assess the wide range of needs (from small disasters to large catastrophes) and design scalable response operations, i.e., that could satisfy the needs by adjusting upwards or downwards the input resources to provide the supply of goods/services needed at the site. The dual effort of studying the wide range of needs, and designing the corresponding response functions, in a way that could be seamlessly expanded or contracted to meet the needs in the ground, will ensure that a similar template of action be used in a wide range of scenarios. Equally important is that these plans be specific enough to be of help to responders as they should consider and identify: location of DCs and RCs, alternative arrangements in case that some of these facilities are damaged, staffing arrangements, need for

prepositioning of supplies, and the like. Taken together, these recommendations could significantly increase robustness and flexibility of disaster response plans.

Recommendation #3: Design Plans for Easy Integration of Outside Help

The complexity and magnitude of the PD-HL efforts—particularly the ones after large disasters and catastrophes—stresses the need to engage all segments of society in the response, as this is the only way to minimize human suffering and expedite the path to recovery. However, doing so requires considerable planning to avoid duplication of efforts, interference, and all the other problems that arise from lack of coordination; as well as the establishment of clear priorities that ensure maximum effectiveness of the delivery of aid. Achieving this requires, in addition of coordination, a reasonable subdivision of the tasks to be performed, and a minimum level of standardization of individual assignments so that there is agreement what needs to be done. In the PD-HL case, this may require subdividing a large urban area into smaller districts to be assigned to different relief groups, and providing basic training to ensure that all involved know that to do. There are also important technical details that need to be planned for, e.g., to have an adequate supply of fuel at the disaster site to share it with the companies participating in PD-HL.

Recommendation #4: Train Potential Participants in PD-HL

It is important to recognize that PD-HL is a highly technical and complex activity. It stands to reason that if large private companies employ large teams of highly trained professionals to organize their logistics, the more complex PD-HL efforts—which directly impact human suffering—should be granted equal or higher professional status. A significant effort should be undertaken to enhance the technical capabilities of all individuals expected to be involved in a PD-HL effort. As part of this, it is important to:

- Train all likely participants (e.g., local officials, members of the proposed logistic committee including private sector logisticians, leaders of community based social networks), on the basics of PD-HL operations. This must include training on: standards of humanitarian aid, procedures to control material convergence, assessing needs after disasters, estimating impacts on physical infrastructure, team building, and stress management.
- Conduct exercises, both real and simulated (table top), so that all participants develop a sense about what may be expected in a real life scenario.
- Foster, train, and support local and regional social networks—such as the ones created and maintained by religious groups, neighborhood organizations, and the like—so that they are ready to collaborate in the PD-HL effort if the need arises.

Recommendation #5: Preposition Critical Supplies and Equipment

As amply illustrated in this paper and established in Holguín-Veras et al. (2012b), in the aftermath of a large disaster or a catastrophe, it is not realistic to expect that local responders could provide a substantial first wave of resources to help survivors. This is the net result of the likely destruction of local inventories and logistic assets, the huge increases in needs, and that the minimal local inventories that characterize modern supply chains are not likely to be enough to satisfy the emergent needs (Holguín-Veras et al., 2012b). The fundamental implication is that the bulk of the critical supplies needed at the site must be brought from the outside of the disaster area. There are two potential sources for such supplies: (1) supplies stored by private sector operators in, or in transit to, regional distribution centers and warehouses; and (2) emergency stocks of critical supplies maintained by disaster response agencies.

In cases, where there is a regional inventory of critical supplies and equipment not likely to be destroyed by a large catastrophic event, such supplies could be counted to be part of the first wave of resources reaching the site, as long as they are located relatively close to the impacted area. However, this would require the establishment of contracts with the corresponding private sector operators to ensure that the supplies could be requisitioned in case of need. In situations where no such regional distribution networks exist, or when the amount of cargo is not enough to provide a first wave of resources, the only alternative is that disaster response agencies preposition critical supplies. It is important to stress that it is not advisable to rely on local inventories of critical supplies and equipment as these are susceptible of damage and destruction by the event. The cases of Haiti and Japan made this point abundantly clear.

Recommendation #6: Control Material Convergence and Precautionary/Oppportunistic Buying

The research reported in this paper, yet again, highlighted the problems created by the non/low priority component of the material convergence generated by a large disaster; and the necessity to implement proactive procedures to dampen precautionary/opportunistic buying. In this context, it is important to: (1) ensure that proper control procedures are in place to allow only high priority supplies to enter the disaster area, divert low priority supplies to secondary DCs in the outskirts of the impacted areas, and refuse/destroy non priority supplies; (2) implement proactive donation management plans that provide potential donors with guidelines about what and when to donate; (3) engage the media so that they convey a realistic representation of needs; and (4) use information systems to try to match needs on the ground to potential donors (Jaller, 2011; Holguín-Veras et al., 2012b). Regarding the latter, the integration of such information systems for multiple jurisdictions could play the role of a “virtual” pre-positioning of supplies that could make it easier to respond in the case of a large disaster.

Disaster response agencies must also take steps to ensure that precautionary/opportunistic buying of critical supplies does not deplete stocks of critical supplies in the vicinity of the disaster area, which are the supplies best positioned—for reasons of proximity—to be the first wave of resources reaching the site. It is important to keep such purchases under control so that these supplies are available for the benefit of survivors. Doing so would require to: establish agreements with key private sector vendors to allow the requisition of the critical supplies they may have in stock, educate the population about the need to avoid purchases in excess of needs, engage the private sector so that they help steer supplies to the disaster area, put in place rationing schemes until the situation stabilizes, among other potential demand management measures.

Recommendation #7: Foster the Development of Supporting Technologies and Systems

The experience in the immediate aftermath of the Tohoku disasters unambiguously suggests the need to develop and foster the use of technologies and systems to: support prompt and accurate assessment of needs on the ground, facilitate transportation of the supplies, and ensure efficient communications among disaster responders. Integrated systems that combine satellite imagery, GPS, remote sensing, and geographic information systems to provide local responders with an assessment of infrastructure conditions should be a priority (some of these systems already exist or are in development though their use is not yet widespread). In the case of GPS devices, their availability could help drivers unfamiliar with local conditions navigate the area even though when information about road conditions is incomplete. These systems must be complemented with proper communication, computer and backup systems, and the assets needed to do local inspections. Ensuring good communication should be a key priority to ensure a timely assessment of the needs on the ground. This may require prepositioning of

either satellite phones, or priority phones with preferential access to bandwidth, at strategic locations— together with appropriate charging mechanisms, e.g., small generators with a supply of fuel—so that they could be quickly deployed and used for extended periods of time.

8. CONCLUSIONS

The research reported in this paper leads to a number of important conclusions that could benefit future disaster response. The fact that these findings are consistent with what was observed after other catastrophic events, e.g., Katrina and Haiti, clearly suggest that the policy recommendations made in the paper are robust. Among the similarities it is important to highlight: the need to bring large amounts of supplies from the outside of the impacted area to satisfy the needs of survivors and the response process; the importance of prepositioning critical supplies; the magnitude and complexity of the PD-HL challenge, and particularly of the local distribution; the necessity to integrate all segments of Society—the civic society, military, public sector, the various strata of the private sector—to ensure the most efficient response permitted by the circumstances; and the need to proactively manage and control the flows of non/low/high priority supplies that accompany large disasters.

A key conclusion is that the failure to prepare for the worst case scenario, i.e., a catastrophic event, was one of the key reasons that explain the problems found in the PD-HL response. The reason for this apparent oversight is related to the inherent differences in the needs to be satisfied after typical disasters and catastrophes, and the asymmetric scalability of the operations. To start with, it is important to highlight that the typical disaster does not require a large and complex PD-HL operation, as only the much larger catastrophes do. Unfortunately, this fact is not well known. Consequently, it is natural for disaster planners to think that the procedures that work relatively well for the typical disaster—which is the case most commonly encountered by most disaster responders—would work well in the response to a catastrophe. Thus, simpler PD-HL for a small disaster—which typically only requires transporting relief supplies to a handful of DCs and RCs—cannot be scaled up to the respond to a catastrophe, as in this case a large a complex local distribution effort with large numbers of points of distribution is required. Thus, there is asymmetric scalability as a PD-HL designed for a catastrophic event can always be scaled down to meet the needs of smaller disasters, though the converse is not true. Moreover, the importance of prepositioning critical supplies and equipment was yet again made evident. The Tohoku case demonstrated this in a convincing way.

The Tohoku disaster provides ample evidence of the importance of providing for the conditions that enable scalability of the operations. The contrasting examples of the performance of the construction and PD-HL are quite illustrative. In the case of the construction sector, the disaster plans scaled up extremely well. The plans for PD-HL did not, and were quickly found inadequate and abandoned. Simply put, the PD-HL response plans prepared for a disaster could not be scaled up to respond to a catastrophe. It is important to understand the reasons that explain these contrasting performances, even though the corresponding response plans, most likely, were designed under similar assumptions of disaster size.

The analyses of the factors that explain the contrasting performances of the construction and PDHL operations involved indicate that having: access to a regional network of resources and assets, a high level of technical expertise at both the responding agency and the emergent partners from the civic society, strong linkages with numerous and competent potential partners, and high level of capacity to integrate outside help to the response; were some of the factors that allowed the MLIT to successfully scale up

construction operations in response to the catastrophe. In contrast, cities and prefectures did not have: access to regional resources to support the PD-HL effort, technical expertise or extensive contacts with potential partners that could provide help, or the technical capacity to coordinate with multiple providers.

Based on this insight, the paper suggests the creation of a committee comprised of representatives from disaster response agencies, private sector companies in key economic sectors (e.g., food, water, medicine), trade organizations, community and religious groups, that would be trained on PD-HL and be put in charge of PD-HL operations in case of need. The authors expect that these individuals, once properly trained on the specifics of PD-HL, will play an influential role by: contributing their technical expertise, experience, professional connections to regional private sector supply chain networks and assets, and contacts to strategically important social networks, thus increasing the resiliency and efficiency of the response. In addition, the paper suggests that disaster plans: be designed to account for a wide range of events ranging from small disasters to large catastrophes; subdivide the work to be done so that groups of responders could tackle specific areas of need with minimal coordination and overlap; and, strive to standardize the tasks to ensure a minimum level of quality in the work done. Integrating the local social networks part of churches, community groups, and the like, on the local distribution of supplies is very important. This is because these social networks are ideal to do local distribution because they tend to be very large, are well connected, and have a philanthropic interest in helping the people in need.

The research also highlighted the importance of proper and effective donation management and of strategic control of precautionary/opportunistic buying by both households and businesses. The first issue is that, if not controlled, the non/low priority flow of cargo will slowdown high-priority supplies. Preventing this from happening consumes large amounts of resources as non/low priority shipments must be diverted away to prevent the collapse of DCs and entry points to the disaster area. Effective donation management requires a combination of: access control to the disaster area so that non/low priority goods are prevented to enter, or redirected to suitable processing points; public awareness campaigns to educate general public, private and public sector executives about how and what to donate; proactive engagement of the news media; and, information systems to match supply to needs in the ground. The second aspect that needs to be pondered is the need to keep under control precautionary/ opportunistic purchasing of critical supplies and equipment, particularly in the areas in the vicinity of the disaster site. The reason is that, though these purchases are a natural human reaction to the concerns about shortages of supplies, they deplete the inventory stocks that for reasons of proximity are best positioned to support the response effort. Addressing this requires the collaboration of private sector vendors, community leaders, and the media, as outlined in the paper.

Based on these findings, the paper puts forward six policy recommendations: (1) integrate civic society in disaster preparation and response efforts; (2) design plans for a wide range of events ranging from small disaster to catastrophic events; (3) design disaster plans for easy integration of outside help by subdividing potential tasks and striving to standardize the assignments thru training; (4) train potential participants in PD-HL activities and procedures; (5) preposition critical supplies and equipment; (6) control material convergence and precautionary/opportunistic buying; and, (7) foster the development of the supporting technologies and systems. In the opinion off the authors implementing these recommendations could go a long way towards the development of scalable disaster response plans, able to properly fulfill their mandate in a wide range of events.

Taken together, these conclusions shed light into the lessons that should be incorporated in disaster response plans and operations. In spite of the contributions made in this paper, the reality is that PD-HL is

still poorly understood. This unfortunate situation highlights the need for additional field research that helps characterize such complex problems. The knowledge derived from these studies will enable disaster responders to develop adequate procedures for responding to catastrophic events.

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