On the Studies of the Disaster Recovery for the Restoration of Local Communities and Local Governments from the Great East Japan Earthquake

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Abstract. On the afternoon of March 11th, 2011, a magnitude 9.0 earthquake followed by catastrophic tsunami hit northeast Japan, causing massive casualties. This Great East Japan Earthquake has caused serious effects not only in Japan but also in other countries. We should reconsider our energy policies including a question whether to depend on nuclear electric power generation or not in future. In this paper, we will report about this unprecedented disaster, about the impact on the local area, and will share and discuss the present information in cooperation with the local communities from the view point of disaster recovery and try to show the way to restoration by ICT.

Keywords: the Great East Japan Earthquake, Tsunami, Nuclear Power Station, Local Communities, Local Governments, Disaster Recovery, ICT, Virtual Communities.

1 Introduction

The massive earthquake on March 11th, followed by the giant tsunami, and Nuclear Plant accidents caused over 15,000 death, about 9,000 missing, and more than 100,000 evacuees, is officially named as "the Great East Japan Earthquake (GEJE)".

The causes of such a great damage were not only the earthquakes but the following tsunami and the damaged nuclear power plants. Especially the accidents in the plants inside and outside have been releasing the radiation of high density and have made it difficult for the examiners to approach the plants to access and evaluate the actual damages and causes. As the cooling down of the plants has advanced, and the situation appears to be settled down gradually, but the released information about the inside of the plants still changes day by day.

Under such a circumstance, this paper try to describe the research on the present damage situation in the communities involved, focusing on the damage caused by the

M.M. Cruz-Cunha et al. (Eds.): CENTERIS 2011, Part I, CCIS 219, pp. 22–33, 2011.

plants' accidents which have caused the breakdown of the involved communities, the possibility to maintain essential functions of Local communities and Local governments by ICT and lastly a proposal on the restoration of the Local communities and Local governments.

2 Research on GEJE

2.1 Japan Faces an Unprecedented Challenge (Earthquake, Tsunamis and Nuclear Accident)

Occurrence of the Enormous Earthquake. On March 11 th at 14:46 (JST), there was a magnitude (M) 9.0 (preliminary) earthquake at a depth of approximately 25km, off-shore of Sanriku, northeast coast of Japan (fig.1). The magnitude of the main shock, M9.0, is the largest one experienced in Japanese history. This massive earthquake had a maximum seismic intensity 7 observed in Miyagi prefecture, and caused giant tsunami on the pacific coast in northeastern region of Japan.

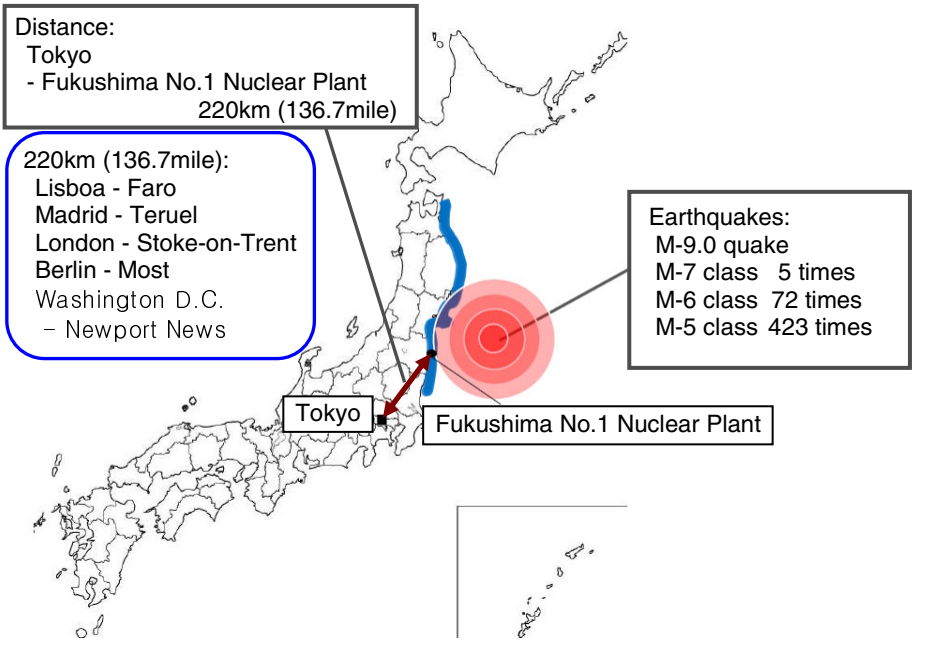

Fig. 1. General view of the epicenter of the earthquakes and the coast part tsunami overcame (Ministry of Economy, Trade and Industry [1]; translated into English by the reporters by adding the distance from Tokyo to the power plants and to other cities and countries)

Earthquake Research Institute, University of Tokyo announced the result of the stricken area investigation, that the largest tsunami height was over 37.9m in Miyako city, Iwate prefecture [2].

This earthquake occurred on the boundary between the Pacific plate and the North American plate (fig.2).

The maximum aftershock was a M7.7 (preliminary) one that at 15:15 on March 11. Shown as follows, Earthquakes M7.0 or over, hit off-shore of the Pacific coast from Iwate through Ibaraki Prefectures. It is thought that the hypocenter area extends widely from the region off-shore of Iwate to Ibaraki prefectures.

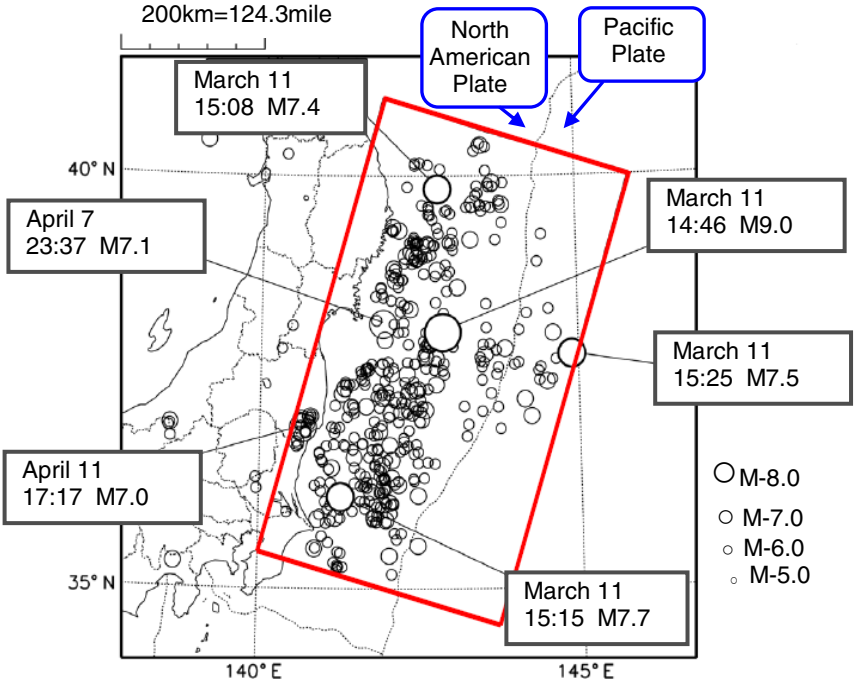

Fig. 2. The epicenters of the main shock and aftershocks (Japan Meteorological Agency[3]; translated into English by the reporters by adding the map and plates)

The Earthquake Research Committee evaluated earthquake motion and tsunami for the individual region off-shore of Miyagi prefecture, to the east off-shore south of Sanriku, and to the south off-shore of Ibaraki prefecture, however, occurrence of the enormous earthquake like GEJE which was linked to all of these regions was out of assumption [4]. With such a giant tsunami, the embankment was no longer useful, and the coastal villages in northeast Japan, including Fukushima Nuclear Plant, received catastrophic damage by the tsunami.

Damages. Because of the repetitious earthquakes on March 11 th, in Kesennuma city there was a very big fire because of the ignition on the fuel oil leaked from ships and factories collapsed by the tsunami. On that day, the life-line including electricity in

the north-eastern region of Japan was heavily damaged, and besides electricity, gas and water were also stopped, since the extensive damages involved roads, railways and even airports.

According to the information released by the National Police Agency officials on May 23 rd, 15,188 peoples were killed, 8,742 were missing, 5,337 were injured, and damaged houses, 98,016 totally collapsed and 50,868 half collapsed. Total 2460 safe shelters were set up in 18 prefectures mostly in northeast regions of Japan, and the evacuees are totals to 108,672 persons [5].

2.2 Rescue Efforts and Foreign Assistance

Soon after the tsunami hit, firefighters, policemen and Self-defense force officials searched and rescued victims. Starting with the rescue teams from Singapore and Korea on March 12 th, many foreign rescue staffs arrived including 144 US staffs, 134 French, 75 Australia, 69 UK members with the rescue dogs [6].

So far, 157 countries and regions as well as 42 international organizations have expressed their intentions of assistance with their general intention of assistance, human resource assistance, relief supplies and donations [7]. The Special Headquarters to Support Disaster Victims is consistently processing the acceptance of the offered relief-goods according to the needs of stricken areas. The goods include radiation protect-goods, radiation dosemeters, personal dosemeters and radioactive-proof suits beside the standard relief-goods like water, food and blankets [7].

3 Nuclear Disaster

3.1 Nuclear Power Stations

Model of Nuclear Plant in Japan. In Japan, at Tokai-village in Ibaraki prefecture, the first commercial electricity production by using atomic energy started in 1963[8]. This first Nuclear plant was a magnox reactor made in England, and was rather expensive. Afterwards, most of the models of Nuclear Plants introduced into Japan were classified into two groups, namely, Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR), and now, five electric power companies including Tokyo Electric Power Company (TEPCO) are using BWR, and other five companies PWR [9].

Situation of Nuclear Plant in hardest hit areas. In Iwate prefecture, highest tsunami was generated, there was no nuclear power plant. In Miyagi prefecture adjacent to Iwate, there was Onagawa Nuclear Plant. Since Miyagi prefecture experienced severe Tsunami attacks in the past, they constructed Onagawa Nuclear Plant in the safer inland area far from the seashore, and the Nuclear Plant automatically and safely stopped on that day, and there was no damage due to Tsunami. On the other hand, Fukushima prefecture adjacent to Miyagi had not experienced any strong Tsunami in the past, they constructed Nuclear Plants in the area near to seashore where they believed to be safe from the statistical points of view.

In Fukushima, there are two Nuclear Plants, Fukushima No.1 and No.2 Nuclear Power Station, and the severely damaged Fukushima No.1 Nuclear Plant is equipped with several BWR, and they were constructed mostly in 1970s including Unit 1, the oldest one made in 1971.

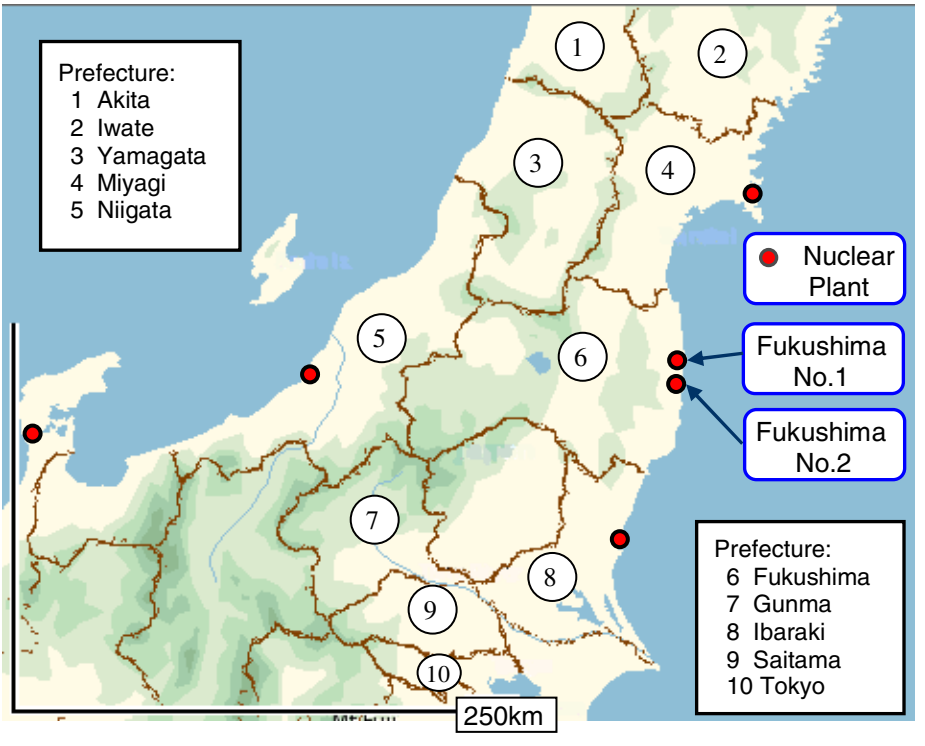

Fig. 3. Prefectures in Northeast regions of Japan, related to this study (made by the reporters)

Damage of Nuclear Plant in Fukushima prefecture. Fukushima No.1 Nuclear Plant has 6 units. Unit5 and unit6 have not operated by the periodical inspection, and totally have cold shut down on that day. Unit 4 is not operated, and is not cold shut down. Unit 1, unit2 and unit3 have operated, and shut down automatically by the earthquake, but cold shut down is not completed [1].

The 14～15m height tsunami reached the nuclear power station which stood 10 meters above sea level. Muddy waters engulfed the main facilities area of the Plant. As the tsunami hits, a power outage and the failure of the emergency generators to provide backup electricity caused the emergency cooling system to stop functioning. The emergency cooling system is the most vital component of the safety system of a nuclear power plant with BWR and must never fail [10].

The government declared an atomic power emergency for the first time, while the government of Fukushima Prefecture advised residents to move out from the nuclear power plant area to evacuate.

When the hydrogen explosion in the building of the nuclear plant occurred, the radioactive substance leaked to the atmosphere. Therefore, the evacuation of the residents in the peripheral area of the power plant was unavoidable.

3.2 Key Challenges

Cool Down the Reactors. After the explosion, sea water was injected to the reactor core. Because dose of radiation is too high to enter the room, the best way appeared to cool down by pouring sea water. TEPCO recovered external power, connecting to the control room. After May, when the fuel pellets were meltdown starting 4hours after the tsunami, as reported, all the melted fuel pellets have accumulated at the bottom of the vessel. The fuel pellets collected at the bottom of the vessel and the radiation leaking was also incontrovertible. It will be necessary to cool the reactor and spent fuel pool to stable.

Contain the Spread of Radioactive Substances. April 1st, highly contaminated water discovered leaking into the sea. April 6th, leak of contaminated water into the sea was stopped by injected polymer. About soil and atmosphere, April 1st, TEPCO sprayed synthetic materials on the surface of the ground and debris to prevent radioactive substances dispersion [1]. Some school removed the surface soil of the school yard/ground to prevent dispersion. In future, disposal method of the contaminated the rubbles and soil and securing of disposal facilities become problems.

Rigorous and Intensive Monitoring. About two months after GEJE, cooling down of the reactors in Fukushima No.1 Nuclear Plant is still continued, and complete cold shut down has not yet been made. To estimate the present state of radiation pollution, the measurement of the radiation in the environments, such as, air, water, soils, plants, animals, foods, and others are needed. Therefore, rigorous and intensive monitoring of the environments, and correct and quick announcement of monitoring results to the residents is necessary. For instances, each local government monitors the radio-activities of the air every hour and water every day, and obtained monitoring results are released instantly on their Website.

According to the data reported by the Ministry of Education, Culture, Sports, Science and Technology, air pollution due to the release of radio active substances from Fukushima No.1 in the air in the northeast area of Japan decreased constantly. On May 10th, so far as the atmospheric dose concerns, only the parts of Fukushima, Miyagi, Ibaraki, Chiba prefectures exceeded the value ordinary of the past. The earth pollution of cesium 137 in Namie town has decreased to 68,716 becquerel/kg from the highest 220,000 becquerel/kg but the more decrease will be doubtful after this as the radiation in the air will be dropped by rain the amount of cesium137. As for the sea pollution, the research from March 23 to May 7th on the cesium 137, the April 15 hit the highest, 186.0 becquerel/L in the offing of Fukushima. The research on the pollution on the earth and sea will be of most importance.

Ensure the Safety of Food and Products. According to the report, the radiation higher than the standard was found in the spinach, milk in Fukushima and the adjacent Ibaraki and kounago small fish from the Fukushima offing and the government

stopped the shipment. The radiation rate is checked daily and the earliest stopped shipment was on March 21st. In May, the radiation has been still found among portions of vegetables.

4 Disaster Impact on Local Communities

4.1 Impact on Japanese Economy

Estimated Economic Damage of the Earthquake and Plan for Reconstruction. On March 23rd, the government announced the estimated calculation of 16-25 trillion yen ($195-305 billion) for the damaged roads and facilities, the biggest calamity since the last war. The estimation did not include the cost in the damaged nuclear power plants and radiation in TEPCO. Eventually the total estimation will be further greater. The estimation was based upon the old data of the past Hanshin Great Earthquakes and the cost for the tsunami was doubled. Also the calculation excludes the cost of damage of the TEPCO as it describes the radiation problems in the category of electric, gas, and water. The government postponed the information until after they collect more data [11]. Prime Minister Kan's speech on April 1st and April 12th, in short-term, clearing debris, erecting temporary housing, rehabilitating industrial facilities, in mid-term and long-term creating disaster-resilient local community, eco-friendly social system, and welfare-oriented society.

The government established "Reconstruction Planning Council" to discuss about future concrete revival plan, and to let a guidance reflect them. April 27th, a special law of decreasing the tax for the refugees was setup. On May 2nd, the budget amounted to 4trillion 153 hundred million Yen as the first revised budget to assist the refugees was announced. The budget includes the construction of temporary housing, clearing debris, maintenance of infra-structure which amount at most 300 man yen for a household. After June, another reformed budget is expected to come out for increase of consumption tax and welfare.

Impact on Energy Supply/Demand in Japan. The power plants in Fukushima has been administered by TEPCO and its generation capacity has decreased by 40 % [1].Since the plant accident in Fukushima was serious, on May 6th, the government requested to stop the nuclear power plant in Hamaoka in Shizuoka prefecture which may have a high possibility of another great earthquake. Upon the request, on May 9th, the company decided to stop the operation of Hamaoka Plant. Because of this, people worry the lack of electricity in this summer. For a solution, the government has decided to reduce the consuming amount of electricity by 15 % at home and in companies. Prime minister Kan commented and announced to reevaluate the energy plan made in June of 2010.

4.2 Evacuation Situations

Evacuate in group to a near-by place (Iitate village). The villagers of Iitate village, which was appointed be in the 'Planned evacuation zone,' took refuge in group to a near-by place. It now involves five villages and towns in April 22nd and the government requested to leave the place by the end of May [12]. According to the

Asahi Newspaper, the government had a conference with the village head of Iitate village and the mayor of Kawamata town and proposed Nagano prefecture (250km from Iitate village), and Aomori prefecture 350km from Iitate village) for the group refugees in April 26th. However, to reflect the refugees' wish, they insisted the closer places and have chosen the adjacent Nihonmatsu city (28km from Iitate village) and Fukushima city in the prefecture (24km from Iitate village). As of April 29th, 6,000 refugees (only the half of the village population) are distributed in the local hotels, inns, public facilities and private apartments. They need more evacuation places.

Evacuate in group to a distant place (Futaba town). Futaba town in the 'Non-entry zone' includes nine cities, towns and villages as of May 24th [12]. 27,175 households are now living in gymnasiums and temporary housings. On March 19th, Futaba town sent its refugees to Saitama city, Saitama prefecture. The administration with 1,500 refugees moved to the city outside Fukushima. Excepting 2,200 out of 6,900 villagers of Futaba town are distributed in several evacuation places in Kawamata town (43km from Futaba town). Thinking of the long-term evacuation, they decided to move to distant places. According to the Asahi Newspaper, the mayor gave the reasons to move in group to distant places saying, "The people can stay in one place with the merit of effective administration. In the long-term, it must be easier to find jobs in Tokyo and Saitama than in Fukushima prefecture with the power plant troubles. Since then, 1,400 are living in a high school in Saitama prefecture.

The diffusion of the evacuees. The population in the off-limit areas, which have a radius of 20km is 78,200 as of April 15th [12]. The table 1 indicates the result of the investigation by Fukushima prefecture [13]. The people who evacuated outside Fukushima prefecture as of April 28 are living in the public housings and establishments. The table excludes those living in the relatives and in the private establishments. As the table shows, the evacuation places are for those more than 1,000. Also we see the diffusion of the evacuees throughout Japan and some live 460km away from Akita and Tokyo.

Table 1. Evacuees from Fukushima prefecture(The map and the distant measures were made by the reporter based on the investigation by Fukushima prefecture [13]. Only the prefectures with more than 1,000 refugees are listed.)

Location from Fukushima prefecture	Range (Radius)	Prefecture	People April 28	People May 27
North	220km	Akita	1,080	--
Northwest	56km	Yamagata	1,861	1,861
West	120km	Niigata	7,782	7,876
Southwest	196km	Gunma	2,730	2,628
South	223km	Saitama	4,301	3,080
South	240km	Tokyo	3,644	4,588
		Other	12,514	11,107 (including Akita)
		Total	33,912	35,670

The longer the evacuation period lasts, the wider the evacuees diffusion is possible. The Itate villagers in the 'Planned evacuation zone' , the middle level of danger, may want to choose their evacuation place closer to their former village, hoping their evacuation period would not last longer.

On the contrary, the Futaba Town people, directly located in the nuclear power plants of the 'Non-entry zone, have chosen distant places where they can find employment, assuming the evacuation will last longer.

The government has not shown how long those in the evacuation zone should stay out of their home districts. When the evacuation period becomes longer, the villagers will find their relocation in distant places where they can restore their life with proper employment. The tendency of diffusion will increase as the longer the evacuation period lasts. The seniors and the elderly people tend to evacuate in groups while the young move individually to seek for employment which causes more diffusion among the evacuees.

5 Proposal for the New Model of Local Communities

5.1 The Restoration of the Community After the Diffusion of the Long-Term Evacuation

The above mentioned is the actual situation after the power plants accidents. Even though the government has not clearly shown the duration of the evacuation, the long-term evacuation will be undoubtedly possible. If the off-limit in Fukushima extends to 20 years like the case of Chernobyl nuclear plant, how do they restore the damaged community?

Our proposal presents that using ICT system would smooth the restoration of the evacuees in future. More concretely, setting up the "Virtual Community" (VC) as a policy would enable the evacuees to communicate with their friends, relatives and the people they used to know in their neighborhood communities. After some years when the off-limits are removed, some of the villagers and the citizens in the area might be able to return to the area. If they would be able to maintain the mutual close contact by the VC : the destruction of the community in reality could be somehow restored after certain lapse of time, if they want, so long as they maintain the communication through the VC.

The VC will record the evacuees' sentimental feelings toward their native home by recording not only the maps and the photos of the areas, but also the kizuna (Japanese) bondage among the people involved in the local areas as social capital.

The participants of the VC will register their real names in order to communicate with their partners, their relatives, and friends. Registration with their real name in the VC is important to select partners, and useful to set up the level of disclosed information.

After 20 years, the generations will be changed and the memories of the participants are only possible to restore by the ICT tools. But for those who can not use the modern techniques, the VC members will visit virtually and actually them and record what they hear in this way, the VC helps to keep the oral history of the destructed which should be handed down to the future generations.

The recorded memories of the participants may include what they widely want to hand down to the listeners who can be limited to their relations.

Since the purpose of the VC is restoration of the destructed/disappeared communities, the VC should be carried on by the VC members who should take care of the administration. The VC should manage the rules and regulations on investigations as their restoration policy. VC will not only to promote the communication among the evacuees, but also inform them on the supplies and services of the money for assistance, as well as the restoration progresses.

5.2 Usage of ICT to Transmit the Memories for Restoration

Presently, the governmental usage of ICT is only limited to gain the information on the refugees' evacuation places based upon the information system of the refugees throughout the nation [14]. For future plan, the government decided the summary of a new system, which plans a start of the use from 2015: control the tax and social security system: each Japanese national will receive his/her own identity number which can be used in anyway at the time of the natural calamity [15]. And they do not yet pay attention to the restoration of the communities.

A community member owns the land, and the Local government provides social services with the residents as community members. At this accident, in the lapse of 20 years, the Central government will eventually buy the contaminated land and the people lose the land and no one will live in the forbidden areas which may eventually bring complete disappearance of the communities. By this influence, significance of existence of the Local government will be doubted.

Even though the communities disappear, someday, it will be possible that some former residents may want to return to their old home. When the areas become livable in some days, who would come and live in the area which still will be somewhat dangerous? Besides, Fukushima prefecture is too distant from Tokyo for anyone to commute for his job. So if the government wishes the areas to be restored, the only people may want to return and live there will be those who used to live with some sentimental reasons like their parents, and grandparents used to live there.

The sentiments for the old home can be maintained only through ICT system which makes it possible to gather the information on the dispersed refugees. If the refugees are living with their family members, they can hand down their memories, but not those who have been away from their home and live in distant places. If a person lives alone, he/she has no one to share and hand down the memories of his/her old communities. Therefore, ICT system seems to be the only and the best solution available to gather the dispersing memories and transmit them to the following generations.

Our proposal is a newly developed one and partly based upon so-called 'SECI Model' which had been reported in the literature 'Knowledge Creation Enterprise' [16]. Briefly, 'SECI Model' is consisted of four processes, namely, (1) Socialization, (2) Externalization, (3) Combination, (4) Internalization. The first process (1) is considered to gain and transmit 'Implicit Knowledge' by mutual experiences, the second step (2) is to change 'Implicit Knowledge' to 'Formalized Knowledge', the third step (3) is to create another/new 'Formalized Knowledge' by combining more than one 'Formalized Knowledge', the last step (4) is to experience the knowledge by

practicing 'Formalized Knowledge', and again go back to the first process. Thus, these four processes go through continuously, and these cyclic processes will be available to knowledge creation.

Memory and knowledge are not completely identical, but "Popular Information" such as memory "is existence that supports Knowledge basement" [17]. Therefore, memory is very closely related with knowledge, and this knowledge creation processes are also very closely related with the memory transmission processes, such as transmission of evacuees' memories to their descendants.

If well-organized local governments, communities and evacuees participate in the same VC, real civil officers would behave as virtual civil officers, and might contribute to evacuee's memory transmission processes to others including their descendants. Also, the local governments damaged by GEJE as well as the refugees' memories on their old towns and villages should be able to continue by VC.

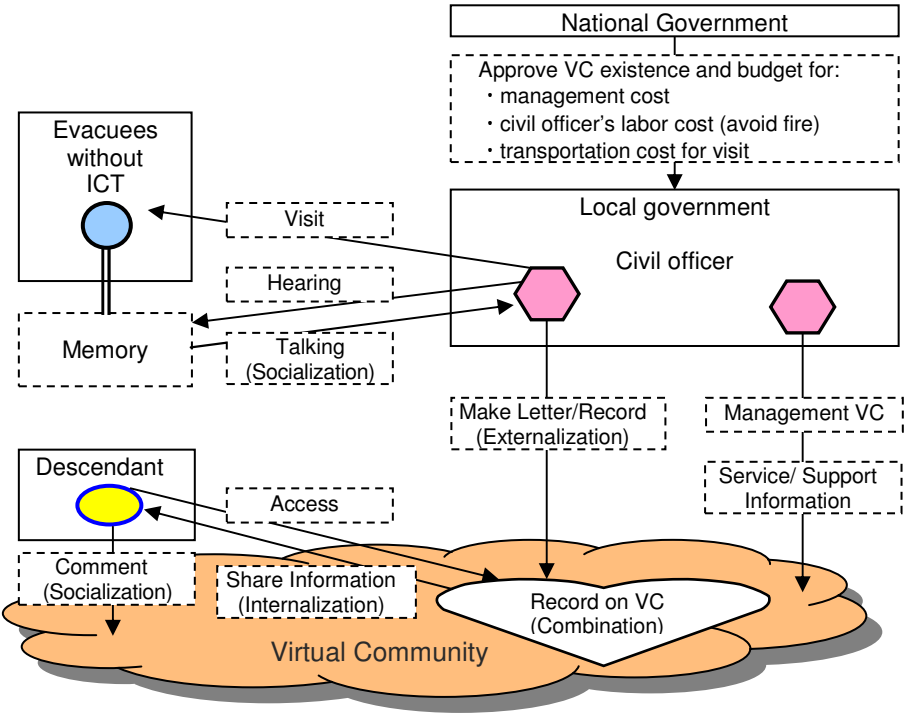

Fig. 4. This schematic figure depicts outlines of virtual community (VC) newly proposed in this paper. Various relationships among governments, evacuees, their descendants are given focusing on continuation of the 'memories' of those without ICT among the diffused evacuees

6 Conclusion

In this paper, we researched on GEJE, announced by the Minister of Foreign Affairs, who described the late calamities saying, 'the hardest national crisis since World War II in Japan', and showed the current damaged situation for the stricken area. Also, we

see the diffusion of the evacuees throughout Japan, who had evacuated their home towns because of the nuclear disaster.

Even though the government has not clearly shown the duration of the evacuation, the long-term evacuation will be undoubtedly possible.

Therefore, we think the necessity of the restoration model for the Local Communities and Local Governments of planned for the long- term evacuation for the evacuees from their home land.

Accordingly, we newly proposed Virtual Communities as the model to restore the Local Systems including both communities and local governments, by using ICT with build-up memories and records of evacuee's home towns.

The method of using such ICT would contribute greatly to maintain Local Systems, and to smooth out restoration of the Local Systems.

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