How do organizational processes recover following a disaster? - A capital resiliency model for disaster preparedness -

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Abstract

This paper explores how organizational processes are recreated following their destruction in unexpected disasters. It applies the notion of an organization as a capital conversion and capital creation system. It also focuses on systems resilience, the measure of a system's persistence and ability to absorb disturbances while reconstructing relationships between system entities.

Based on the analysis of empirical evidence collected from the Great East Japan Earthquake disaster in 2011, we propose a resiliency model incorporating a broader interpretation of the notion of capital. The model consists of five dimensions of capital: economic, social, symbolic, human, and organizational. Once a given capital is destroyed together with its creative organizational processes, communities will attempt to regain resilience by compensating with other dimensions of capital.

Analyses demonstrate the importance of recreating organizational capital that coordinates capital conversion and recreation processes to meet the vital need of the residents. Examining this process of capital conversion and creation enables us to extend the notion of resilience.

1. Organizational processes for saving lives

Following an unexpected disaster, many organizational routines and processes are suspended. This paper explores how organizational processes are recreated after destruction in unforeseen disasters. It brings to bear the notion of the organization as a capital conversion and capital creation system [1]. It also focuses on systems resilience, the measure of a system's persistence and the ability to absorb disturbances [2] while reconstructing relationships between system entities.

Many parties are spontaneously involved in emergency relief, from individuals to international agencies, such as the Red Cross. However, the foremost response to a disaster comes from local organizations [3]. "Local" may refer to government, or voluntary and private organizations, but it is local government which owns "the first line of official public responsibility [4]." It has prime but differing responsibilities for its citizens in (1) confirming their whereabouts and safety of residents, (2) delivering essential information to residents, (3) operating evacuation centers and supporting evacuees, (4) transporting and managing relief goods, and (5) issuing disaster victim certificates [5]. All of these operations are essential for saving lives and supporting evacuees right after a disaster.

In this paper, organizational processes refer to a multitude of tasks joining together to perform disaster relief operations. A "process" originally is defined as collections of tasks that transform inputs into outputs [6]. Each given process executes an important function and, in itself, consists of a system which must accomplish an objective [7, p.270] and create value through input-output conversion.

This paper introduces the "capital resiliency model" as a systematic framework of how organizations realize resilience through capital conversion and capital creation. "Capital" in this paper is defined as a source for creating value. This means, we regard a system that keeps organizational processes functional as one type of capital. Information systems are a good example of this in that they are a critical element in conducting and supporting disaster relief operations.

This paper presents the following sections: (1) reconsideration of disaster management plans underpinning disaster preparedness, (2) submission of a capital resiliency framework to overcome the gap between plans and realities in the field, (3) presentation of empirical research data from three municipalities affected by the Great East Japan Earthquake, (4) development of a capital resiliency model, and (5) conclusion.

2. Limits of conventional plans

Generally, organizations draw up a disaster management plan intending to mitigate damage from a devastating disaster situation. The plan is designed to make people, facilities, and organizations robust. It defines the chain of command and the tasks to be performed [7]. However, the problem is that a plan is often effective only in simulated situations, in other words, in any type of expected event. Plans fail to deal with departures from expected outcomes. In reality, unexpected calamities require an adaptable capability which recognizes new opportunities in any given situation [8] , i.e., previously unseen "capital," which allows the formulation of an effective response. Thus, we should change the conventional purpose of disaster management to one of preparing an organization to think creatively about the unthinkable so that quality decisions will be made following a disaster [9].

This by no means reduces the importance of conventional planning. It is of course useful to make predictions regarding damage and plan responses to a range of situations. Determination of the chain of command is critical, and it is wise to stock up on supplies based on a careful estimation of need. Such plans should also be widely shared by all people concerned.

The Great East Japan Earthquake, one of the greatest earthquakes faced by mankind, illustrates the reality of the unexpected. On March 11, 2011, Japan was struck by the Great East Japan Earthquake. The movement of tectonic plates along the Pacific Rim created a rupture zone 500 km long. Measuring 9.0 on the Richter scale, the earthquake produced a tsunami of 40 meters hitting the coastline and devastating cities and towns. The Fire and Disaster management Agency reported 19,225 deaths, 6,219 injuries and 2,614 missing as of March 2015. It also reported 127,830 houses totally lost and more than 1,000,000 partially destroyed. This earthquake was unique in that it caused severe damage to a very wide area, above all due to a massive tsunami that was beyond any prior assumptions.

All business operations, including those of public organizations, were suspended and remained so for some time in areas directly affected by the earthquake and tsunami. In some areas, power supply and connectivity were completely lost at the most critical life saving phase immediately following the earthquake. In those areas, people were instantly faced with a situation they had never experienced and which had never been anticipated in any disaster management plan.

From this earthquake, we have come to recognize the importance of flexibility when making decisions in executing disaster management plans [10]. However, at the same time, we should consider that the very point of plans and processes is to maintain consistency. To achieve this consistency, mechanisms of creating value through system processes are not meant to change [12, p.164].

3. Capital resiliency framework

To overcome this contradiction in requirements, this paper proposes a capital resiliency framework with the definition of an organization as a capital conversion and capital creation system [1]. Capital is a durable and transforming production factor [11]. It is a prior investment intended to create future value. In this sense, this paper defines the following five dimensions of capital that are inspired by Mandviwalla et al. [1] (Table 1).

Table 1. Capital Typology [Partly modified ref.1]

Dimension of capital	Definition
Economic	Financial, physical or manufactured resources
Social	Individual or organization empowered by the social connections
Symbolic	The amount of honor or prestige possessed within a given social structure
Human	Skills, knowledge and abilities that individuals use to generate income or other useful outputs
Organizational	Institutionalized knowledge stored in databases, routines, patents, manuals and structures to support an organization's goal

One form of capital can modulate changes in another form through organizational processes (e.g., spending economic capital on education to increase human capital). The intent of this paper is to demonstrate that capital conversion can play a critical role in enhancing the resilience of systems. Among the five dimensions of capital, organizational capital is key to realizing resilience as it provides the conversion processes for recreating capital.

The discussion surrounding resilience originally started with the examination of ecological systems [12]. It began by differentiating resilience and stability [2]. Resilience is recognized as a measure of a system's persistence and the ability to absorb disturbances while maintaining the existing relationships between system entities, while stability is defined as the ability of a system to return to an equilibrium state after a disturbance [2]. Subsequently,

the concept of resilience expanded its scope to include the analysis of organizations [13], of supply chain management [14, 15], engineering [16-19] and business modeling [20, 21].

Though the literature reflects different views of resilience, we take the path of providing adaptive capacity and allow for ongoing, proactive development; i.e., dynamic, adaptive interplay between sustaining and evolving processes in response to change [19, 22-24]. In this sense, we recognize the notion of resilience as the ability to absorb disturbances while reconstructing relationships between system entities, not just maintaining the existing relationships.

The emphasis of this paper is on resilience in emergency management. Resilience discussed in the context of emergency management has been incorporated into the international business process standard as ISO 22301 (formerly British BSI2599), which is intended to maintain business continuity at times of extraordinary stress. However, disaster management demands more personnel to handle new problems that arise in the field [25]. Different types of demands and responses should emerge in such an environment, and it requires different levels of capacity within the system [26].

To explore the requirement for capacity more systematically, this paper combines the notion of capital with resilience. The five dimensions of capital introduced previously can play different roles through their own particular conversion and creation systems. The resulting capital resiliency framework is proposed as a tool for all organizations to employ in future disaster situations. When we consider the reality of unexpected events happening, the capital resiliency framework reaches well beyond the predetermined plan (Figure 1).

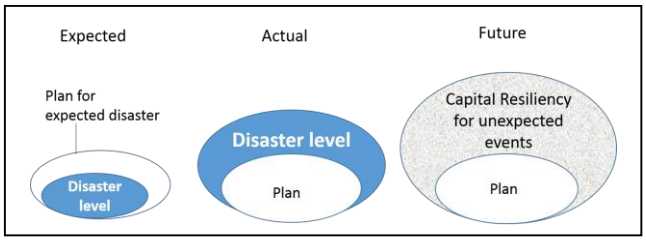

Figure 1. Desirable disaster preparedness

In this regard, preparedness is at the opposite end of "plans" that are made on the basis of predictable damage. Damage within assumptions can be dealt with by plans. What the Great East Japan Earthquake taught us is that the attempt to avoid unexpected events by managing plans in advance is impossible. Thus, our research leads us to consider how organizations realize resilience through capital conversion and capital creation. This question is based on the assumption that adaptive capacity should be seen as a necessity following a disaster.

In the following section, we show the reality of realizing resilience in the Great East Japan Earthquake.

4. How organizational processes were recreated during the disaster

The empirical research of this paper is based on interviews with officials from three municipal governments that experienced huge damage from the Great East Japan Earthquake. The two-hour interviews were conducted in December 2011, nine months after the earthquake. The two respondents from each town were officials of information systems departments in charge of managing their systems when the earthquake struck. They were asked about preparedness, the level of damage, and the recovery process of ICT equipment including power supply, network connectivity, information systems, and related facilities. The interview reports were checked and officially verified. Archived documents were referenced and additional telephone interviews conducted to fill in missing information subsequently.

Within the administrative structure of the Japanese government, municipalities occupy the third rung. National Government occupies the top tier, followed by prefectural governments (47 of them) and municipal governments (1,742 cities, towns and villages as of January 1, 2014). Legally, the function of municipal governments is to provide a variety of services to their citizens but above all they are obligated to maintain resident information, i.e., the data that serves as the foundation for government. Prefectures, on the other hand, are defined more loosely as wide area governments.

Among many organizational processes for conducting disaster relief operations, we focused our interviews on those most revealing about (1) relocation to temporary offices (restoration of economic capital) and (2) resumption of certificate issuing operations (restoration of organizational capital). Establishing certification is the most important operation that municipalities have to undertake in a disaster situation because the victims require certificates for identification in banks or elsewhere in their effort of reconstructing their everyday lives. Therefore, gaining an understanding of how this operation is to be recovered must be given the highest priority.

As we discuss each case, we will label (in brackets) each dimension of capital in question, it either having been lost or reconstituting a candidate for capital

conversion and creation. Following the outline of each case, we synthesize our findings for each dimension of capital.

4.1. The case of Otsuchi Town – system recovery with overwhelming complexity

The case of Otsuchi Town located in Iwate prefecture, one of the hardest hit municipalities in the Great East Japan Earthquake, illustrates the extent of the catastrophe well.

The town lost its Mayor (*human and symbolic capital*) in the tsunami and his deputy's term was nearing its end on June 20, 2011. As many decisions in emergency situation require high level authority, absence of a legitimate leader hindered relief operations. This forced the town to concentrate its efforts on implementing a mayoral election. Thus priority was placed on restoring the Basic Resident Registration Network System (*organizational capital*; this paper considers ICT environment as organizational capital, as it comprises tools to integrate a range of operations) that would enable the town to generate a voter list.

The task was not easy. Otsuchi Town lost one-third of its employees (*human capital*) when its three-story town office building (*economic capital*) was completely engulfed by the tsunami. The server room located on the first floor was submerged in muddy water, which disabled all the machines in the room (*economic capital*). All residential data including backup was lost (*organizational capital*). As it was apparent that the old system could not be repaired, the decision was made to recreate the ICT environment (*organizational capital*) from scratch in a temporary town office (*economic capital*) located in the community center.

The assumption had never been made that servers, robustly designed to withstand severe earthquakes, could actually be lost. Lack of preparation further complicated recovery. Most importantly, a security system to protect sensitive data on the servers blocked efforts to extract data from them.

This problem was solved by salvaging residential data from a flooded server's hard disk. Before salvage was complete, the town was able to use a back-up database (*organizational capital*) that was fortuitously maintained by the town's system vendor (*social capital*). The back-up data were then fed into a temporary system that the town had prepared in the community center by March 29 (*organizational capital*). The system vendor lent out the server for system development (*social capital*).

On April 13, restored residential records salvaged from the server hard disk were fed into a second temporary system (*organizational capital*) also prepared in the community center. It enabled Otsuchi to resume resident services including the issuance of residential certificates. The tax system and the residential record network system were also restored at this time. Naturally, the data was not current, but was rather that of March 11 when the tsunami had hit. On April 25, officials moved to temporary government office buildings that were set up in the grounds of Otsuchi elementary school (*economic capital*).

Recovery of the Basic Resident Registration Network System, necessary to provide synchronized service in multiple locations, required the reconstruction of physical landline cables as well as of communication servers and firewalls (*organizational capital*). The temporary government building was too small to house these, so they were also placed at the community center. Server room construction and network connection were completed on June 15. Firewalls were installed on June 29. Preceding that, fiber optic cable had been laid between the temporary town government building and the community center building on May 20. A communications server was brought in on July 6 and went into operation after preparatory works on July 15. The town was finally ready to update its voter list by receiving data from other towns reporting people who had moved out of town following the earthquake (*organizational capital*).

Air conditioning became an issue by July at the town's temporary government building. Thus, all of the primary servers were moved back to the community center where there was functional air-conditioning.

The mayoral election was carried out five months after the earthquake and two months after the deputy's term had expired, on August 28, 2011. Thus the town had been lacking a legitimate leader when leadership was critically needed.

On September 20 temporary servers were replaced with permanent servers.

In summary, slow recovery of information systems caused a delay in the election process that, in turn, hindered all other recovery processes. It is obvious that slow recovery was caused by information systems complexity, in other words, lack of adaptive capacity. The system was designed securely because it deals with residential information, which is supposed to be the most important and confidential data municipal governments possess. Preparedness for elections is not usually included in a disaster relief operation; however, this case illustrates the vulnerability of complex, hierarchically organized systems [18] in an unexpected situation as they are resistant to stress only within narrow boundaries.

4.2. The case of Futaba Town – recreation of ICT environment from scratch

Futaba town, located in Fukushima Prefecture is the local government for the sites of Unit 5 and Unit 6 of Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant. Units 1 through 4 of this power plant are located approximately 2 kilometers from Futaba.

On March 11, the information department personnel of Futaba left the government building in order to remove notices about a town council in session. As soon as they arrived back at the government building, they were hit by massive tremors (at 2:46 p.m.). They immediately went to check on the server room. There did not seem to be any visible damage, so they did not shut down the system. Also, there was no power outage at the government building. They then left the server room, intent on performing a more detailed check later.

At 9:23 p.m. on that same day, the national government issued an order to the surrounding areas of Fukushima Daiichi Nuclear Power Plant Unit 1 for the evacuation of residents within a 3 km radius of the unit, and it imposed an indoor restriction of residents living within a 10 km radius. In the early morning of March 12, the day following the earthquake, the national government changed its evacuation order and requested residents within a 10 km radius of Power Plant Unit 1 to leave.

Before evacuating to another town, information department officials placed backup tapes inside the server room (*organizational capital*). They saw off evacuating residents and then began evacuating themselves. Everyone proceeded west from the evacuation shelter, set up in town, together by car and town bus on National Route 114. The road became so congested with evacuees from towns in the area that it took the officials well over five hours to arrive at the evacuation site in Kawamata, Fukushima Prefecture. This site is located 65 km away from the town, so usually this journey would have taken about an hour and a half. Officials had intended to return to the government building right away because they had never expected the accident of the Nuclear Power Plant to become such a large calamity. So they carried nothing with them but the clothes that they were wearing. On arriving at Kawamata, they prepared a list of the names of the evacuees, and distributed food and supplies such as blankets.

On March 19, officials moved to Saitama City, which is located in 270 km away from the town. The place they escaped to was a concert hall (*economic capital*), so there was no equipment for conducting municipal operations. When officials arrived, there were 10 pairs of printers and computers (*organizational capital*) that were donated by another municipality (*social capital*), which wasn't heavily damaged in the earthquake but had experienced evacuation when a large earthquake had hit Japan back in 2004. The machines were offered voluntarily, without having been explicitly requested by Futaba. This enabled the town personnel to input evacuee information. Fixed phone lines were also provided. On March 20, a system vendor entrusted with the management of information systems (*social capital*), began to use the resident information that it had received from Futaba on March 10 for initial taxation calculations. With his help, the officials were able to view the resident information on Excel and check residents' whereabouts (*organizational capital*).

On March 31, administrative functions were transferred to the former Saitama Kisai High School (closed in 2008) (*economic capital*), and operations were carried out at this site as Futaba's Saitama branch. The officials temporarily entered Futaba together with the Self-Defense Forces at the end of March and in early April. On those occasions, they picked up the devices that they needed for operations, and the backup tapes that they had placed in the government building on March 12 (*organizational capital*). At the Saitama branch, using these backup tapes, they launched a resident information system on a provisional server (a notebook computer), and began issuing residence certificates. They also provisionally restored the family register system with the help of the system vendor (*social capital*), based on the data that they had acquired around that time. A private telecommunications company carried out networking inside the branch. The network and the Internet were connected in early April. Operations for the issuance of tax payment certificates, resident certificates, family register personal matter certificates, and registered seal certificates were resumed on April 18.

On April 22, the entire area of Futaba became a restricted zone which means people were not allowed to enter the area (*symbolic capital*).

Officials created and managed a list of the names of evacuees using Excel starting from when they were transferred to Saitama (*organizational capital*). Excel was the most user-friendly system available at that point of time with officers being accustomed to using it on a day-to-day basis. In order to respond in a prompt manner in the aftermath of the disaster, officials thought it would be better to utilize the system of just one company rather than those of the multiple system vendors that had been entrusted with the management of information systems.

In September, the network was connected with the data center of one particular system vendor, and Futaba switched from its provisional server to a server which enabled storage of its backup data inside the data center (*organizational capital*).

On October 28, Futaba opened a Fukushima branch (*economic capital*). This branch was also connected with the data center, and Futaba carried out contact point operations, such as the issuance of certificates.

4.3. Case of Namie Town – repeated escape with minimal ICT capital

Namie, located in Fukushima Prefecture is adjacent to the northern part of Futaba. At 3:33 p.m. on March 11, the first large tsunami arrived at the shore of Namie. In the town, 12 evacuation shelters were opened. Power went off immediately after the earthquake, so means of communication with the outside could no longer be used. Information from the national government regarding the status of the nuclear disaster did not reach the town at all.

In the morning of March 12, power supply resumed and the Mayor, relying on information from television, decided to evacuate residents from within a 10 km radius of the Tokyo Electric Power Company Fukushima Daiichi Nuclear Power Plant. At 1 p.m. on that day, the Mayor decided to transfer the town's disaster response headquarters to the Tsushima branch located in the northwest area of the town (*economic capital*). As they were evacuating to the Tsushima branch, information department personnel took along three personal computers from the government building (*organizational capital*). Furthermore, in order to identify persons affected by the tsunami, the officials exported the basic resident register data in CSV format, and took it with them as well (*organizational capital*). They did not have enough time to take any data other than this. At 3:36 p.m. on March 12, a hydrogen explosion took place at Unit 1 of the power plant. The Tsushima branch could not use fixed telephone lines, so made use of two satellite phones that had been provided by Fukushima Prefecture (*social capital*), in order to make contact with the prefectural government. At 3:41 p.m. on March 13, another hydrogen explosion occurred at Unit 1 of the power plant, and then at 11:01 a.m. on March 14, a hydrogen explosion also occurred at Unit 3 of the power plant.

On March 15 at 4:30 a.m., the Mayor, based on independent judgment, decided to evacuate to outside the town, and requested asylum at the adjacent city of Nihonmatsu, which is located around 70 km west from the town. At 10 a.m. on that same day, the Mayor ordered an evacuation of all of Namie, and the citizens and town personnel began evacuating to the Nihonmatsu Towa branch (*economic capital*). Personnel took along 10 computers to Nihonmatsu: the three personal computers that they had taken from the town government building to the Tsushima branch, and seven personal computers that had originally been set up at the Tsushima branch (*organizational capital*).

After transferring office functions to the Nihonmatsu Towa branch, officials set up a network in order to share one printer among the multiple personal computers, though operations were carried out in a standalone manner (*organizational capital*).

When the officials temporarily went back to the government building office around March 20, they removed the family register server.

On April 4, they built a simple server using the backup data of the basic resident register, tax, and welfare systems that had been stored at the data center (*organizational capital*). The server at the data center had originally been used as a backup, so the town was using it at the courtesy of a business operator (*social capital*). Starting from late that month, they connected the network with the data center (to maintain the basic resident register, without multiplexing), and used that set-up for operations. The officials continued to use the standalone minimal system with one printer and personal computers to carry out the issuance of certificates, just in case the circuit went down.

On April 22, the area within a 20 km radius of the Fukushima Daiichi Nuclear Power Plant became a restricted zone. Namie was partly included in this area (*symbolic capital*).

Certificate issuing operations were resumed in mid-April at the Nihonmatsu Towa branch.

At the beginning of May, the officials built an internal network (not connected to the Internet) that included a file server (*organizational capital*).

The most intricate job that the information department personnel undertook after the disaster was preparing a list of the names of evacuees and confirming the survivors. Officials input the name list that the citizens had written by hand at the evacuation shelter, using an Excel format. They recalled that when preparing the name list, they failed to require citizens to provide their names in phonetic script (hiragana rather than kanji, i.e., Chinese characters) and their dates of birth. Checking these two types of data against the basic resident register would have been the most reliable way of preparing the name list. As it turned out, the name list had many names and addresses that were written at the evacuation shelter and in some cases these hand-written addresses did not match with the data that the officials had brought with them in CSV format. Furthermore, people were

moving from the evacuation shelters to the houses of relatives, so the evacuation locations of citizens were constantly changing, and it was extremely difficult to specify their whereabouts.

As the evacuation location of residents could not be registered on the basic resident register system, it was impossible to send out notifications related to public administration and education, etc.

5. Capital recreating processes

In the following sections, we illustrate how each capital was damaged but converted and recreated to meet the urgent needs of town officials and citizens. Again, this paper employs the five dimensions of capital described in Table 1.

We also show that each capital was restored not independently but in a mutually reinforcing interaction. The conclusion of this paper presents a model for how such interaction restores capital and eventually recovers organizational processes that support citizens' lives.

Among the many organizational processes, we chose (1) relocation to temporary offices and (2) resumption of certificate issuing operation as our observation targets. The former explains the restoration of economic capital and the latter describes the restoration of organizational capital creation processes. They were the two key process reconstruction tasks in our three studies. Each town was forced twice to move to temporary offices and spend around one month to resume certificate issuing operations (Table 2).

Table 2. Timing of relocating to temporary office and resuming operations after the earthquake

	Moving to temporary office-1	**Moving to temporary office-2**	**Resuming issuing operation**
Otsuchi	2 weeks	6 weeks	4 weeks
Futaba	1 week	3 weeks	5 weeks
Namie	1 day	4 days	4-5 weeks

This delay was caused by the evacuation of whole towns, which forced town personnel to recreate their ICT environment from scratch.

5.1. Impact of capital loss in municipalities

Economic and human capital are often cited when we talk about the devastating effects of a disaster since these dimensions of capital are easy to measure and understand. As for the Great East Japan Earthquake, the number of the missing and injured as well as the number of houses destroyed or damaged can be expressed numerically. The impact of losing certain dimensions of capital, such as the office building, the Mayor and government employees in the case of Otsuchi, turned out to seriously delay the recovery processes. The Mayor represents the town's symbolic capital. In addition to this, one-third of municipal officials, approximately 40 personnel (of 136 officials at work in at the time of the earthquake) were lost. Imagine how difficult a situation they faced going toward recovery. The situation remained intractable because the disaster management plan did not foresee such forms of economic and human capital loss. However, most serious was the loss of organizational capital. Otsuchi was about to lose its residential data, which is one of the most important components necessary for the resumption of certificate issuing operations. Until salvage was in fact accomplished, officials did not believe their latest residential records would recover.

Neither Futaba nor Namie town lost their economic capital in terms of physical structures. However evacuation of the entire town following the accident of the Fukushima Nuclear Power Plant reduced economic value significantly which, in turn, removed symbolic capital from the town. Identity of any municipality is bound up with its geography. Thus, the loss of "homeland" represents serious damage to its symbolic capital. Futaba and Namie had to replace their office with unfamiliar locations several times. Organizational capital was destroyed with each evacuation. Residents were forced to move outside the town and this meant they were deprived of social capital at the same time.

Common to all three case studies was the destruction of a workable ICT environment, due to the loss of electricity, network connectivity, servers, etc. In other words, organizational capital was lost and required to be recreated in times of ongoing evacuation and upheaval. Among all, loss of symbolic and organizational capital had perhaps the greatest negative effect on the towns' recovery process. It is obvious that symbolic capital takes long time for its recovery once it is destroyed, i.e., Otsuchi took five months for having its mayoral election, and Futaba and Namie still cannot move back to their original homeland even more than 4 years after the earthquake. Long recovery times for symbolic capital also effect organizational capital.

We should now move on to discuss how each dimension of capital was recreated.

5.2. Capital conversion and recreation

In our studies the municipalities were usually successful in finding a substitute for their lost economic capital. In Otsuchi, municipal buildings and land (a community center and the grounds of an elementary school) were converted to provide a temporary office. In the other towns, a municipal branch office and an old high school building were turned into temporary offices. These solutions did not assume the evacuation status to continue as long as it did, but our observations show, in contrast to other dimensions of capital, that it was less difficult to convert whatever facilities were at hand and recreate economic capital.

It is obvious that human capital cannot be easily recovered once it is lost. After his election, the new Mayor of Otsuchi asked other municipalities to send relief staff and support his town's disaster relief and recovery operations. Consequently, the number of relief staff in Otsuchi rose to 150 as of April 2014, exceeding the original number of officials. The national government allocated a special budget for the town's revival, requiring additional staff.

In this instance we can observe the power of social capital offered by other municipalities. Municipalities that were not heavily damaged helped out not only with relief staff but also with the ICT environment, such as personal computers and printers, as we saw in the case of Futaba. Along the same lines, social capital, which in these cases comprises voluntary support by a number of system vendors, greatly contributed to stabilizing the situation in three municipalities and recreating organizational capital. As shown in Table 2, Otsuchi resumed certificate issuing operations four weeks later regardless of losing its residential record data. System vendors lent out or donated servers and personal computers and supported building network connectivity.

In addition to this, vendors offered town officials residential record backups for operations such as taxation calculations. These contributions were not tied to usual business but were a response to the urgency of the moment, demonstrating the strength of the relationship between them and the town.

Officials in Futaba had to return to the original town office building to pick up the backup tape and only five weeks later recovered certificate issuing operations. Namie, on the other hand, used a data center to manage its residential record data and did not have to fear data loss. Nevertheless, it took four or five weeks, almost the same amount of time as for the other two towns to restart proper operation.

In a nutshell, residential record data and donated hardware were input to produce useful infrastructure for recreating the environment in its basic components and conducting operations. We can see how social capital allows conversion into organizational capital.

However, these conversions could not have been possible without both human capital, which in this paper mainly refers to town officials, and economic capital. Officials in Futaba and Namie physically delivered personal computers, a tape and a CSV file with much needed residential data. Though the effectiveness of human capital should have been ensured by the disaster management plan, explicit instructions listed in the plan could in no way deal with the actual situation on the ground. Officials made their decision based only on their personal experience.

Through this capital conversion and recreation process, symbolic capital can easily be weakened, or lost, whereupon it is difficult to recover. Its loss reduces the value of economic capital as we see in the case of Futaba and Namie. Based on its definition, symbolic capital is interpreted within a social structure. That is, social capital is a necessary element for the development of symbolic capital. However, the loss of symbolic capital experienced by Futaba and Namie gradually unfastened residents' social connections. Once they lost the symbolic capital that constituted the physical boundary of social capital, reconnection was difficult. This initial observation needs further evidence to support generalization, but our data show that social capital and symbolic capital have a reciprocal relationship.

Figure 2 is a capital resiliency model that summarizes discussions in this section.

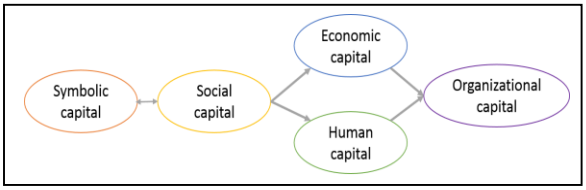

Figure 2. Capital resiliency model

6. Development of capital resiliency model

The notion of resilience offers adaptive capability that sometimes affects the shape of the ecosystem in instances where it faces uncertainty [23, 27]. The focus of this paper is to understand how each dimension of capital facilitates such an adaptive capability through its capital conversion and capital creation system. As ordinary business operations show, capital conversion converts inputs to outputs by adding value. Capital creation is the product of this value adding process. However, based on the notion of resilience, a disaster requires capital to be recreated, not just being created. In this sense, we recognize the

process of enhancing resilience as a capital conversion and recreation system.

It is obvious that each dimension of capital plays different, though not independent roles in recreating disaster management operations. Organizational capital has the most important role in the recovery process because it provides the conversion processes for recreating capital. In this paper, it refers to resuming certificate issuing operations, which becomes most important for residents following a disaster.

Disaster preparedness should clarify the way of organizational capital recovery. However, from empirical data of this research, the situation was beyond the assumption of institutionalized or explicit knowledge. Organizational capital was recreated depending on the situation in the field. This means, as long as calamities are diverse, the process of organizational capital recovery will take different routes. Without adaptive capacity, organizational capital cannot be restored.

Figure 3 summarizes how capital that supports municipal citizen services was destroyed and recovered in the three towns examined.

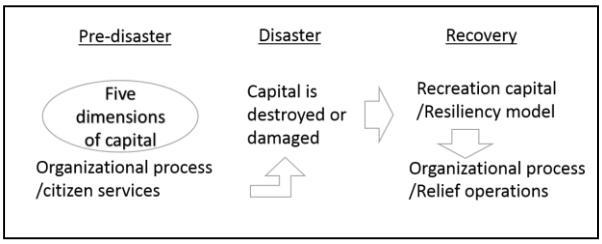

Figure 3. Capital recovery process

In pre-disaster times, organizational processes yield a structured five dimensions of capital as a stable system for citizen services. Following a disaster of unexpected magnitude and/or nature, these organizational processes are destroyed and capital is destroyed or damaged. Buildings and personnel might be lost permanently. In the recovery stage, communities are faced with the task of reassembling the disintegrated capital, with the addition of newly supplied relief, to form new capital enabling support of the vital needs of residents.

As Figure 2 shows, recognition of such capital recovery processes make us aware that, at least in the analyses of disaster recovery, the five dimensions of capital should not be considered in isolation but as a set of hierarchically structured, organic relations. Symbolic and social capital are mobilized to reconstruct economic and human capital that enables the recreation of new organizational capital that eventually supports services to residents.

The analysis highlights the importance and urgency of recovering organizational capital. To achieve this, nurturing social and symbolic capital in normal times should be considered in preparation of emergency situations. Although they may not be the central components of service delivery systems, they are critical in the restoration of vital organizational capital.

Social and symbolic capital are related, in that social structure affects the creation of symbolic capital and at the same time, social capital requires the continuous existence of symbolic capital. Social capital in general requires trust for it to work [28, p.167]. Relationships based on strong trust enable the production of something from what's available at any given time to improvise people's responses in the face of uncertainty [28]. The example of a vendor in Futaba helping out with data for initial tax calculations, thereby enabling officials to check resident whereabouts from their temporary office (a concert hall in Saitama), illustrates how social capital nurtured in ordinary times helps to create an innovative solution to an unexpected problem. Japan might have naturally high levels of social capital because of its culture and homogeneity, an aspect which might require further analyses in future research.

7. Conclusion

Resilience identifies the capacity for collective action in the face of unexpected extreme events that shatter infrastructure (capital in its various forms) and disrupt normal operating conditions [29] [30]. For developing a future disaster-tolerant government or community, the capacity to mobilize responses in the field is important. When we think how to accomplish this approach, we tend to focus on the restoration of buildings and personnel.

This paper advances the capital resiliency model to reveal organizational processes taking several forms depending on capital dimension, with the aim of achieving resilience. Case analyses demonstrate the importance of recreating organizational capital that manages capital conversion and recreation processes to meet the vital need of the residents.

The other implication derived from this research is that we should pay more attention to data preservation. We now recognize that data as organizational capital will not be recoverable once it is completely lost. In terms of building e-governments for the future, this could be an important topic worthwhile discussing.

The model was developed on the basis of three sets of data stemming from one disaster. It will require empirical evidence from future research to generalize the model and affirm its reliability. However, at the

same time, we recognize that this model enables us to analyze and develop the notion of resilience more systematically.

8. References

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