Socio-economic and environmental impacts of Match 2011 earthquake, tsunami and Fukushima nuclear accident in Japan

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Introduction

On March 11, 2011 the strongest recorded in Japan earthquake off the Pacific coast of North-east of the country occurred (also known as the Great East Japan Earthquake, 2011 Tohoku earthquake, and the 3.11 Earthquake) which triggered a powerful tsunami and caused a nuclear accident in the Fukushima Daichi Nuclear Plant Station. It was the first disaster that included an earthquake, a tsunami, and a nuclear power plant accident.

The triple 2011 disaster has had immense impacts on people life, health and property, social infrastructure and economy, agri-food chains, natural and institutional environment, etc. in North-eastern Japan and beyond [Al-Badri and Berends, 2013; Biodiversity Center of Japan, 2013; Buesseler, 2014; Fujita et al., 2012; IAEA, 2011; IBRD, 2012; Koyama, 2013; Kontar et al., 2014; Nakanishi and Tanoi, 2013; NIRA, 2013; UNEP, 2012; Vervaeck and Daniell, 2012; Watanabe A., 2011; Watanabe N., 2013; WHO, 2013; WWF, 2013].

Due to the scale of the disasters and the number of affected agents, the effects' multiplicities, spillovers, and long time horizon, the constant evolution of the nuclear crisis, the lack of "full" information and models of analysis, etc. the overall impacts of the 2011 disasters is far from being completely evaluated. Furthermore, most of the domestic information and publications have been in Japanese, which make it difficult for international public to get a full insight on the scales and diverse implications.

The goal of this paper is to assess the socio-economic and environmental impact of Match 2011 earthquake, tsunami and Fukushima nuclear accident in Japan. Firstly, a short description of the three events is presented. Next, the overall impacts on population, health and displacement assessed. Third, the effects of economy are evaluated. After that, diverse impacts on agri-food chains are presented. Finally, the impact on natural environment is assessed.

A wide range of official governmental, farmers, industry and international organizations, and Tokyo Electric Power Company (TEPCO) data as well as information from publications in media, research and experts reports, etc. have been extensively used.

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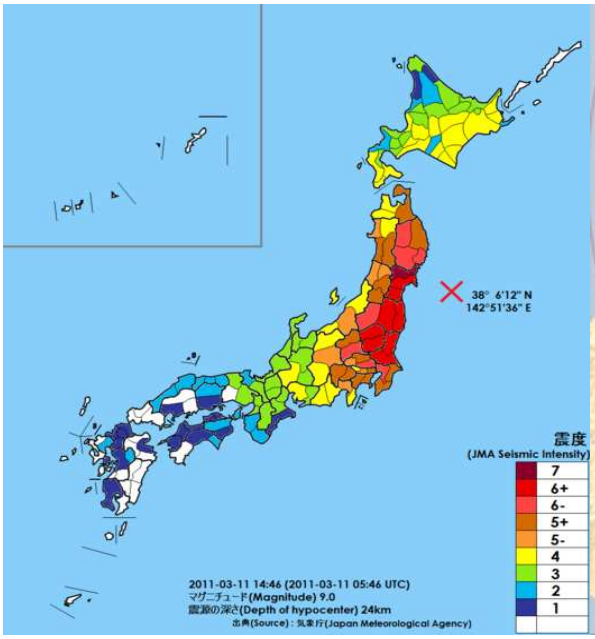
1. Description of events

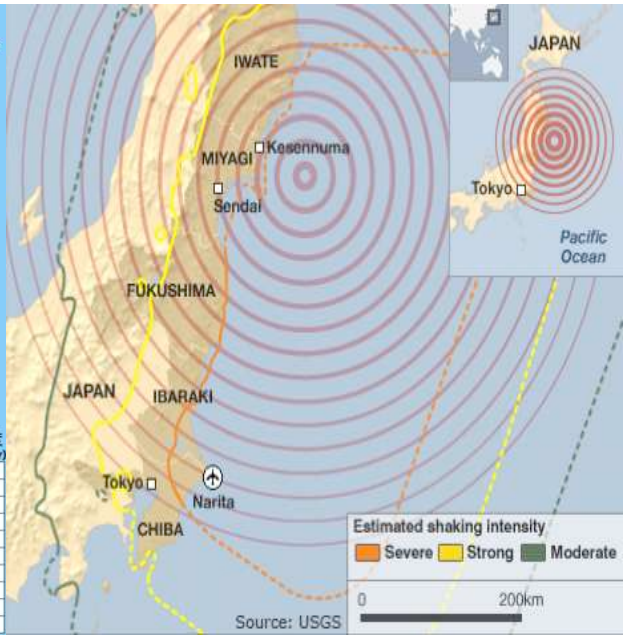
On March 11, 2011 at 14:46 Japan Standard Time[2] a mega thrust undersea earthquake occurred off the Pacific coast of Japan widely known as the Great East Japan Earthquake [Japan Meteorological Agency, 2014]. The earthquake hypocenter was at a depth of 24 km and epicenter 130 km (38° 6.2′ N, 142° 51.6′ E) East of the Oshika Peninsula of Tōhoku region, Honshu island (Map 1).

Map 1. Epicenter and seismic intensity of March 11, 2011 earthquake



Source: Japan Meteorological Agency

Map 2. Areas affected by March 11, 2011 quake



Source: U.S. Geological Survey

The earthquake was with a magnitude of 9.0 Megawatt (Mw) [Japan Meteorological Agency, 2011]. Its seismic intensity was 7 in the Northern part of Miyagi prefecture (Kurihara city), 6+ in the Southern and Central part of Miyagi prefecture, Nakadoti and Hamadori of Fukushima prefecture, the Northern and Southern part of Ibaraki prefecture, the Northern and Southern part of Tochigi prefecture, 6- in the Sothern part of coastal area, the Northern part of inland area and the Southern part of inland area of Iwate prefecture, Aizu region of Fukushima prefecture, the Southern part of Gunma prefecture, the Southern part of Saitama prefecture, and the North-west part of Chiba prefecture, and a lower intensity in other areas of the country (Map 1 and Map 2).

The Great East Japan Earthquake was the most powerful earthquake ever recorded in or around Japan, and the forth most powerful earthquake in the world since 1900 [Japan Meteorological Agency, 2013].

The main earthquake, lasting approximately six minutes, was preceded by a number of large foreshocks first major of them being on 9 March (with 7.2 Mw). Almost 1000

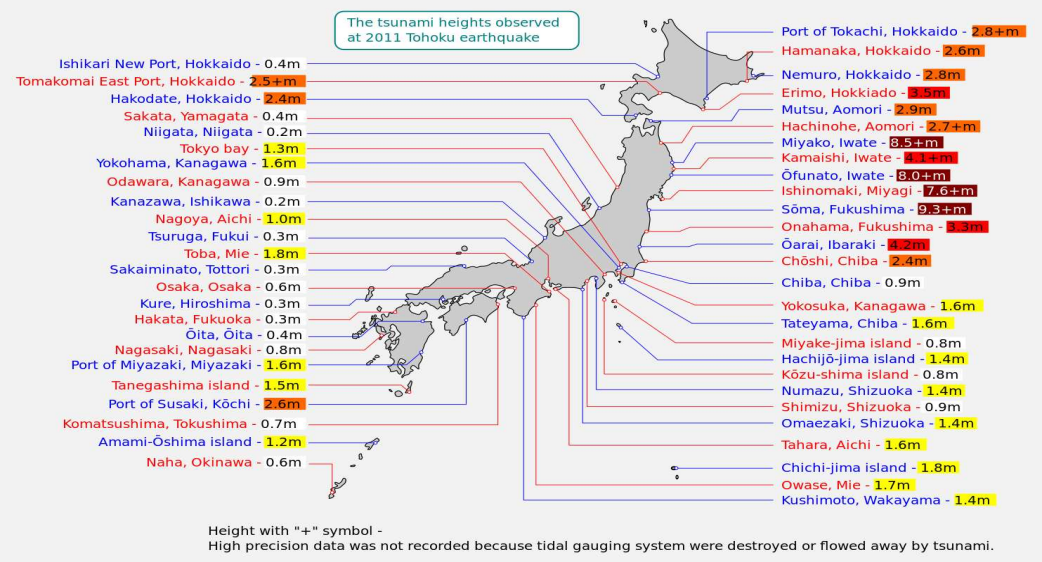
[2] 05:46 Universal Time Coordinated

aftershocks of magnitude 5.0 Mw or greater occurred since the initial quake by the end of 2013 [Japan Meteorological Agency, 2014].

According to some estimates The Great East Japan Earthquake moved Honshu island 2.4 m east, dropped vertically a 400 km stretch of the Pacific Ocean coastline by 0.6 m, and shifted the Earth axis between 10 cm and 25 cm [Chang, 2011; Deutsche Welle, March 14, 2011]. The greatest confirmed land subsidence was in Oshika Peninsula, Miyagi (1.2 m), Rikuzentakata, Iwate (0.84 m), Ishinomaki, Miyagi (0.78 m), Kesennuma, Miyagi (0.74 m), Ōfunato, Iwate (0.73 m), Minamisanriku, Miyagi (0.69 m), Kamaishi, Iwate (0.66 m) etc. [Geospatial Information Authority, 2011]. Experts say that the land subsidence is permanent which makes such areas more susceptible to flooding during high tides.

The Great East Japan Earthquake triggered powerful tsunamis that spread over the wide area from Hokkaido to Okinawa[3] (Map 3 and Map 4). According to estimates an extensive coastal area surpassing 400 km was hit by tsunami higher than 10 m that submerged plane areas more than 5 km inland [Mori et al. 2011].

Map 3. Great East Japan Earthquake observed tsunami heights in Japan

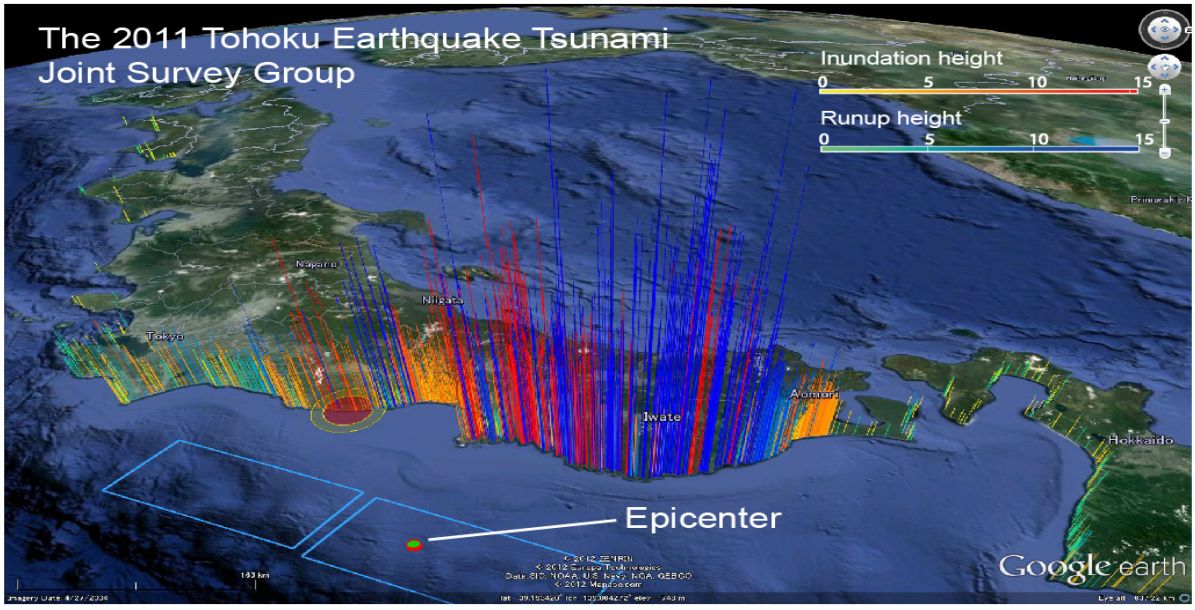


Source: Japan Meteorological Agency

The exact figures for heights of tsunami waves are not known. Official data for the maximum heights of tsunami are: more than 9.3 m in Souma, Fukushima prefecture (March 11, 15:51), more than 8.5 m in Miyako, Iwate prefecture (March 11, 15:26), more than 8 m in Oofunato, Iwate prefecture (March 11, 15:18), and more than 7.6 m in Ishinomaki, Miyagi prefecture (March 11, 15:25) [Japan Meteorological Agency, 2014]. Some reports indicate that tsunami waves reached heights of up to 40 meters at Omoe peninsula, Miyako city, Iwate prefecture, and travelled up to 10 km inland in Sendai area [NHK, August 13, 2011]. This height is also deemed the record in Japan historically [Yoshida, 2012]. The earthquake caused a vertical drop in the coastline 0.6 m, which allowed the tsunami to travel farther and faster onto the land.

[3] Simulations available on http://walrus.wr.usgs.gov/tsunami/sendai11/

Map 4. March 2011 Tsunami runup heights along Japan coastline



Source: Tohoku Earthquake Tsunami Joint Survey Group

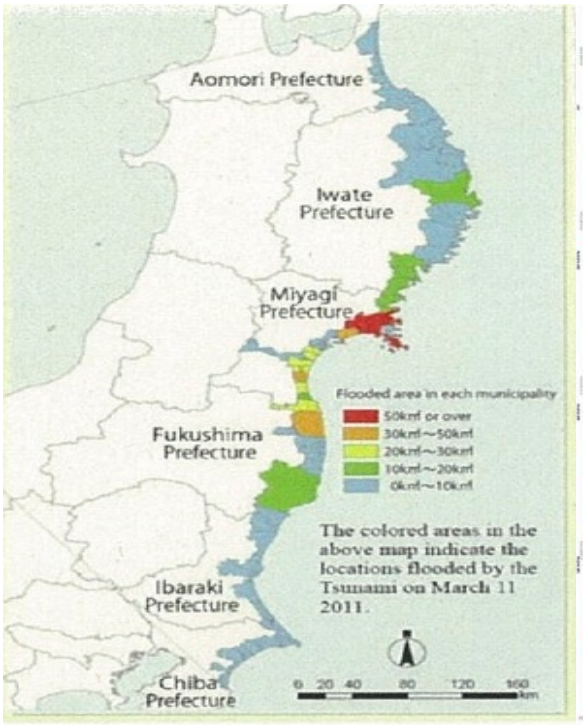
The tsunami raced outward from the earthquake epicenter at speeds that approached about 800 km per hour [Britannica, 2014]. Experts suggest that it would have taken 10 to 30 minutes to reach the areas first affected, and then areas further North and South based on the geography of the coastline [Deutsche Welle, March 11, 2011]. The timing of the earliest recorded tsunami maximum readings ranged from 15:12 to 15:21 or between 26 and 35 minutes after the earthquake had struck [Japan Meteorological Agency, 2011]. Tsunami have traveled across the Pacific Ocean to Chile and highly likely returned to the Japanese coast about two days later with 30-60 centimeters height [The Japan News, May 2, 2014].

The most severe effects of the tsunami were felt along a 670-km long stretch of coastline from Erimo, Hokkaido, in the north to Ōarai, Ibaraki, in the South, with most of the destruction occurring in the hour following the earthquake [Biggs and Sheldrick, 2011]. The most severely affected areas were areas Kuji, Ōfunato, Rikuzentakata Kamaishi, Miyako, Ōtsuchi, and Yamada in Iwate prefecture, Namie, Sōma and Minamisōma in Fukushima prefecture, and Shichigahama, Higashimatsushima, Onagawa, Natori, Ishinomaki, and Kesennuma in Miyagi Prefecture[4].

The tsunami inundated a total area of approximately 561 km^2 or 4.53% of the total territories of the six Northeastern prefectures of Honshu island [Geospatial Information Authority, 2011]. The most affected was Miyagi prefecture where 16.3% of the territory was flooded by seawaters. The worst affected by flooding were Wakayabashi and Migagino words of Sendai (60.4% and 4.5% of the total areas inundated), Watari-cho (47.9%), Iwanuma (43.9%), Shishigahama town (38.5%), Yamomoto-cho (37.5%), Higashimatsushima (36.3%) and other areas (Map 5, Picture 1).

[4] detail maps of areas hit by the tsunami are available at: http://danso.env.nagoya-u.ac.jp/20110311/map/index_e.html

Map 5. Areas flooded by tsunami



Source: JICA

Picture 1. Tsunami flooded areas of Sendai

Source: U.S. Geological Survey

The earthquake and the tsunami caused a nuclear accident in one of the world's biggest nuclear power stations - the Fukushima Daiichi Nuclear Power Plant, Okuma and Futaba, Fukushima prefecture (Picture 2). The tsunami arrived at the plant station around 50 minutes after the initial earthquake. The 14 meter high tsunami[5] overwhelmed the plant's seawalls and damaged cooling systems and control rooms (Figure 1). Three out of the six reactors (units 1, 3 and 4) suffered large explosions from March 12 to March 15, 2011 [Tokyo Electric Power Company, 2011]. Level 7 meltdowns occurred[6] leading to releases of huge radioactivity into the environment [Nuclear and Industrial Safety Agency, April 12, 2011].

Diverse radioactive materials were released from the containment vessels of the power plant as a result of deliberate venting to reduce gas pressure, deliberate discharge of coolant water into the sea, and uncontrolled events. The official data for the radionuclides released into the atmosphere from Fukushima accident are presented in Table 1.

Radioactive elements were released by the nuclear plant into: the atmosphere in the form of radioactive gases or radioactive particles (aerosols) dispersed into the air, a portion of which fell on the ground soil and formed residual radioactive deposits; the marine environment, directly in the form of liquid releases into the sea and indirectly due to fallout on the sea's surface from radioactive aerosols dispersed over the ocean.

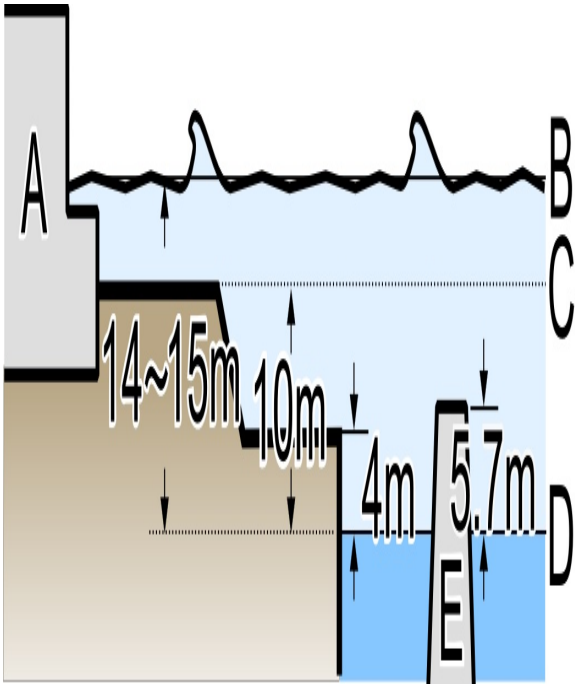
[5] Nuclear Regulation Authority has concluded that the tsunami triggered the meltdown [NHK World, July 18, 2014]. It rejected the conclusion of the Diet commission (July 2012) that the earthquake caused the reactor to lose power-damaging pipes leading to the meltdown before tsunami hit the plant.

[6] International Nuclear Event Scale (INES) runs from 0 (indicating abnormal situation with no safety consequences) to 7 (indicating accident causing widespread contamination with serious health and environmental effects). Prior to Fukushima, the Chernobyl disaster was the only level 7 event.

Picture 2. Fukushima Daiichi Nuclear Plant

Source: Tokyo Electric Power Company

Figure 1. Tsunami height at the nuclear plant



A - plant building; B - peak tsunami height;
C – site ground level; D - average sea level;
E - sea wall
Source: Wikipedia

Table 1. Radionuclides released from Fukushima nuclear power plant (Bq)[7]

Nuclide	Half life	Amount	Nuclide	Half life	Amount
Xe-133	5.2 days	1.1×10^{19}	Pu-238	87.7 years	1.9×10^{10}
Cs-134	2.1 years	1.8×10^{16}	Pu-239	24065 years	3.2×10^{09}
Cs-137	30.0 years	1.5×10^{16}	Pu-240	6537 years	3.2×10^{09}
Sr-89	50.5 days	2.0×10^{15}	Pu-241	14.4 years	1.2×10^{12}
Sr-90	29.1 years	1.4×10^{14}	Y-91	58.5 days	3.4×10^{12}
Ba-140	12.7 days	3.2×10^{15}	Pr-143	13.6 days	4.1×10^{12}
Te-127m	109.0 days	1.1×10^{15}	Nd-147	11.0 days	1.6×10^{12}
Te-129m	33.6 days	3.3×10^{15}	Cm-242	162.8 days	1.0×10^{11}
Te-131m	30.0 hours	5.0×10^{15}	I-131	8.0 days	1.6×10^{17}
Te-132	78.2 hours	8.8×10^{16}	I-132	2.3 hours	1.3×10^{13}
Ru-103	39.3 days	7.5×10^{09}	I-133	20.8 hours	4.2×10^{16}
Ru-106	368.2 days	2.1×10^{09}	I-135	6.6 hours	2.3×10^{15}
Zr-95	64.0 days	1.7×10^{13}	Sb-127	3.9 days	6.4×10^{15}
Ce-141	32.5 days	1.8×10^{13}	Sb-129	4.3 hours	1.4×10^{14}
Ce-144	284.3 days	1.1×10^{13}	Mo-99	66.0 hours	6.7×10^{09}
Np-239	2.4 days	7.6×10^{13}			

Source: Nuclear and Industrial Safety Agency, 2011

[7] *Becquerel* (Bq) is a unit for measuring substance's radioactivity equal to number of nuclear decays per second. *Sievert* (Sv) is a unit to quantify biological effects of radiation. Bq is converted into Sv through formula that factors in elements including the type of nucleus and type of radiation exposure.

There have been diverse estimates about the total amount of radioactive elements released into environment as a result of the nuclear accident. Assessments of Tokyo Electric Power Company[8], related government agencies of Japan (Nuclear Safety Commission, Japan Atomic Energy Agency, Nuclear and Industrial Safety Agency, and the French Institute for Radiological Protection and Nuclear Safety for the major radioactive materials released into the air and the sea during the period March-September, 2011 are summarized on Table 2 and Table 3.

Table 2. Estimates on amounts of radioactive materials released into atmosphere for March 12-31, 2011 as result of Fukushima nuclear plant accident (PBq)

Organizations and dates:	Rare Gas	I-131	Cs-134	Cs-137	INES*
Tokyo Electric Power Company (May 24, 2012)	500	500	10	10	900
Nuclear Safety Commission (August 22, 2011)	-	130	-	11	570
Nuclear and Industrial Safety Agency (February 16, 2012)	-	150	-	8.2	480
Institute for Radiological Protection and Nuclear Safety (February 28, 2012)	2000	200	30		-
Reference: Chernobyl accident	6500	1800	-	85	5200

* value obtained by converting amount of radioactivity into iodine equivalent

Source: Tokyo Electric Power Company, Institute for Radiological Protection and Nuclear Safety, Nuclear Safety Commission, Nuclear and Industrial Safety Agency

Table 3. Estimates on amounts of radioactive materials released into ocean between March 26-September 30, 2011 as result of Fukushima nuclear plant accident (PBq)

Organization	Period of assessment	I-131	Cs-134	Cs-137
TEPCO	March 26-September 30, 2011	11	3.5	3.6
Japan Atomic Energy Agency	March 21-April 30, 2011	11.4	-	3.6
Institute for Radiological Protection and Nuclear Safety	March 21-mid-July, 2011	-	-	27

Source: Tokyo Electric Power Company, Institute for Radiological Protection and Nuclear Safety, Japan Atomic Energy Agency

According to the May 2012 nuclear power plant's estimates the cumulative radiation releases amounts 538.1 petabecquerel (PBq)[9] of iodine-131, caesium-134 and caesium-137, out of which 520 PBq was released into the atmosphere between March 12–31, 2011 and 18.1 PBq into the ocean from March 26 to September 30, 2011 [Tokyo Electric Power Company, 2012]. A total of 511 PBq of iodine-131 was released into both the atmosphere and the ocean, 13.5 PBq of caesium-134 and 13.6 PBq of caesium-137. Releases of other radioactive nuclides into air, groundwater and ocean such as strontium, plutonium-238, 239, 240, and

[8] the operator of the Fukushima nuclear power plant

[9] The becquerel (Bq) is the The International System of Units (SI) derived unit of radioactivity defined as the activity of a quantity of radioactive material in which one nucleus decays per second.

241[10], and neptunium-239[11] were also reported. At least 900 PBq had been released into the atmosphere in March 2011 alone. By November-December 2011 the emissions dropped from around 220 billion Bq immediately after the accident to 17 thousand Bq or about one-13 millionth the initial level[12].

One year after the accident the Institute for Radiological Protection and Nuclear Safety's provisional estimates for the total radioactive releases into the air were:

- radioactive noble gases: 6,550 PBq (the same order of magnitude as the Chernobyl accident), composed mainly of xenon-133;
- radioactive iodine: 408 PBq (about ten times less than the Chernobyl accident), including 197 PBq of iodine-131 and 168 PBq of iodine-132;
- radioactive tellurium: 145 PBq including 108 PBq of tellurium-132 with its decay product iodine-132, and 12 PBq of tellurium-129 with its decay product tellurium-129;
- radioactive caesium: 58 PBq (about three times less than the Chernobyl accident), including 21 PBq of caesium-137, 28 PBq of caesium-134 and 9.8 PBq of caesium-136 [Institute for Radiological Protection and Nuclear Safety, 2012].

The Institute for Radiological Protection and Nuclear Safety also estimated that between March 21 and mid-July, 2011 around 2.7×10^{16} Bq of caesium-137 (about 8.4 kg) entered the ocean, about 82% having flowed into the sea before April 8, 2011. The later radioactivity represents the most important individual emission of artificial radioactivity into the sea ever observed.

Given the prevailing winds at the time of accident only 20% of the atmospheric fallout is estimated to have fallen on land with the majority of the remainder deposited to the North Pacific [Morino et al., 2011]. Contaminated waters were transported far into the Pacific Ocean by currents causing a great dispersion of the radioactive elements[13] [Buesseler, 2014].

Various publications show greater details about different radioactive materials released by the nuclear plant and their geographical dispersion [Busby, 2012; Buesseler, 2014; Chino et al., 2011; Morino et al., 2011; Tsumune et al. 2012; UNSCEAR 2013 Report].

Different assessments of radioactivity from the Fukushima plant ranged from 10-40% of that of Chernobyl accident while significantly contaminated area is estimated to be 10-12% that of Chernobyl's. For example, the largest source of Cs137 is global fallout from weapons testing amounting 950 PBq (including 600 PBq in the ocean), Chernobyl accident contributed 100 PBq, while releases from Fukushima plant are estimated to be between 4-90 PBq (including 10-50 PBq atmospheric and 3.6-41 PBq direct ocean) [Buesseler, 2014]. Cesium 137 leaks from Fukushima are compared with the amount released by 168 atomic blasts similar to that in Hiroshima in the end in of World War II [The Telegraph, August 25, 2011].

Since the accident there have been continued spills of contaminated water at the plant grounds and into the sea. On August 20, 2013 it was announced that 300 metric tons of heavily contaminated water had leaked from a storage tank [Tokyo Electric Power Company,

[10] 120 gigabecquerel (GBq)
[11] 7.6 terabecquerel (TBq)
[12] Due to human activities at the plant the emissions rose again up to 19 thousand Bq in January 2012.
[13] Recently it has been announced that for the first time trace amounts of radioactive cesium-134 emitted from Fukushima nuclear plant were detected off the northern California coast in water collected about 150 km off Eureka in August 2014 [The Japan News, November 17, 2014].

2013]. On February 27, 2014 it was revealed that another leak of 110 tons of contaminated water occurred [The Japan News, February 27, 2014]. A new up to a ton water leaks was reported on April 14, 2014 [NHK World, April 14, 2014]. On June 6, 2014 TEPCO announced that up to 3.4 tons of radioactive water may have leaked from barriers surrounding storage tanks [NHK World, June 6, 2014]. Moreover, about 11,000 tons of water used to cool melted-down fuel leaked out of reactor buildings into underground utility tunnels, from where it is believed to be flowing out to sea [NHK World, June 25, 2014].

Furthermore, the underground tunnels of the facilities have been filled with highly radioactive water, which is believed to be leaking into the nearby sea after mixing with groundwater [NHK World, November 25, 2014]. In June 2014 TEPCO found that radioactive water can easily spread in a deep layer of groundwater[14] and could be spilling into the ocean. On June 4 as much as 4,700 becquerels of tritium per liter were detected in a well near the No. 1 reactor building [NHK World, June 25, 2014]. Water pressure in the layer was lower than that of a shallower layer making it easier for contaminated water to spread in the deep layer.

After a strong typhoon in October 2014 it was found high levels of radioactive cesium in groundwater (up to 460,000 becquerels per liter)[15] in the compound of the nuclear plant in wells around the reactors buildings [NHK World, October 25, 2014]. TEPCO began pumping up groundwater from the wells on a trial basis in August 2014 and full-scale operations in October[16].

Since May 2014 TEPCO has been releasing water in the ocean from "groundwater bypass operation"[17] as more than 8,600 tons of groundwater has been discharged so far [The Japan News, June 28, 2014]. The first (about 560 tons) groundwater released in May contained 0.016 becquerel of cesium-134 per liter, 0.047 becquerel of cesium-137 and 220 becquerels of tritium [The Japan News, May 21, 2014].

Consequently, the significant pollution of sea water along the coast near the nuclear plant persist as a result of the continuing arrival of radioactive material transported towards the sea by surface and ground water running over contaminated soil as well as the leakages and releases from the power station[18].

Furthermore, in summer 2014 TEPCO announced that more than one trillion becquerels of radioactive substances were released as a result of debris removal work (280 billion becquerels per hour) at one of the plant's reactors [NHK World, July 23, 2014]. The

[14] deep layer of water is about 25 meters below the surface.

[15] 800 to 900 times the previous peak level of 500 becquerels per liter.

[16] TEPCO plans to treat the tainted groundwater and discharge it into the ocean to deal with the buildup of contaminated water. Local people strongly oppose the plan and utility has yet to discharge water into the ocean.

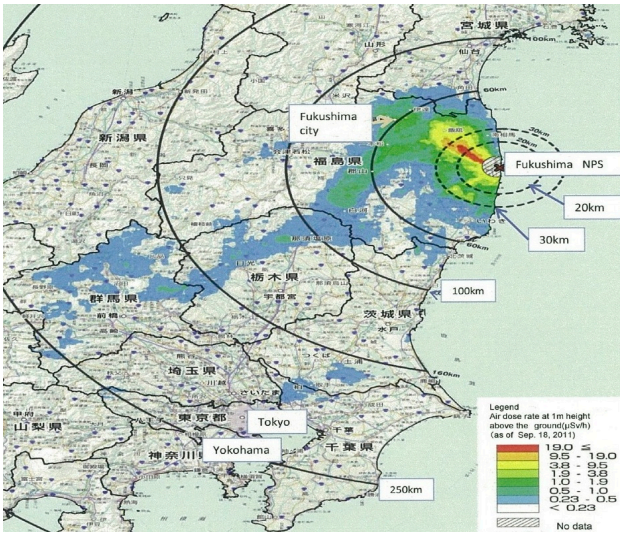
[17] intended to reduce the amount of radiation-tainted water at the plant. Groundwater is pumped up from 12 wells near the 1 to 4 reactors before it flows into the basement of the reactor buildings, temporarily stored in a tank and is released into the sea once radiation levels are confirmed to be lower than TEPCO standards.

[18] In October 2014 the concentrations of Cs-134 and Cs-137 in the seawater around Fukushima nuclear plant in outer layer varied between 0.0013-0.4 Bq/L and 0.011-1.2 Bq/L while in lower layer they were between 0.0013-0.099 Bq/L and 0.0046-0.034 Bq/L [Nuclear Regulation Authority, 2014].

plant is believed to be still releasing an average of 10 million becquerels per hour of radioactive material.

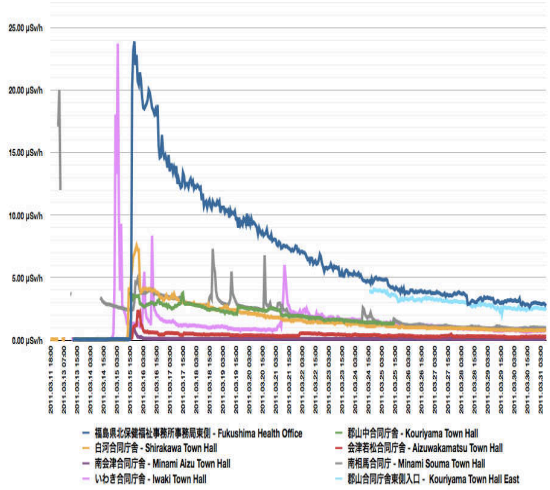
Radioactive contamination from the nuclear plant has spread in the region and beyond though air, rains, dust, water circulations, wildlife, garbage disposals, transportation, and affected soils, waters, plants, animals, infrastructure, and population. High levels of radiation were detected in large areas surrounding the nuclear plant and beyond (Map 6). Besides, numerous anomalous "hot spots" have been discovered in areas far beyond the adjacent region – e.g. in the year after the accident there were about 150 reports in Tokyo alone [Ministry of Education, Culture, Sports, Science and Technology, 2012].

Map 6. Radioactive pollution caused Fukushima accident (September 18, 2011)



Source: Ministry of Environment, 2014

Figure 2. Fukushima prefecture towns by radiation levels, March 11-31, 2011



Source: Fukushima prefectural government

The highest radioactive contamination has been within 20-30 km from the Fukushima nuclear power plant where the authorities have been implementing a 20 km (800 sq. km) exclusion zone and other restricted areas since March 12, 2011. On March 20 the reported air radiation rate outside the evacuation zone ranged from 0.7 μSv/h (35-40 km to West from nuclear plant) to 110 μSv/h (30 km to Northwest from the plant) [Ministry of Education, Culture, Sports, Science and Technology, 2011]. Radiation monitoring in 47 prefectures of Japan showed a wide variation, but an upward trend in 10 of them on March 23, 2011 [Nuclear Regulation Authority, 2011].

March-May 2011 soil monitoring in Fukushima prefecture showed the presence of radionuclides reaching up to 710,000 Bq/kg of I-131, 282,000 Bq/kg of Cs-134, 290,000 Bq/kg of Cs-137, 270,000[*6] Bq/kg of Te-129m, 100,000 Bq/kg of Te-132, 23,000[*6] Bq/kg of Cs-136 and 4,300[*6] Bq/kg of La-140 in samples from Namie town [Nuclear Regulation Authority, 2012].

More detailed surveys have found out that cesium 137[19] had strongly contaminated the soils in large areas of eastern and northeastern Japan [Yasunaria et al.; Nuclear Regulation

[19] Two months after the accident, with disappearance of radionuclides with a short half-life (Te-123, I-132 and I-131), the majority of residual deposits were made up by Cs-134 and Cs-137 (Institute for

Authority, 2011-2014]. On November 12, 2011, officials reported that long-lived radioactive cesium had contaminated 30,000 sq. km of the land surface of Japan while some 11,700 sq. km was found to have radiation levels that exceeded Japan's allowable exposure rate of 1 mSv[20] per year[21] [Ministry of Education, Culture, Sports, Science and Technology, 2011]. Outside Fukushima prefecture reported soil radiation of cesium-134 and cesium-137 was between 30,000 and 100,000 Bq/m^2 in Ichinoseki and Oshu (Iwate prefecture), in Saku, Karuizawa and Sakuho (Nagano prefecture), in Tabayama (Yamanashi prefecture) and elsewhere.

Plutonium-238 and 239+240, Strontium-89 and 90, Tellurium-129m and Silver-110m fallouts have been also detected in the affected regions [Ministry of Education, Culture, Sports, Science and Technology, 2011, 2012]. The highest levels of Pu-239 and Pu-240 combined were 15 becquerels per square meters[22] in Fukushima prefecture and 9.4 Bq in Ibaraki prefecture. Nevertheless, measured plutonium, and radioactive strontium, tellurium and silver were very small compared with the accumulated effective doses for 50 years of Cesium 134 and 137.

In July-August 2011 detected concentrations of radioactive elements in river and well water samples in affected regions were: maximum values for river water of 1.9 Bq/kg for Cs-134 and 2.0 Bq/kg for Cs-137, for well water of 0.85 Bq/kg for Cs-134 and 1.1 Bq/kg for Cs-137, and Strontium 89 and 90 in river waters of 5.5×10^{-2} Bq/kg and 1.8×10^{-2} Bq/kg accordingly [Ministry of Education, Culture, Sports, Science and Technology, October 2011].

The extent of radioactive contamination of air, waters and soils in Japan has been monitored and updating constantly[23]. In Fukushima prefecture the radiation levels vary according to location (and even within the same locality because of the numerous "hot spots"), it has been decreasing but it still higher than the levels before the disaster[24] (Figure 2, Table 4, Map 7).

In other prefectures the environmental radioactivity levels have been stable or decreased but mostly they are still higher than the period before the accident (Table 5).

The National Diet of Fukushima Nuclear Accident Independent Investigation Commission[25] concluded that the Fukushima nuclear accident "cannot be regarded as a natural disaster. It was a profoundly manmade disaster - that could and should have been foreseen and prevented. And its effects could have been mitigated by a more effective human

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Radiological Protection and Nuclear Safety, 2012). The later were contributing more than 80% of the activity of residual deposits after May 20, 2011.

[20] The sievert (Sv) is a derived unit of ionizing radiation dose in the International System of Units and measures the health effect of low levels of ionizing radiation on the human body.

[21] On April 19, 2011 the official "safe" radiation exposure levels was drastically increased from 1 mSv to 20 mSv per year. Recommended by the International Commission on Radiological Protection limit for a member of the public is 1 mSv/y (for "Post-emergency situation" 20 mSv/y) and for the radiation worker 20 mSv/y.

[22] compared to a global average of 0.4 to 3.7 Bq/kg from the atomic bomb tests.

[23] Up to date environmental radioactivity levels can be found on http://radioactivity.nsr.go.jp/en/

[24] in April 2014 radioactivity levels inside 20 km zone of Fukushima nuclear plant was still extremely high - from 0.2 μSv/h in Nahara and Tomioka towns up to 12.5 μSv/h, 16.8 μSv/h and 28.6 μSv/h in Futaba, Namie and Okuma towns [Nuclear Radiation Authority, 2014].

[25] Formed to investigate the background and cause of Fukushima Daiichi nuclear disaster on October 7, 2011 and chaired by Kiyoshi Kurokawa.

response" [The National Diet of Japan, 2012]. It was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by these parties. They effectively "betrayed the nation's right to be safe from nuclear accidents".

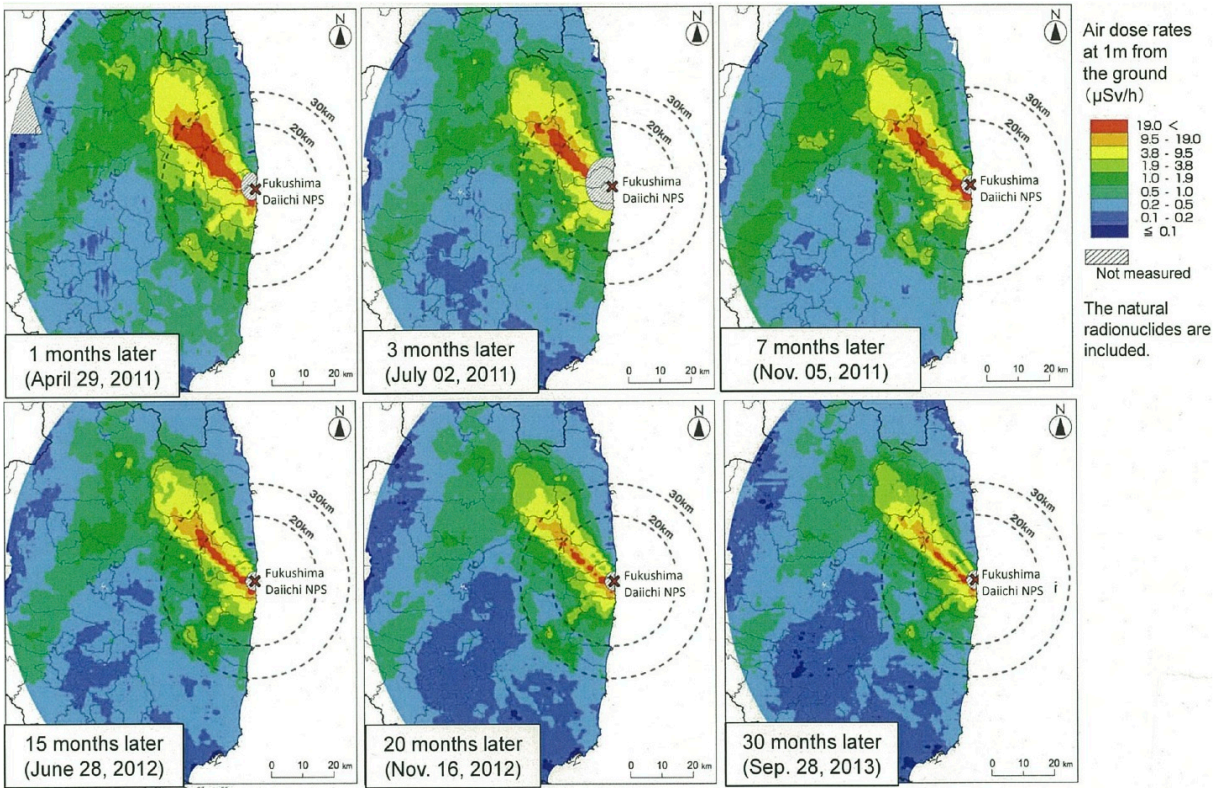
Table 4. Evolution of environmental radioactivity in Fukushima prefecture (μSv/h)

	Ken-poku, Fukushima City	Ken-chu, Koriyama City	Ken-nan, Shirakawa City	Aizu, Aizu Wakamatsu City	Minami Aizu, Minami Aizu Town	Soso, Minami Soma City	Iwaki, Iwaki City Taira
Direction and distance from nuclear power plant	North west, about 63km	West, about 58km	South west, about 81km	West, about 98km	West south West, about 115km	North, about 24km	South southwest, about 43km
Normal value*	0.04	0.04-0.06	0.04-0.05	0.04-0.05	0.02-0.04	0.05	0.05-0.06
April 2011	2.74			0.24			0.66
March 2012	0.63			0.1			0.17
June 11, 2013	0.35	0.18	0.13	0.07	0.05	0.15	0.09
March 8, 2014	0.27	0.15	0.11	0.07	0.03	0.13	0.08

*radioactivity levels surveyed in 2010

Source: Fukushima prefectural government

Map 7. Evolution of air radiation rates in 80 km zone from Fukushima nuclear power plant



Source: Nuclear Regulation Authority, 2013

Recent disclosure of the records of interviews of the government panel investigating the nuclear crisis (so-called "Yoshida file")[26] also illustrates how badly the government handled crisis management at Fukushima nuclear power plant and how serious the situation was [NHK World, September 11, November 12, 2014; The Japan News, September 13, 2014].

Table 5. Environmental radioactivity at 1m height in prefectures of Japan (μSv/h)

Prefecture (monitoring post)	Before March 11, 2011	March 20, 2011*	March 20, 2012*	March 20, 2013	March 20, 2014	December 5, 2014
Hokkaido (Sapporo)	0.02-0.105	0.027-0.028	0.028-0.033	0.034	0.037	0.039
Aomori (Aomori)	0.017-0.102	0.021-0.023	0.018-0.024	0.021	0.026	0.032
Iwate (Morioka)	0.014-0.084	0.025-0.040	0.021-0.029	0.038	0.039	0.032
Miyagi (Sendai)	0.0176-0.0513	0.15**	0.051-0.053	0.055	0.054	0.047
Akita (Akita)	0.022-0.086	0.034-0.041	0.034-0.036	0.054	0.052	0.056
Yamagata (Yamagata)	0.025-0.082	0.040-0.129	0.037-0.039	0.092****	0.092	0.089
Fukushima (Fukushima)	0.037-0.046	2.1***	0.89	0.82	0.27	0.22
Ibaraki (Mito)	0.036-0.056	0.159-0.263	0.074-0.075	0.077	0.079	0.071
Tochigi (Utshunomiya)	0.030-0.067	0.136-0.164	0.050	0.079	0.084	0.073
Gunma (Maebashi)	0.016-0.049	0.069-0.103	0.025-0.026	0.071	0.076	0.064
Saitama (Saitama)	0.031-0.060	0.052-0.062	0.046-0.047	0.047	0.055	-
Chiba (Ichihara)	0.022-0.044	0.031-0.033	0.037-0.038	0.058	0.069	0.049
Tokyo (Shinjuku)	0.028-0.079	0.044-0.049	0.049-0.050	0.057	0.071	0.061
Kanagawa (Chigasaki)	0.035-0.069	0.046-0.048	0.044-0.045	0.042	0.052	0.038
Nigata (Nigata)	0.031-0.153	0.047-0.052	0.046-0.052	0.063	0.071	0.072
Toyama (Imizu)	0.029-0.147	0.049-0.054	0.046-0.048	0.064	0.084	0.085
Ishikawa (Kanazawa)	0.0291-0.1275	0.047-0.063	0.046-0.051	0.052	0.063	0.064
Fukui (Fukui)	0.032-0.097	0.046-0.053	0.044-0.049	0.061	0.073	0.071
Yamanashi (Kohu)	0.040-0.066	0.044	0.043-0.044	0.051	0.056	0.051
Nagano (Nagano)	0.0299-0.0974	0.06-0.067	0.038-0.040	0.067	0.070	0.065
Gifu (Karamigahara)	0.057-0.110	0.061-0.066	0.060-0.061	0.067	0.076	0.070
Shizuika (Shizuoka)	0.0281-0.0765	0.035-0.040	0.029	0.041	0.055	0.039
Aichi (Nagoya)	0.035-0.074	0.039-0.042	0.039	0.068	0.071	0.068
Mie (Yokkaichi)	0.0416-0.0789	0.046-0.051	0.045-0.046	0.070	0.081	0.071
Shiga (Otsu)	0.031-0.061	0.034-0.037	0.031-0.032	0.065	0.081	0.074
Kyoto (Kyoto)	0.033-0.087	0.039-0.045	0.037-0.038	0.048	0.063	0.054
Osaka (Osaka)	0.042-0.061	0.042-0.046	0.042-0.043	0.080	0.083	0.091
Hyogo (Kobe)	0.035-0.076	0.036-0.037	0.036-0.037	0.072	0.091	0.073

[26] former manager of the power plant Masao Yoshida, former Prime Minister Naoto Kan and 17 others was relised in September 2014, and more 56 in November 2014. The government plans to disclose interviews with all 772 government and TEPCO officials if interviewees give approval.

Nara (Nara)	0.046-0.080	0.048-0.053	0.047-0.048	0.077	0.062	-
Wakayama (Wakayama)	0.031-0.056	0.031-0.033	0.031-0.032	0.081	0.083	0.094
Tottori (Touhaku)	0.036-0.110	0.063-0.075	0.062-0.063	0.071	0.073	0.081
Shimane (Matsue)	0.033-0.079	0.038-0.041	0.037-0.039	0.056	0.054	0.067
Okayama (Okayama)	0.043-0.104	0.049-0.053	0.048-0.049	0.067	0.082	0.075
Hiroshima (Hiroshima)	0.035-0.069	0.048-0.053	0.046-0.049	0.086	0.081	0.093
Yamaguchi (Yamaguchi)	0.084-0.128	0.094-0.096	0.091-0.095	0.080	0.075	0.083
Tokushima (Tokushima)	0.037-0.067	0.037-0.039	0.037-0.038	0.069	0.070	0.070
Kagawa (Takamatsu)	0.051-0.077	0.053-0.054	0.054-0.057	0.063	0.067	0.067
Ehime (Matsuyama)	0.045-0.074	0.047-0.051	0.046-0.048	0.084	0.098	0.098
Kochi (Kochi)	0.019-0.054	0.026-0.030	0.025-0.026	0.035	0.041	0.044
Fukuoka (Dazaifu)	0.034-0.079	0.036-0.040	0.036-0.037	0.066	0.060	0.070
Saga (Saga)	0.037-0.086	0.040-0.049	0.040-0.041	0.064	0.048	-
Nagasaki (Omura)	0.027-0.069	0.028-0.033	0.030-0.031	0.074	0.053	0.065
Kumamoto (Uto)	0.021-0.067	0.027-0.032	0.027-0.028	0.049	0.043	0.066
Oita (Oita)	0.048-0.085	0.049-0.053	0.040-0.050	0.057	0.055	0.065
Miyazaki (Miyazaki)	0.0243-0.0664	0.026-0.028	0.026	0.060	0.034	0.038
Kagoshima (Kagoshima)	0.0306-0.0943	0.034-0.039	0.034	0.056	0.047	-
Okinawa (Uruma)	0.0133-0.0575	0.020-0.021	0.023-0.031	0.021	0.022	0.034

* Minimum and maximum readings; ** Tohoku University data; ***MEXT data; ****March 24 data

Source: Nuclear Radiation Authority

2. Human damages and health effects

The March 2011 earthquake and resulting tsunami killed almost 15,900 people[27], injured more than 6,100 and destroyed the lives of thousands more (Table 6). The majority of deaths were from tsunami and among elderly.[28] The biggest number of victims has been from Miyagi, Iwate and Fukushima prefectures where whole communities were wiped out by the powerful tsunami. Three and a half years after the disaster 2,601 people are still listed as missing and search for them has been continuing.

Table 6. Number of confirmed deaths, missing and injured person associated with March 2011 earthquake (February 10, 2014)

Prefectures	Deaths	Missing	Injured	Prefectures	Deaths	Missing	Injured
Hokkaido	1	-	3	Gunma	1	-	39
Aomori	3	1	111	Saitama	-	-	45
Iwate	4,673	1,142	213	Chiba	21	2	229
Miyagi	9,537	1,283	4,145	Kanagawa	4	-	138
Akita	-	-	4	Nigata	-	-	3
Yamagata	2	-	29	Yamanashi	-	-	2
Fukushima	1,607	207	182	Nagano	-	-	1
Tokyo	7	-	117	Shizuoka	-	-	3
Ibaraki	24	1	712	Mie	-	-	1
Tochigi	4	-	133	Kochi	-	-	1
Total					**15,884**	**2,636**	**6,147**

Source: National Police Agency

What is more, official data for the "disaster related deaths"[29] have been growing reaching 3,076 in 10 prefectures by the end of March 2014 [NHK World, May 6, 2014]. The majority of victims are from Fukushima prefecture (1,691), followed by Miyagi prefecture (889) and Iwate prefecture (441).

June 25, 2014 data for Fukushima prefecture show that 1,729 people have died as a result of lingering effects of the accident exceeding the 1,603 deaths caused directly by the disaster [Fukushima Minpo News, June 26, 2014]. Nevertheless, it is becoming increasingly difficult to identify a relationship between deaths and the accident due to the long period of time that has lapsed[30].

[27] Latest figure is 15,889 (September, 2014).

[28] Around 94.2% of deaths are tsunami related. Around 600 are assumed to have died from earthquake-related stress and chronic disease, around 265 should be earthquake-collapse related, and around 230 could be related to other causes such as fire, landslides etc. Around 56% of the dead were over 65 years old [Vervaeck and Daniell, 2012].

[29] They are recognized by a panel of experts (including medical doctors and lawyers) set up by each municipality, and a sum of 5 million yen is paid as consolation money to family for death of a main income earner (half sum for other family members).

[30] government intends to provide municipal authorities with information on accident-related deaths in an "aggressive manner" to help standardize norms for identifying such fatalities.

Deaths associated with the disaster include people who died as a result of having to change their environment and lifestyle, and live as evacuees away from home, family, business and community for a long period time. Many of the Fukushima victims are from municipalities near the damaged Fukushima nuclear plant. For instance, in Minamisoma, Namie and Tomioka, which partly or fully have been off-limits due to high radiation, accordingly as many as 447, 317 and 225 deaths have been indirectly blamed on the disaster.

What is more, at least 97 people affected by the disaster have died unattended[31] in temporary housing units in Iwate, Miyagi and Fukushima prefectures, and experts say that the number of solitary death cases would likely increase in future [The Japan News, March 2014].

Officials linked the number of suicide deaths to disaster of 2,916 as of September 2013 [LDP, 2014]. In 2013 disaster related suicides in Fukushima[32], Miyagi and Iwate prefectures were associated with deteriorating health of 22 of them, money problems of nine more, and family issues of five.

Many farmers from the affected areas and beyond who saw their businesses and livelihood destructed also suffered stress and anxiety [Murayama, 2012; Watanabe, 2011]. For instance, a 64-year-old farmer in Sukagawa was pushed over the edge since he lost "everything he had ever worked for during his life"[33]. One day after the government imposed a ban on the sale of cabbages he took his life [The New York Times, March 29, 2011]. Another dairy farmer in 50s killed himself on the land he struggled to maintain since tsunami and nuclear crisis began few months after the disaster [CNN, June 14, 2011].

There have been also many reports for affected survivors from disaster exposed to a high risk or suffering from various diseases after the accident – injuries, respiration problems due to dust an contamination, dehydration, exhaustion, shocks, etc. In a number of places rapidly spreading pneumonia epidemic (mostly among elderly) was registered due to overpopulated rooms, poor oral hygiene, destructed facilities, and lack of specialists and sufficient care [HNK World, July 28, 2014]. For instance, in the three months after the disaster in Kesenuma, Motoyashi and Otomo hospitals 225 were admitted suffering from pneumonia, 52 of whom consequently died. Similarly in Ishinomaki 122 were hospitalized in days after the disaster at rate 7 times higher than the normal one.

What is more, as a result of long stay in temporary accommodations many experienced diverse health problems. For instance, in Ishinomaki, where there are 6000 people living in such accommodations, there has been increasing number of complains and sicknesses due to molt and bacteria multiplied in temporary houses [NHK World, July 23, 2014].

Another factor for increased health risk has been caused by radiation exposure after the nuclear accident. The levels of radiation exposure of population varied according to the

[31] There is no precise definition of the Japanese term "kodokushi" (meaning "solitary death") and officials do not record statistics on such deaths.

[32] Disaster related suicide rate has been on the rise in Fukushima [The Japan News, March 13, 2014].

[33] The farmer was reported to have lost his house in the earthquake but had a field of 7,500 organically grown cabbages ready for harvest when the government prohibition was announced.

direction from the Fukushima plant and the time spent in contaminated zones[34]. Major pathways humans were exposed to radioactive materials after the accident were: external exposure from radionuclides deposited on the ground; external exposure from radionuclides in the radioactive cloud; internal exposure from inhalation of radionuclides in the radioactive cloud; and internal exposure from ingestion of radionuclides in food and water [World Health Organization, 2012]. However, the gap between our understanding of the biological effects of radiation in humans and the determination of regulatory values in too wide [Fukumoto, 2013].

Workers in the nuclear plant have suffered the highest exposures[35]. According to the data 167 workers received radiation dose more than 100 mSv[36], which is the level expert demonstrated measurably increases risks of cancer [United Nations Scientific Committee on the Effects of Atomic Radiation, 2014]. For additional 20,000 TEPCO workers[37] and for roughly 150,000 citizens from the fallout zone exposures were lower. For instance, in Namie town and Iitate village, nearby communities where the evacuation was delayed, residents received 10 to 50 mSv. There are still occasional reports for radiation overexposure of workers at the plant [NHK World, May 8, 2014]. Furthermore, working in some areas[38] and using some new methods (e.g. pouring cement into underground tunnels) are likely expose workers to more radiation than originally expected [NHK World, November 25, November 28,2014].

Experts estimates that for adults in Fukushima prefecture the average lifetime effective doses to be of the order of 11 mSv or less, and the first-year doses to be one third to one half of that [United Nations Scientific Committee on the Effects of Atomic Radiation, 2014; World Health Organization, 2012]. For children and other vulnerable groups (old people, sick persons) these doses have been much higher (Table 7).

[34] Biological effect (danger) of radiation vary according to the quility, energy, dose (how much one absorb), and the dose rate (the time one is exposed to a dose) of radiation, and the organs exposed and dose rate [Fukumoto, 2013].

[35] Reported maximum combined cumulative effective dose for TEPCO workers is 678.80 mSv while the avarage for 31,383 workers and contractors from March 2011 to December 2013 is 12.61 mSv [Tokyo Electric Power Company, 2014].

[36] Cumulative exposure limit for workers responding to nuclear emergencies is 100 mSv. Three days after the accident, government raised the limit for workers at Fukushima plant to 250 mSv and kept it for 9 months [NHK World, July 10, July 30. 2014].

[37] Expert report asked the government to conduct a lifelong survey on 19,000 people who worked in immediate aftermath of the accident to see whether their exposure to radiation causes cancer or other illnesses. Such survey would provide important knowledge on radiation's impact on health and serve as a guideline for residents of Fukushima prefecture [NHK World, May 16, 2014].

[38] E.g. operator expected to lower radiation level to 1 millisievert an hour in No.3 reactor upper part but it found out that even after cleaning up radiation could reach 60 millisieverts an hour in some areas and over 10 mSv in many others.

Table 7. Estimated average effective radiation doses in different regions of Japan (mSv)

Age groups in 2011	Fukushima prefecture	Miyagi, Gunma, Tochigi, Ibaraki, Chiba and Iwate	Rest of Japan
1 YEAR EXPOSURE			
Adults	1.0 - 4.3	0.2 – 1.4	0.1 – 0.3
Child 10 year old	1.2 - 5.9	0.2 – 2.0	0.1 – 0.4
Infant 1 year old	2.0 - 7.5	0.3 – 2.5	0.2 – 0.5
LIFETIME EXPOSURE			
Adults	1.1 - 11	0.2 – 4.0	0.1 0.6
Child 10 year old	1.4 - 16	0.3 – 5.5	0.1 - 0.8
Infant 1 year old	2.1 -18	0.4 – 6.4	0.2 – 0.9

Source: United Nations Scientific Committee on the Effects of Atomic Radiation, 2014

Thanks to the timely undertaken measures by the authorities (warnings, protection, evacuation, monitoring, decontamination, treatment), the radiation levels for the general population have been well below the norms required to damage human health[39]. Nevertheless, there have been debates and great concerns about the risks for people exposed to lower doses since risks are lower and hardly to detect [Akiyama et al., 2012; Fisher *et al.,* 2013; Foodwatch, 2011; Hasegawa, 2013; Pacchioli, 2014; Rosen, 2013].

According to an official report 180,592 people in the general population were screened for radiation exposure in March 2011 and no case was found which affects health (Nuclear and Industrial Safety Agency, 2011). The World Health Organization anticipated that there would be no noticeable increases in cancer rates for the overall population, but somewhat elevated rates for particular sub-groups [World Health Organization, 2013]. For example, infants of Namie town and Iitate village were estimated to have a 6% increase in female breast cancer risk and a 7% increase in male leukemia risk.

The latest UN report of more than 80 international experts also pointed out that no deaths or serious illnesses have so far been reported from the radiation exposure from the nuclear accident. It concluded that no discernible increased incidence of radiation-related health effects (e.g. rate of cancer) are expected among exposed members of the public or their descendants" [The Japan News, April 3, 2014; NHK World, May 28, 2014]. However, it warned that "an increased risk of thyroid cancer can be inferred for infants and children" stressing the need for continued research[40]. The maximum radiation dose for a year after the Fukushima crisis began was estimated at 9.3 mSv for adults in areas near the Fukushima plant and at 13 mSv for 1-year-old infants.

[39] Since April 2011 the maximum annual allowable radiation exposure to let evacuees return to the areas near nuclear plant is 20 mSv. For Fukushima schools a target of exposure dose 1 mSv/y was set up which should be used in decision making on limiting outdoor activity at schools.

[40] November 2014 interim report of expert panel, based on a survey of some 370,000 people aged 18 or younger in Fukushima prefecture, also suggests that that thyroid cancer cases are unlikely to be linked to exposure to radiation from the nuclear accident calling for more child thyroid checks [Fukushima Minpo News, November 15, 2014; NHK World, November 27, 2014].

People living and working in different locations of the affected regions have been exposed to diverse levels of radiation[41]. What is more, even in the same locations the radiation level often differs due to the different precision of instruments or local hot spots. In addition, people are constantly exposed to small amount of no harmful natural background radiation – it is approximately 2.1 mSv per person in Japan, including 0.3 mSv from space, 0.33 mSv from land, 0.48 mSv from Radon etc. and 0.99 mSv from food [National Institute of Radiological Science, 2014].

In addition, confusion has been also spreading among municipalities tasked with radiation cleanup under changing government decontamination policy[42] [Fukushima Minpo News, July 22, 2014]. Under the new policy, the government will determine decontamination needs by using radiation exposure data collected from individual dosimeters (which tend to be lower than the current safe dose) leading to reduction areas of government-mandated decontamination.

Some municipalities welcome that new policies since it will allow to scale down decontamination efforts in areas where radiation levels are unlikely to go down significantly. However, others are worried that residents will be confused. For instance, according to Date officials, the city measured the radiation exposure of its 52,000 citizens wearing dosimeters (July 2012-June 2013) and results showed that per-year exposure levels for nearly 70% of them (even in areas where aerial radiation levels exceeded 0.23 microsievert per hour) was less than 1 millisievert in total [Fukushima Minpo News, July 22, 2014]. Moreover, Tamura officials declare that city will not change its decontamination plan, since if the cleanup projects are scaled back, it would cause anxiety among residents. Some experts[43] also suggest that new approach is inappropriate since many residents have deliberately stayed indoors and if they start to go out like they used to, the individual radiation doses might go up.

The official monitoring of agricultural and food products conducted after April 2012 indicates that the violation rates on new food safety standard (1 mSv/year) have been much less than 1% [Ministry of Health, Labor and Welfare, 2014].

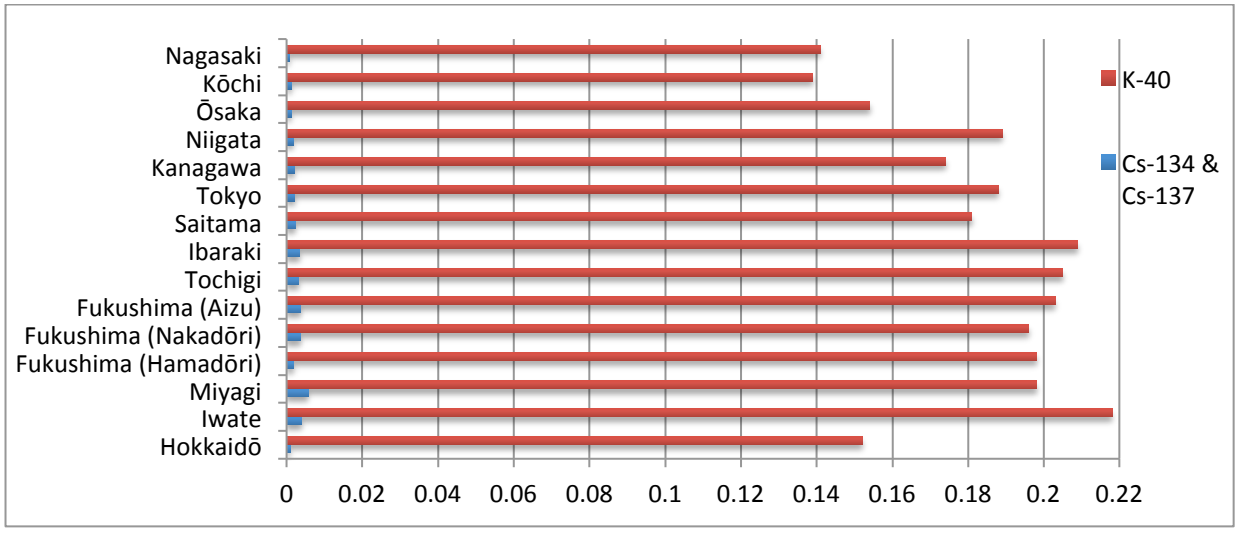
What is more, surveys in most affected regions indicate that the annual radiation intakes from foods have been below 1 mSv/year (Figure 3). For instance, according to the September–October 2012 survey the estimated annual radiation doses from radioactive cesium in foods were in safety limit (Figure 4). It ranges from 0.0009 to 0.0057 mSv/year being highest in Miyagi prefecture and certain regions of Fukushima prefectures. At the same time, annual radiation doses from radioactive potassium (naturally occurring in foods) were between 0.14 and 0.22 mSv/year as no significant changes found comparing to before the accident.

[41] Government maintains that radiation exposure on residents in Fukushima Prefecture are no different from those of similar surveys in other prefectures [The Japan News, May 18, 2014].

[42] Government has been decontaminating areas whose aerial radiation reading is 0.23 microsievert per hour or more, based on its policy of keeping annual radiation exposure for individuals at 1 millisievert or less.

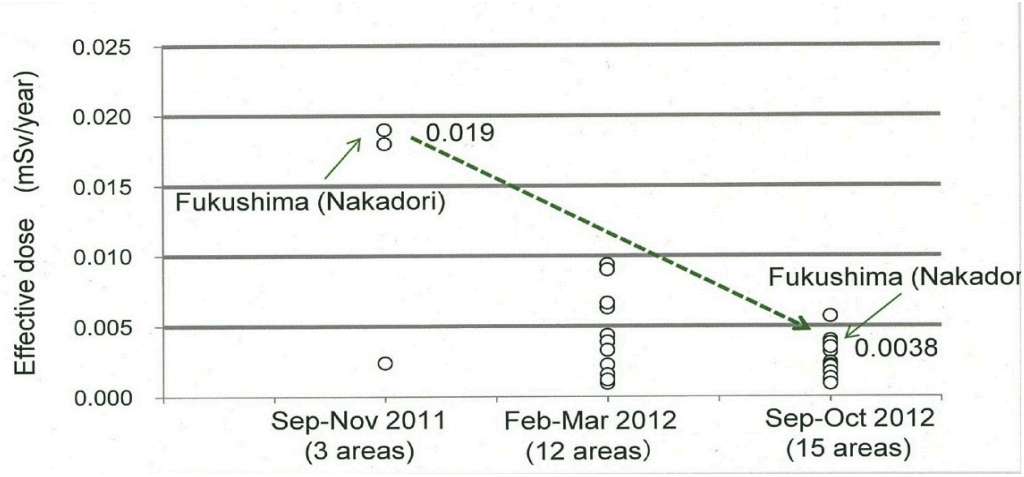
[43] E.g. Keizo Ishii, director of the Research Center for Remediation Engineering of Living Environments Contaminated with Radioisotopes, Tohoku University.

Figure 3. Estimation on annual dietary intake of radionuclides for September-October 2012 in Japan (mSv/year)



Source: Ministry of Health, Labor and Welfare

Figure 4. Evolution of effective dose from Cs-134 and Cs-137 in foods in Nakadori area of Fukushima



Source: Ministry of Health, Labor and Welfare

Furthermore, radiation doses from radioactive cesium have been found to be decreasing over time - for 15 studied areas it was lower comparing to previous estimates for September-November 2011 (0.0024–0.019 mSv/year) and February-March 2012 (0.0009–0.0094 mSv/year). Likewise, in Fukushima prefecture (Nakadōri Area) the effective dose from radioactive cesium in foods has been decreasing constantly and it is less than 1% of the maximum allowed level[44] [Ministry of Health, Labor and Welfare, 2012].

According to a large panel of experts the radiation uptake in such ranges is not harmful for the human health (Ministry of Health, Labor and Welfare, 2012). Furthermore,

[44] From 0,01 mSv/y in September-November 2011 it dropped to 0,038 mSv/y in September-October 2012.

"health effects" from extra cumulative exposure above the official limit are difficult to be verified based on the current available knowledge[45]. Therefore, even if people are exposed to more than "around 100 mSv" of the extra cumulative exposure, it will not necessarily mean they will have adverse health effect [Koizumi, 2011].

Some publications also demonstrate that the additional dose of Fukushima radionuclides received by consumers of Pacific Bluefin tuna can be estimated to result in two additional fatal cancer cases per 10,000,000 exposed people [Fisher et al. (2013].

November 2013-February 201 survey of the Fukushima Consumer Cooperative found out that the levels of radioactive cesium in home-cooked meals in the prefecture were slightly above the limit for radioactive cesium[46] for 4% of participating households [Fukushima Minpo News, March 7, 2014]. Nevertheless, the internal exposure to radioactive materials of all screened household members was below the 300Bq threshold for human radiation exposure.

Despite that in many places the radiation level and overall artificial exposure are less than the level in some onsens[47] or certain medical check-ups, many show a great concern on current figures[48]. That worries have been further enforced by the controversial opinions of experts in the filed, slow process of decontamination in some areas and ecosystems (e.g. forests, farmlands), unresolved issue with safe disposal of contaminated debris in certain areas, some deficiency of the food safety control systems, continuing radiation leakages in the nuclear plant, etc.

It is known that when a large amount of radioactive cesium enters ecosystem and agri-food chain, it quickly becomes ubiquitous, contaminating water, soil, plants, animals, foods, etc. Radioactive cesium bioaccumulates, bioconcentrates, and biomagnifies as it moves up the food chain. Routine ingestion of foods contaminated with "low levels" of radioactive cesium has been shown to lead to its bioaccumulation in the heart, endocrine tissues, kidneys, small intestines, pancreas, spleen and liver. This process occurs much faster in children than in adults. Our interviews with local residents have found out that the cases of diverse complains and hospitalization in Fukushima has been increasing since the nuclear disaster.

What is more, it is believed that the health effects of the radiation release have been "primarily psychological rather than physical effects". Many consumers and producers alike "lose peace of mind" having food with (lower than official safety limit but nevertheless) radiation contamination. As one Fukushima farmer was cited to say "his family is taking

[45] there is a limitation to verify the effect arising from additional radiation exposure (including carcinogenesis and other influences since); difficulty to distinguish explicitly the effect of radiation and other effects; population of epidemiological studies were not large enough; and inaccuracy of estimated radiation exposure [Koizumi, 2011].

[46] the highest level detected in one household of 2.6 Bq/kg for Cesium 137 and 1.1 Bq/kg for Cesium 134.

[47] hot springs regularly visited by many Japanese.

[48] It is true in other countries as well – e.g. a recent US report on the lessons from the Fukushima crisis of the National Academy of Sciences notes that poor communication between the central government and local governments, as well as a lack of clear standards about radiation levels that require decontamination led to public distrust in the government [NHK World, July 25, 2014].

extreme care to protect their health by choosing only "safe" food, resulting in "a nerve-wracking lifestyle." [Kakuchi, 2013].

Furthermore, long periods of evacuee life, lost property and employment have caused many people to grow isolated or develop physical or mental problems. For instance, evacuees from Namie reported that their health deteriorated after evacuating and they feel more irritable compared to before [Pushpalal et al., 2013]. Stress has been causing disputes among evacuees, lack of sleep, and increased smoking or drinking to alleviate psychological pain. Depression and family collapse have been also increasing. More than a half of evacuated live apart from the extended family, which is another reason for frustration.

A 2014 survey indicates that 68% of evacuated households in Fukushima prefecture have one or more members with health problems such as lack of sleep or depression [NHK World, April 30, 2014]. Data from the Fukushima Center for Disaster Mental Health shows that consultations for emotional instability, such as irritation, depression and mood swings, increased 50% since 2012, forming 19% of total health consultations [The Japan Time, March 1, March 1, 2014]. Official survey has also found that almost 34% of children in Iwate, Miyagi and Fukushima prefectures who were aged 3 to 5 at the time of March 2011 earthquake now suffer from post-traumatic stress disorder such as sleeping disorders, flashbacks etc. [The Japan News, March 2, 2014].

It was also reported that many elderly men cannot cook, so they became unable to maintain a balanced diet or develop a habit of turning to alcohol, and as a result they can easily fall ill [The Japan News, March 20, 2014). All these problems have been further aggravated by the lack of enough specialized doctors, health care centers and social workers in all affected areas.

Data show that the suicide-prevention hotline in Fukushima prefecture received record 18,194 calls in 2013[49] and consultations related to the 2011 disasters still stand out from the other issues [Fukushima Minpo News, June 5, 2014]. The content of consultations has also changed over time - unlike the first days of the disasters, when new supply lines were in dire need, nowadays callers often discuss issues regarding mental distress. In 2011 almost 12% of all calls were related to the quake and nuclear crisis. In 2012 the later fell to just bellow 5% but counselors spent more hours talking to each person on average. Most recent topics range from arguments between spouses over whether to leave Fukushima, to the way fathers feel estranged from families after being forced to move out of the house to find work. Sense of loss and isolation, as well as pessimism about life in general, have recently stood out, while many used to mention "a sense of unity" and "preciousness of life" in the early stage of the disasters[50].

[49] In 2011 the hotline handled fewer calls than 2010 (13,677 versus 16,649) because the telephone network had been damaged by the quake and Koriyama's office remained out of service for about a month afterward [Fukushima Minpo News, June 5, 2014]. In 2012 the number of calls was up 30% (17,881).

[50] According to experts the rise in calls is an alarming sign indicating that aftereffects have reached every corner of residents' lives and reflecting the diversity of the mental problems rooted in March 11.

Free legal consultations service for the disaster victims[51] has also been on a rise – e.g. in fiscal 2013 totaled 48,418 nationwide (up 12.6% from the previous year) as more than 80% (39,288 cases) were in Iwate, Miyagi and Fukushima prefectures [The Japan News, September 11, 2014]. Family legal troubles, including divorce and inheritance, topped the list at 39.2%, followed by financial troubles such as loans between friends at 25.4%, multiple debts, including double loan problems, accounted for 13.7%, and real estate issues such as land purchases by municipalities aimed at post- disaster reconstruction were 10.5%.

Healthcare has also been a major issue for the more than 30,000 people who have worked at the nuclear plant since the accident [NHK World, May 8, 2014]. There are reports that Fukushima disaster workers self medicating with alcohol to deal with stress, PTSD, depression, negative work environment, poor wages, wage- skimming, substandard living conditions and fear about future [McCurry, 2013].

Surveys of the Fukushima Labor Bureau demonstrated that 68% of business operators involved in radioactive decontamination work have been violating the law [Fukushima Minpo News, March 13, 2014]. According to the officials 446 business operators were involved in 1,105 cases of legal violations, out of which 67% with labor conditions (such as failure to pay wages), and almost one third with health and safety (such as a lack of safety training, failure to conduct prior checks on the amounts of radiation at work sites, etc.). Only for April to August 2014 there were 130 complaints of unpaid wages and inadequate safety measures for workers employed to decommission the Fukushima plant [NHK World, September 22, 2014].

Some people are also concerned about the deteriorating work quality as the number of staff unfamiliar with working at nuclear plant environment[52] increases [The Japan News, October 21, 2014]. According to TEPCO 25 workers experienced some work-related difficulties, such as injury or heat stroke in 2012, but that figure increased to 32 in 2013. What is more, in March 2014 a 55--year-old man died after he was buried in soil while excavating it[53].

Consequently, the Nuclear Regulation Authority announced it will consider revisions to the law for protecting nuclear plant workers' health in emergencies responding to calls in negotiations that started 3 years ago with the Tokyo Occupational Safety and Health Center[54] [NHK World, July 10. 2014]. The later stresses that such revision is vital for ensuring that nuclear plant workers are better prepared for emergencies and that workers must be informed of how radiation exposure could affect health and decide in advance whether to give consent.

The number of workers taking part in the decommissioning and other work at the Fukushima nuclear plant has doubled to more than 5,700 in the past year [HNK World,

[51] System provides free legal consultations to any quake victims who visit Japan Legal Support Center offices without any prerequisites (e.g. income). The government intends to extend the service period by three years after expiration date (end of March 2015).

[52] manpower shortages have occurred because veteran workers left Fukushima unsatisfied with short-term contracts and working environment. At the same time there are many employed from other regions of the country where it is dificult to find job with no experience in working at nuclear plant.

[53] the first fatality since decommissioning work started.

[54] Nationwide information center on occupational safety and health issue. Until middle of 2014 the nuclear regulator maintained that it is not in charge.

September 29, 2014]. According to TEPCO contractors hire most of them[55] and they are responsible for labor safety[56] [NHK World, July 17, September 29, 2014].

Furthermore, the Nuclear Regulation Authority recently approved a proposal to study raising the emergency radiation exposure limit beyond the current legal accumulative limit of 100 mSv [NHK World, July 30, 2014]. It will decide on the level by referring to the overseas standards as well as on how to get prior consent from workers and train them for such cases.

Therefore, the entire long-term health impact of the triple disaster is hardly to be assessed presently.

[55] more than 10,000 workers are registered on TEPCO contractors' lists.

[56] TEPCO recently started to take measures to improve working conditions – e.g. it is constructing a large rest building on the premises that can accommodate 1,200 people.

3. Evacuation and migration

The earthquake, tsunami and the nuclear accident have caused a large evacuation involving some 470,000 (the third day after the earthquake) and over 320,000 displaced persons on a longer-term basis [Reconstruction Agency, 2014].

By March 15, 2011 the official number of evacuated people overpassed 440,000 (World Health Organization, March 15, 2011). The greatest number of evacuees and stranded persons were from Miyagi, Fukushima and Iwate prefectures where they accounted for a good portion of the entire population (Table 8). The number of refugees moved to other prefectures was also quite considerable – 52,000 in Fukushima prefecture, 7,500 in Miyagi prefecture, and 1,500 in Iwate prefecture [Pushpala et al., 2013].

Table 8. Number of evacuation centers and evacuees, March 17, 2011

Prefectures	Evacuation centers	Evacuees	Stranded	Share of population, %
Aomori	32	367	-	0.03
Iwate	386	48,439	≈10,000	4.39
Miyagi	1,063	191,467	>6,050	8.37
Yamagata*	28	2,712	-	0.23
Fukushima	556	131,665	98	6.3
Ibaraki*	185	7,567	-	0.25
Tochigi	148	1,028	-	0.05
Nigata*	51	2,674	-	0.11
Total	>2,398	385,919	>16,150	2.56

* including evacuees from Fukushima and/or Miyagi

Source: World Health Organization, 2011

Immediately after the nuclear accident the government recommended[57] evacuation of about 78,000 people living within a 20-km radius of the power plant and sheltering in own homes of about 62,000 others living between 20 and 30 km from the plant. In April 2011, the evacuation of about 10,000 more people form areas further to the Northwest of the plant was recommended (so called "Deliberate Evacuation Area") because of the high levels of radioactive material on the ground[58].

On April 22, 2011, Fukushima prefecture was divided into following areas (Map 8):

1) Restricted Area in 20 km radius around the nuclear plant where entry is prohibited (excluding those engaged in emergency response).

2) Deliberate Evacuation Area other than Restricted Area, where annual cumulative radiation dose was expected to reach 20 mSv per year. Overnight stay is prohibited but it is permitted to pass through or commute to workplace (in case continued operation is approved by local authority).

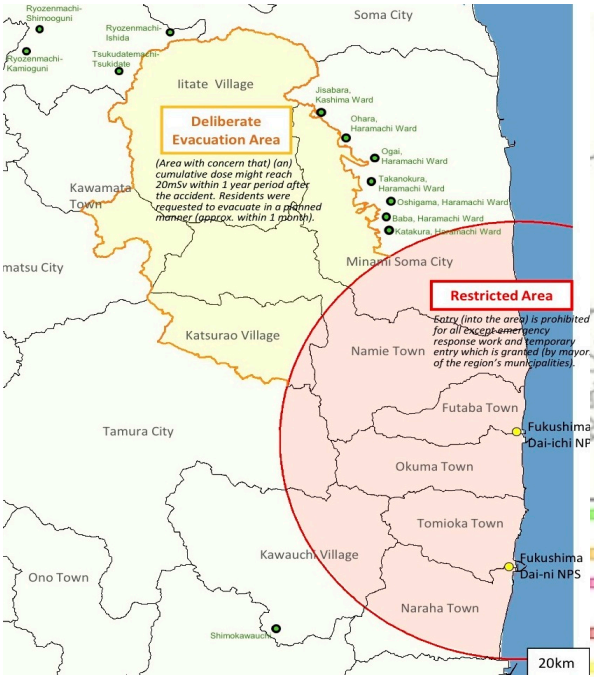
[57] Evacuation order was placed on March 15, 2011. A high percentage of residents of Minamisoma, Kawamata and Iitate received information from TV, radio or the internet [The National Diet of Japan, 2012]. The Mayor of Namie recounted that he made desision for evacuation on March 12 after learing from tv and there was not directives from government [Pushpalal et al., 2013].

[58] Population of 11 municipalities in six towns and villages (Tomioka, Okuma, Futaba, Namie, Katsurao and Iitate) of about 81,000 had to be evacuated from the no-entry zone after nuclear disaster.

3) Evacuation prepared areas in case of emergency[59] - 20-30 km radius from Fukushima nuclear plant where certain groups (pregnant women, with special needs) are not permitted.

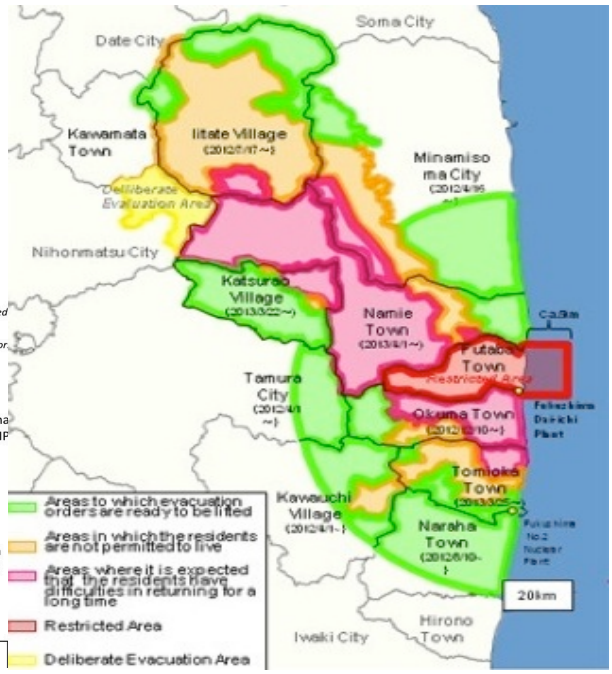
4) Specific Spots Recommended for Evacuation - sites with a cumulative dose of 20 mSv/y and above.

Map 8. Restricted, Deliberate evacuation, and Specific spots areas (September 30, 2011)



Source: Ministry of Economy, Trade and Industry, 2011

Map 9. Present status of evacuation and restricted areas (March 30, 2014)[60]



Source: Reconstruction Agency, 2014

In the end of 2011 the government decided to rearrange the areas to which evacuation orders have been issued into following categories (Map 9):

1) Areas to which evacuation orders are ready to be lifted - it is confirmed that the annual integral dose of radiation will definitely be below 20mSv. People can pass through the areas along main roads, return home temporarily (staying overnight is prohibited), and enter the areas for the purpose of public benefit. They can also resume businesses such as manufacturing and conduct related maintenance, repair, or transport activities. Resuming farming depends on the degree of limitation on rice planting and the extent to which radiation has been removed from the ground. For hospitals, welfare facilities, or shops, work is limited to that for preparation for resuming businesses. People are not required in principle to take or

[59] Lifted on September 30, 2011.

[60] On April 1, 2014 the evacuation order for a portion of Miyakoji District, Tamura City was lifted, which was the first complete lifting in the initial "no go zone" within a 20-km from the nuclear plant. On October 2014 evacuation advisory was lifted for the bulk of Kawauchi village within 20 km of the nuclear plant. The status of western part of the village also changed to a zone preparing for lifting of evacuation advisory. According to many these will be a test wether people would be ready to return back to areas surrounding nuclear plant [Fukushima Minpo News, October 1, 2014].

carry out protection measures, such as screening or measures to control the radiation dose when they enter the areas temporarily.

2) Areas in which residents are not permitted to live – the annual integral dose of radiation is expected to be 20 mSv or more. People can temporarily return home in the areas (but staying overnight is prohibited), pass through the areas along main roads, and enter the areas for the purpose of public benefit, such as for repairing the infrastructure or conducting disaster prevention-related work. Entry is not recommended but allowed during daytime.

3) No entry areas - the annual integral dose of radiation is expected to be 20 mSv or more within five years and the current integral dose of radiation per year is 50 mSv or more. People are legally required to evacuate from the areas, for which physical barriers to entry such as barricades are placed at the boundaries of the area. People may temporarily return home to meet domestic needs and requirements as far as possible, while those who are in charge thoroughly screen people for radiation, control individual doses of radiation, and require the people entering the zone to wear protective gear.

4) Restricted area – 20 km radius from the Fukushima plant (other than areas 1, 2, 3).

5) Specific spots recommended for evacuation.

The evacuations greatly reduced (by up to a factor of 10) the levels of exposure that would otherwise have been received by those living in evacuated areas [United Nations Scientific Committee on the Effects of Atomic Radiation, 2013].

The overall number of evacuees has decreased significantly and in February 2012 there were 342,509 evacuees living in 1,200 municipalities in 47 prefectures around the country [National Policy Unit, 2012]. Most of them (94.1%) were in temporary and public housings[61], hospitals etc., some 4.9 % lived with relative, friends etc., 97 stayed in hotels and similar facilities, and only 584[62] remained in evacuation centers (community hall, school etc.) in 2 prefectures.

The reconstruction process has been progressing rapidly, as most evacuees were moved to temporary built houses by September 2011[63]. Some evacuees have moved to permanent homes and return to a normal life. Vital infrastructure such as major road, railway, harbors, and telecommunications network have been quickly restored, and essential public services such as hospitals, schools, water and energy supply etc. quickly re-established. In recent months there has been considerable progress (decontamination, lifting evacuation orders, rebuilding, re-opening administration, hospitals, schools, train services, etc.) in some parts of the evacuation zone around the crippled nuclear plant as well [NHK World, April 1, April 24, June 2, 2014; The Asahi Shinbun, April 7, 2014; The Japan News, June 1, 2014].

At the same time diverse national and local initiatives for building disaster resilient towns have been in progress, including the collective relocation of residential areas to safe

[61] By July 2011 there were built 46,081 units of temporary housing (about 88% of planned number) and 73% of evacuees had moved into 73% of the temporary housing available [World Health Organization, July, 2011].

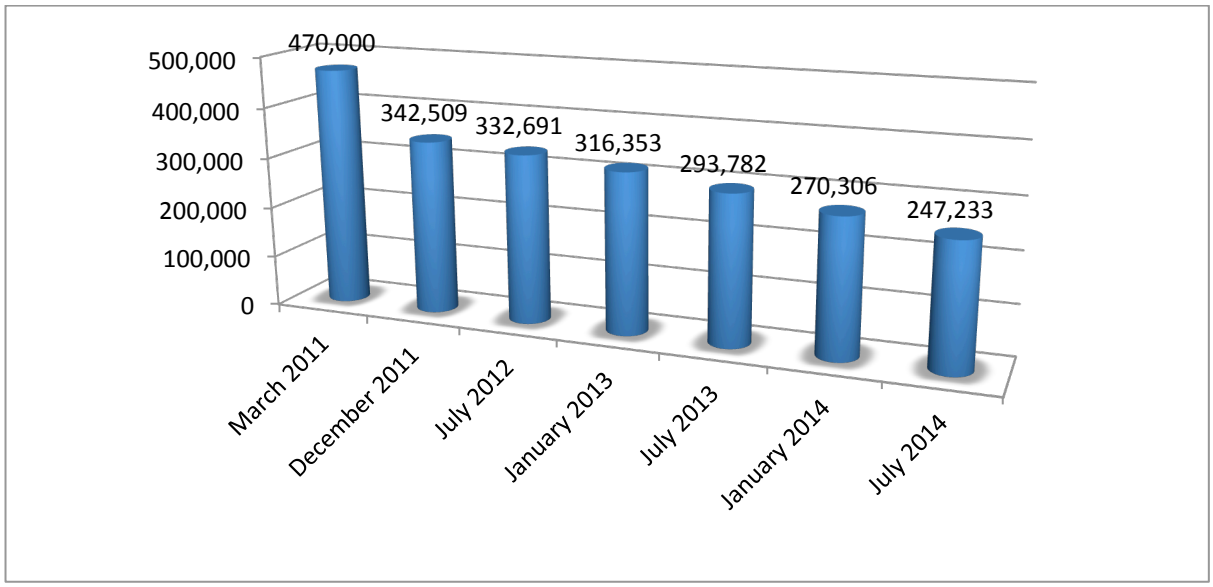
[62] Compared with 41,143 in June 2011 [Reconstruction Agency, 2014].

[63] At the same time only 99 evacuees were reported living is shelters in July 2013 and none since then [Reconstruction Agency, 2014].

places such as higher ground in 276 districts in 26 municipalities[64], and the readjustment and leveling of land for residential areas in 58 districts in 19 municipalities [Reconstruction Agency, 2014]. Latest data indicates that while 81% of planed housing reconstruction started merely 11% have been completed[65] [Reconstruction Agency, 2014].

There are still more than 247,000 evacuated people living in temporary housing and other makeshift facilities nationwide (Figure 5). What is more, a significant number of them live outside home prefectures – e.g. in the end of August 2014 as many as 47,149 former Fukushima residents are living outside the prefecture, 6,974 people from Miyagi prefecture, and 1,513 from Iwate prefectures. Furthermore, many evacuees have been moved multiple times before settling to a "permanent" place or returning home[66] [NHK, August 4, 2014].

Figure 5. Evolution of number of evacuees in post disaster years



Source: Reconstruction Agency, National Police Unit

In August 2014, a great portion of the evacuees still lives in "temporary housing, etc." (93.38%) as most of them are in "private sector houses" (110,339 people in 46,221 houses), a significant portion "in temporary houses" (93,017 people in 42,590 houses), and the rest in "public houses, etc." (21,979 people in 8,201 houses) [Reconstruction Agency, 2014].

In Iwate, Miyagi and Fukushima prefectures more than 90,000 people live in makeshift housing [The Japan News, September 12, 2014]. In the end of July 2014 the occupancy rate of temporary housing stood at 79% in Iwate prefecture, 80% in Miyagi

[64] It is estimated that 22,000 households need to be resettled to higher ground or further in land in the 3 disaster prefectures, including 6,900 in Ishinomaki, 3,000 in Higashi Matsushima, and 2,000 in Sendai [Yonekura, 2013]. The resettlement project budget for 5 years is 350 billion yen (out of 19 trillion yen of the overall Reconstruction budget).

[65] Construction of public houses in most affected 3 prefectures is expected to complete in 2015 and private houses in 2017.

[66] For instance, in the year after the accidents approximately 70% of the residents of Futaba, Okuma, Tomioka, Naraha and Namie had to evacuate four times or more [The National Diet of Japan, 2012].

prefecture, and 78% in Fukushima prefecture, while only a faction of planned public housing were completed - 12.7% in Iwate, 9.8% in Miyagi and 7.3% in Fukushima prefecture.

Continued use of the makeshift facilities[67] has been an issue as their conditions rapidly deteriorate (damages, bacteria, etc.). Recent deadly mudslides also caused fear about the safety of makeshift housing residents since some of these houses were built in sediment related "caution zones"[68] [The Japan News, November 2, 2014].

The construction of public housing has remained slow, with only about 10% of planned 30,000 new low-rent units completed in most affected Miyagi, Iwate and Fukushima prefectures by the end of August, 2014 [NHK World, September 10, 2014]. According to the officials selecting locations and acquiring land plots take time as well limited availability of workers and building materials have been delaying factors. Recent data indicate that about 330 of the completed units in 19 municipalities are unoccupied while in other locations applicants outnumber the available units[69].

The progress in projects to relocate tsunami stricken communities has also been slow and merely 10% of the areas planned for relocated communities had been developed by the end of January 2014 [NHK World, March 11, 2014]. A new town is coming to existence in Tamaura-Nishi district of Iwanuma (Miyagi Prefecture), where residential land has been developed for a collective relocation project [The Japan News, September 11, 2014]. About 60% of about 1,800 people who lived in the city's six districts along the tsunami hit coast will move into the housing units. The new town will have 336 residences, including 178 publicly operated housing units scheduled to be completed by the end of the fiscal 2014[70]. Bus services started in October 2014, but a large supermarket is set to be opened in summer 2015.

The post disaster reconstruction has been much more delayed in Fukushima prefecture [The Japan News March 11, 2014]. A mid October public opinion poll indicated that for 86% of voters reconstruction work "has not progressed at all," or "has not sufficiently progressed" [The Japan News, October 28, 2014].

More than three and held years after the accident about 127,000 Fukushima prefecture residents are still displaced, of which 101,000 are from the "Evacuation Order Area"[71] [Reconstruction Agency, 2014]. The number of evacuees within Fukushima prefecture is

[67] In principle, people are allowed to live in the temporary housing for up to two years but the maximum period was extended to five years in Iwate and Miyagi under a special measure for areas hit by large-scale disasters, and until the end of March 2016 in Fukushima.

[68] in August 2014 a wave of mudslides swept away houses in such caution zones in Hiroshima. In Miyagi and Iwate prefectures 52 still live in temporary housing and prefectural governments are considering the transfer residents in such areas to other locations.

[69] vacancy is attributed to the changing needs of evacuees during delayed reconstruction – e.g. many people started rebuilding their lives by finding jobs and homes in communities where they had moved while some simply cannot afford to move again.

[70] some people have already started to live in 27 newly built residences, 120 housing units are currently being constructed, while other residences have yet to be built.

[71] Including 32,000 from Evacuation lifting preparation area, 23,000 from Residence restricted areas, and 25,000 from Returnnig back difficult areas [Reconstriction Agency, 2014].

81,000[72], and most of them (92,59%) are living in temporary houses (including private), 4,94% are in employees houses, etc., and the rests are staying in houses of relatives and friends.

Furthermore, around 45,000 of Fukushima evacuees are still evacuated outside[73] the prefecture [Reconstruction Agency, 2014]. Most of them are in Tokyo (6,300), Yamagata (4,700), Nigata (4,100), Ibaraki (3,400) and Chiba (3,300) prefectures. Available data show that 81% of them live in the temporary housing complexes including apartments or civil servants housings, and the rest stay with relatives and friends [Fukushima Prefecture Government, 2014].

About 40% of the first batch of public housing for people displaced by the Fukushima nuclear disaster will not be ready by the end of fiscal 2015[74], forcing those who evacuated to wait longer for permanent homes [Fukushima Minpo News, August 5, 2014]. According to the prefecture it takes longer than expected to conclude deals with landowners of construction sites for large housing complexes while work to transform forests and rice paddies into residential land is also going slowly.

The cleaning up and disposal of enormous amount of earthquake and tsunami debris has been largely completed in Miyagi and Iwate prefectures but still legging behind in Fukushima prefecture [Reconstruction Agency, 2014]. Decontamination of lands, houses, roads etc. in the evacuation and other contaminated zones has been a complex and slow process with less than a half of houses decontaminated in the three most affected prefectures.

About 70% of monitored 58 municipalities in 7 prefectures had completed or almost completed decontamination by the end of March 2014 while remaining 16 failed to meet initial deadline as 12 cities and towns have sought extensions from 1 to 3 years of government funding for the clean up [NHK World, May 15, 2014].

The decontamination has not been proceeding as planned in evacuation zone as well [NHK World, June 10, 2014]. The Environment Ministry was planning to finish decontaminating 11 cities, towns and villages by the end of March 2014 but extended the decontamination period for 6 of them by 2 to 3 years.

About 17,500 households were registered in the high-radiation evacuation zones as of April 2014 [NHK World, June 25, 2014]. All 24,500 former residents in 7 municipalities in no-entry zone remain evacuees [NHK World, June 23, 2014]. In no entry areas there are 9,100 homes designated as unsuitable for living for a long period of time since radiation exposure exceeds 50 millisieverts per year. The government has yet to decide whether to conduct full-scale operations to remove the radioactive materials because it is unclear whether decontamination will be effective and feared that workers may be exposed to high levels of radiation.

[72] about 24,000 people of them evacuated to Iwaki and an increasing number have resettled in the city [The Japan News, October 28, 2014].

[73] only reported number to the government. It is assumed that the actual number should be higher.

[74] In August 2014 the prefectural government revealed that 1,600 housing units of the first 3,700 planned will likely face delays up to 9 months (residents were scheduled to move in by March 2016). Additional 1,190 more expected to be built in the same period are likely to be delayed by a year.

What is more, experimental decontamination[75] results show that current decontamination technology has limits and considerable time would be needed to clean up tainted areas. Radiation levels in some areas near the damaged nuclear plant have been more than halved due to decontamination but still remain high [NHK World, June 10, 2014]. For instance, radiation levels in residential districts of Namie town averaged 3.26 to 8.47 microsieverts per hour (about 40 to 50% of the pre-decontamination levels) and in Futaba town averaged 3.01 to 4.46 microsieverts per hour (about 20 to 30% of the pre-decontamination levels). These figures are more than 10 times higher than the government set level (0.23 microsieverts per hour) that requires decontamination. Consequently, the government will consider whether to carry out full-scale decontamination of such areas after asking former residents whether they hope to return to hometowns as well as receiving suggestions on reconstructing the no entry areas.

This estimate suggests that decontamination work may reduce radiation levels at no entry zones below the government set maximum annual threshold of 20 millisieverts in 10 years [NHK World, June 23, 2014]. In places with an annual radiation reading of 100 millisieverts, decontamination would lower levels to a range of 9 to 19 millisieverts by 2021 while areas with 50 millisieverts would see a drop to between 6 and 11 millisieverts[76]. Nevertheless, radiation levels in no-go zones are expected to remain far above the internationally recommended safe level even a decade after the nuclear disaster[77].

Besides, the progress in decontamination work does not necessarily mean residents' return is smooth [The Japan News, October 28, 2014]. For example, evacuation instructions were lifted in eastern parts of the Miyakojimachi district in Tamur in April 2014 but only about one third of the 354 registered residents have returned until October (mostly elderly). This is largely because living circumstances in the district have not returned to previous state[78].

August 2014 survey in Namie and Tomioka indicated that 50% of former residents have made decision "never return to hometowns" [NHK World, October, 2014]. The later figure was much higher than in 2013 indicating that some "undecided" have taken decision not to return for a good because of difficulties (e.g. lack of infrastructure, sufficient government support, etc.) and risks[79].

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[75] carried at 6 locations in October 2013 - January 2014 in areas regarded as unsuitable for living (annual exposure to radiation exceed 50 millisieverts).

[76] Based on a hypothetical model in which a person spends 8 hours a day outdoors and lives in a house built of wood. In case decontamination does not take place, the annual radiation reading of 100 millisieverts would naturally drop to 37 millisieverts by 2021, and a reading of 50 millisieverts would drop to 19.

[77] According to the International Commission on Radiological Protection the average person should not be exposed to more than one millisievert annually.

[78] Before the disaster residents were able to reach hospitals and large commercial facilities in Okuma in about 30 minutes by car, which is still in evacuation zone.

[79] In 2013 one third of evacuees from Namie responded that they will never return because "there is no hope of radiation levels decreasing", "the nuclear accident will not be brought under control", and ""it will be difficult to rebuild social infrastructure" [Pushpalal et. al., 2013]. Among those who want to return, 70% stated that certain conditions would have to be met before they return such as decrease in

In December 2013 the government compiled new guidelines for helping people affected by the nuclear accident including financial assistance for residents who plan to return home because their evacuation orders have been lifted and those who need to move elsewhere. For residents of areas where evacuation orders are still in place, the government will cover the cost of purchasing homes if people want to start new lives elsewhere, and provide a lump sum compensation for the mental distress they could suffer after 2017.

Many evacuees have been refusing to return back even after decontamination is completed because of the persisting high radiation in forests around houses, and some hot spots in neighboring areas. That is especially true for the younger generation who chose to stay away because of the health risk, and destructed business and community infrastructure (schools, medical facilities), etc.

In some cases (e.g. Kawauchi village) there has been a drop in the radiation levels[80] and improvements in infrastructure but the government postpone removal of the evacuation advisory after consultations with and opposition by residents [The Japan News, July 14, 2014]. Residents in the area where the evacuation advisory was lifted on October 1, 2014 numbered 275 of 139 families, out of total, 48 people of 22 families have applied for long-term stays at their homes[81] [Fukushima Minpo News, October 1, 2014].

For some places there is no clear timetable for the end of decontamination and rebuilding process. Consequently, evacuees have been rebuilding their new life and business in other places. For instance, 67% of the Okuma evacuees who answered a government questionnaire in October 2013 said they did not wish to return home under current conditions [NHK World, July 3, 2014]. They have been asking for more public support to acquire new houses outside hometown not seeing any prospect of restoring infrastructure, as radiation levels remain high, and their houses and farmland ruined. Evacuees are also having concerns about the safety of an intermediate storage facility for nuclear waste, which will be built in the town.

According to the evacuees the compensation from TEPCO and other financial aid they have been receiving is not enough to rebuild their lives [NHK World, July 3, 2014]. They asked the Okuma government to request more state compensation for evacuees who have given up returning home rather than for decontamination. They also called on the municipal government to present support measures for them as the head of the district suggesting "the town government should work not only for evacuees hoping to return home but also for those giving up the idea".

In many places diverse organizations have been set up to support residents who will return. For instance, a community-based organization has been set up to support residents who will return to Naraha town after the evacuation order is lifted[82] [NHK World, June 30, 2014]. The support organization (including three officials and volunteers) will provide services such

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radiation levels, rebuilding infrastructure for daily living, and having a certain percentage of other residents also returning.

[80] by an average of 63% from tprior to decontamination work and bellow government safety standards.

[81] 53.5% of the village population (2,758) live inside the village on a temporary or permanent basis.

[82] early 2015 after decontamination work is over.

as keeping the houses in order, weeding residents' gardens, building ties among residents, and consultations on radiation exposure.

Data suggests that more and more evacuees have been settling down permanently away from hometowns [NHK World, June 25, 2014]. Residents of evacuation zones are entitled to tax reductions if they acquire a new house or land while they have to live elsewhere and such was given to nearly 1,400 applicants during the fiscal year that ended in March, 2014[83].

Major reasons for the slow progress of reconstruction and returning back of the evacuees have been: a slow pace of decontamination of lands, existing hotspots and restricted mobility in evacuated areas, difficulties of land acquisition for building cites, series difficulties in safe disposal of contaminated soil and debris, population fears regarding radiation hazards, lack of job opportunities, unrestored critical services and infrastructure, problems for attracting bids from contractors, spikes in construction material prices and manpower shortages, absence of communities consensus for certain projects, uncertainty for future developments, etc. [The Japan News, March 4, March 11, April 3, April 4 and April 11, 2014; Hasegawa, 2013; Matanle, 2012; NHK World, March 11, May 8, May 29, 2014].

According to the mayors in most affected prefectures many among them do not expect reconstruction work to be completed by the end of fiscal 2015 [The Japan News, March 4, 2014]. Many residents of evacuated towns and villages require "more decontamination" before allowed returning home [The Japan News, April 3, 2014; NHK World, May 8, 2014)]. Some part of the population also think that more efforts have to be concentrated on areas that were damaged by the earthquake (rather than the tsunami and radiation) that need to be rebuilt [The Japan Times, March 19, 2014].

All these issues have caused further pressure to accelerate reconstruction process and pledge by the government people to feel not only "the hard side of reconstruction, but also reconstruction of their hearts" [Abe, 2014]. It has also lead to a shift from the previous policy (December, 2013) of "eventually having all those who were forced to live as evacuees return home" and include support measures for evacuees who have decided to live elsewhere than their hometown".

In June 2014 the Reconstruction Agency announced that the government is granting about 80 million dollars to Fukushima prefecture and its 16 municipalities to assist local rebuilding projects (such as designing public rental housing for returning residents who had to evacuate), for resumption of farming and industrial activities, etc. [NHK World, June 17, 2014]. That money is part of about 1.6 billion dollars earmarked by the government to help local governments jump start projects in areas where evacuation orders have been being lifted hoping that will speed up rebuilding efforts in areas that experienced delays because of evacuation orders. Fukushima prefectural government estimates that ¥3.9 trillion will be needed for reconstruction work over a 10-year period from fiscal 2016 [The Japan News, October 28, 2014].

The process of evacuation and reconstructions has been associated with a number of challenges such as: failure for timely evacuation from certain highly contaminated areas, slow response of authorities, lack of sufficient public information in the first stages of the disasters,

[83] more than twice the number of cases in the previous year.

mistrust to public and private institutions, multiple displacements of many evacuees, divided communities and families, bad communication between different organizations, lack of financial resources, insufficient manpower and building materials, ineffective use of public funds, discrimination toward some evacuees, emotional conflicts between evacuees (about "self-evacuation", compensations, rebuilding modes), insufficient and unequal compensation, substandard labor conditions for decontamination workers, increased number of individual and organized criminal cases, numerous lawsuits against TEPCO and authorities, revisions in national energy, disaster prevention etc. policies, etc. [Akiyama et al. 2012; Fukushima Minpo News, February 17, March 13, 2014; Hasegawa, 2013; The Japan News, March 4, March 6, March 11, March 12, March 27, April 4, 2014; The Japan Times, March 13, 2014; NHK World, March 13, June 12, 2014; Manoliu, 2014].

The 2011 disasters occurred at areas that had been facing problems of depopulation and aging [Nemoto, 2014]. Populations of prefectures hardest hit by the disasters have continued to decline during the last 3 years [NHK-World, March 11, 2014]. In Iwate, Miyagi and Fukushima prefectures total population dropped by more than 132,000 between March 1, 2011 and February 1, 2014. In the first year the population declined by about 85,000 as many people died or were evacuated, in the second year, the number fell by 29,000, and the third year by 17,000[84].

Fukushima prefecture has seen the largest population decline in post disaster years - 86,077 people since March 1, 2011 (Figure 6). What is more there has been significant decline in age groups up to 65, and increase in older population[85].

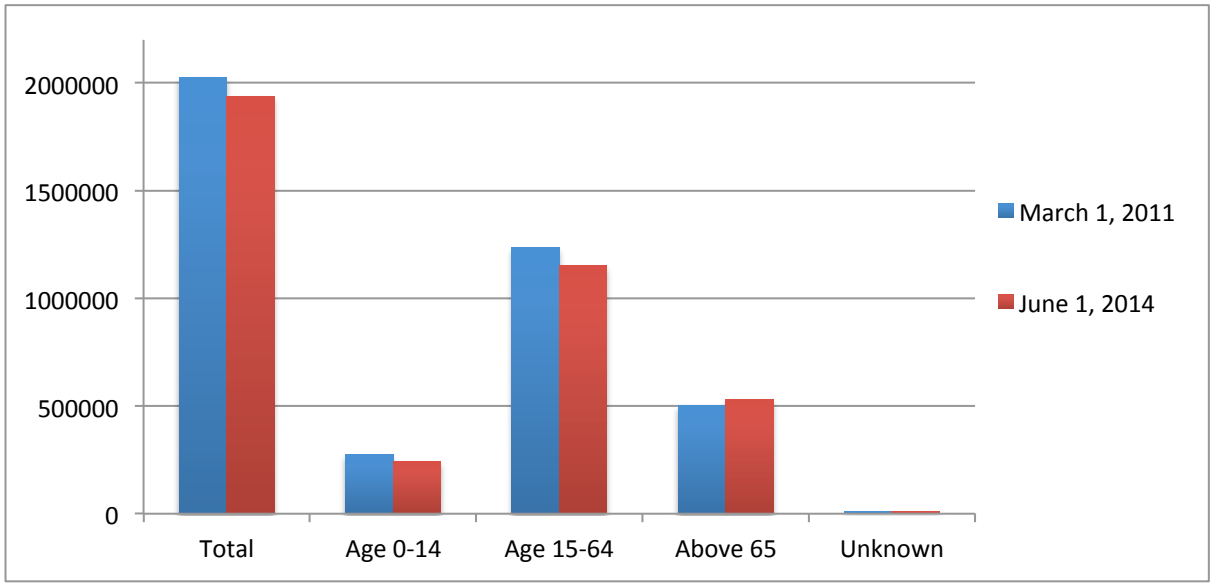
Most people especially younger one have been reluctant to return to home places due to the health risk, lack of basic infrastructure and services, reduced employment opportunities etc. What is more, the overall population has been decreasing due to out-migration since the nuclear accident (Figure 7).

The most recent data show that Fukushima prefecture saw its population fall at a slower pace of 0.72% in 2013[86], which is seen by officials as an indicator that the impact of the nuclear accident has softened [The Japan News, June 25, 2014]. On the other hand, Miyagi prefecture registered a 0.06% increase apparently due to a rise in the number of people moving to take part in reconstruction work.

In 2011 Fukushima's fertility rate fell 0.04 point from the previous year to 1.48 and another 0.07 point to 1.41 in 2012 [Fukushima Minpo News, June 5, 2014]. In 2013 the number of newborn babies in the prefecture was 14,546 last year or up 776 from 2012. The total fertility rate stood at 1.53 which was the levels prevailing in the years immediately before the disasters. The later increase was the largest among all Japanese prefectures and boosted prefectural rate to the 15th highest level across the nation (from 33rd in 2012).

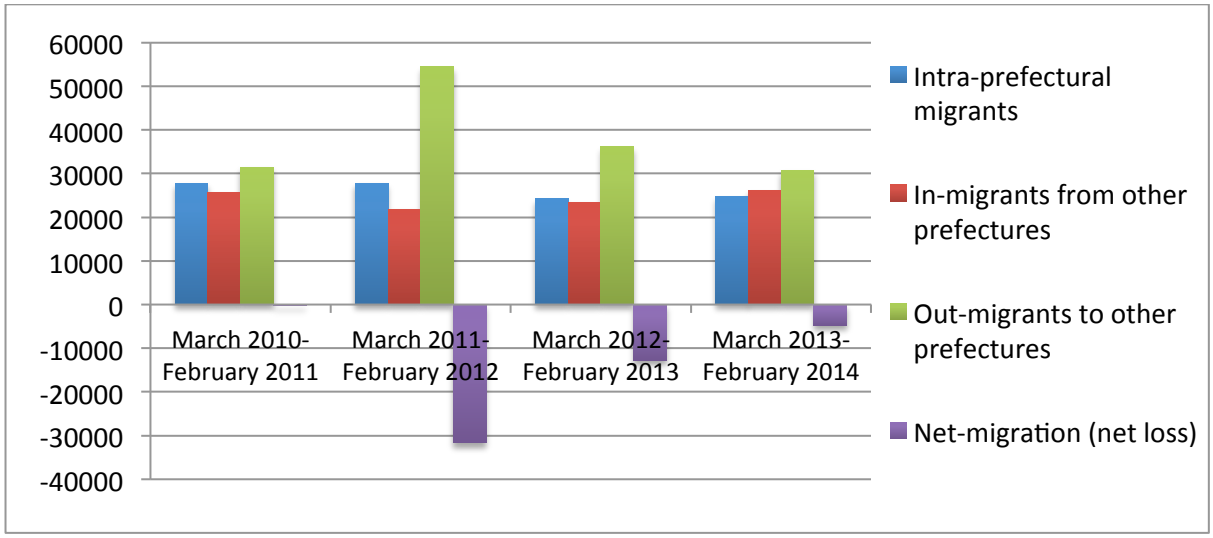
[84] Populations began rising recently in some stricken areas (e.g. Iwanuma, Miyagi) due to progress in community relocation projects as well in urban and inland areas such as Sendai and Morioka.
[85] Currently, 27.3% of the total population is older than 65, of which 53.6% older than 75.
[86] On the backgrownd of the drop of 0.19% for the country as a whole.

Figure 6. Population dynamics in Fukushima prefecture in post disaster years



Source: Statistics Bureau, Ministry of Internal Affairs and Communications

Figure 7. Number of intra-prefectural migrants, in-migrants, out-migrants and net losses in population in Fukushima prefecture



Source: Statistics Bureau, Ministry of Internal Affairs and Communications

All that has been a consequence of policy measures of the prefectural government to cope with a population decline including improved childbearing and rearing environment offering free medical care for young people aged 18 or less, increasing indoor play areas and expanding a scheme for detecting radioactive materials in school lunch meals, among other things.

4. Economic damages and impacts

The earthquake, tsunami and the nuclear accident have caused immense damages in North-eastern Japan and beyond (Picture 3 and Picture 4). They affected directly 62 municipalities in six prefectures, among them 28 in the three worst affected prefectures[87] [International Bank for Reconstruction and Development, 2012].

Picture 3. Tsunami hit lands and property

Source: Associate Press, March 11, 2011

Picture 4. Debris from earthquake and tsunami

Source:

The latest figure shows that 1,220,360 buildings in 20 prefectures have been damaged from the earthquake and tsunami, out of which 10.43% totally collapsed, 22.35% half destroyed, and the rest partially damaged, flooded or burned down (Table 9). The biggest property damages have been registered in Miyagi, Fukushima, Ibaraki, and Iwate prefectures.

Most of the totally and half destroyed buildings were from coastal municipalities - 94% and 75% accordingly[88]. According to experts 42% of damages to buildings come from the earthquake, 39% from the tsunami, and 19% from the nuclear disaster [Daniell et al., 2011].

In addition, there have been reports for numerous damaged roads, bridges, dikes, railways and landslides in 14 prefectures (Table 10).

In the three most affected prefectures the March 2011 disaster left approximately 2,580,000 households without electricity supply, around 420,000 households without gas supply, about 1,660,000 households without Liquefied Petroleum gas supply, and approximately 2,300,000 with interrupted water supply [Government of Japan, 2012].

The triple disaster has cased destruction of many businesses, which incurred big direct and indirect losses in certain sectors (manufacturing, energy, transport, agri-food, etc.) and supply chains in Japan and worldwide [Fujita et al. 2012; Government of Japan, 2012; OECD, 2013; UFJ, 2011].

[87] computer servers in some municipalities were seriously damaged or destroyed, resulting in a loss of essential data. 221 public officials died or remain missing from 17 municipalities in 3 prefectures.

[88] coastal municipalities generally go much inland and therefore not impacted by the tsunami.

Table 9. Number of property damages associated with March 2011 earthquake (February 10, 2014)

Prefectures	Totally collapse	Half collapse	Totally burn down	Partial burn down	Flooded above floor	Flooded bellow floor	Partially damaged	Non dwelling houses
Hokkaido	-	4	-	-	329	545	7	469
Aomori	308	701	-	-	-	-	1006	1402
Iwate	19107	6598	33		-	6	18554	4368
Miyagi	82911	155086	135		-	7796	222893	28893
Akita	-	-	-	-	-	-	3	3
Yamagata	-	-	-	-	-	-	2	96
Fukushima	21235	73388	77	3	1061	338	167211	1117
Tokyo	15	198	1	-	-	-	4847	1101
Ibaraki	2628	24327	31		1799	779	185795	19949
Tochigi	261	2118	-	-	-	-	73246	295
Gunma	-	7	-	-	-	-	17246	-
Saitama	24	199	1	1	-	1	1800	33
Chiba	801	10121	15		157	731	54931	660
Kanagawa	-	41	-	-	-	-	459	13
Nigata	-	-	-	-	-	-	17	9
Yamanashi	-	-	-	-	-	-	-	4
Shizuoka	-	-	-	-	-	5	13	9
Mie	-	-	-	-	2	-	-	9
Tokushima	-	-	-	-	2	9	-	-
Kochi	-	-	-	-	2	8	-	-
Total	**127290**	**272788**	**297**		**3352**	**10218**	**747989**	**58426**

Source: National Police Agency

Table 10. Places with infrastructure damages associated with March 2011 earthquake (February 10, 2014)

Prefectures	Damaged roads	Damaged bridges	Landslides	Break of dikes	Damaged railways
Aomori	2	-	-	-	-
Iwate	30	4	6	-	-
Miyagi	390	12	51	45	26
Akita	9	-	-	-	-
Yamagata	21	-	29	-	-
Fukushima	187	3	9	-	-
Tokyo	295	55	6	-	-
Ibaraki	307	41	-	-	-
Tochigi	257	-	40	-	2
Gunma	36	-	9	-	-
Saitama	160	-		-	-
Chiba	2343	-	55	-	1
Kanagawa	160	1	2	-	-
Gifu	1	-	-	-	-
Total	**4198**	**116**	**207**	**45**	**29**

Source: National Police Agency

There have been considerable damages in agriculture, fishery and forestry sectors. Around 23,600 hectares of farmland were washed away or flooded by the tsunami as well as

considerably salinized by the seawaters [Ministry of Agriculture Forestry and Fisheries, 2014]. In Aomori, Iwate and Miyagi prefectures approximately 4,550,000 poultry, 5,850 hogs, and 750 beef cattle were drowned, crushed or starved [Tohoku Regional Agricultural Administration, 2011]. In addition, large areas of farmland have been contaminated, and many livestock, crops and other products destroyed or devaluated due to the Fukushima nuclear disaster [Bachev and Ito, 2013; Koyama, 2013; Watanabe, 2013].

In total 28,612 fish vessels, 1,725 common use facilities and 319 harbors were damaged by the disaster [Ministry of Agriculture Forestry and Fisheries, 2014]. In Miyagi, Iwate, and Fukushima prefectures an estimated 90% of the fishing boats were rendered unusable by the tsunami [The Japan Times, April 28, 2011] and almost all fishing-ports destructed [Ministry of Agriculture Forestry and Fisheries, 2014]. Similarly, there were desolation of forest lands in 458 points, damaged facilities for forest maintaining and conservation in 275 points, damaged forest roads in 2,632 points, damaged forests amounting 1,065 ha, damaged cultivating facilities for forest products in 476 points, and damaged of processing and marketing facilities, etc. in 115 points [Ministry of Agriculture Forestry and Fisheries, 2014].

Furthermore, enormous amount of rubble and debris have been created by the earthquake and tsunami. In affected 239 municipalities of 13 prefectures the total amount of disaster debris is estimated to be about 20 million tons and tsunami deposits around 10 million tons [Reconstruction Agency, 2014]. The debris (some of them radioactive) has been an enormous obstacle to rescue and impeded reconstruction.

In the most affected Iwate, Miyagi, and Fukushima prefectures the amount of debris and tsunami deposits reached 22.63 million tons [Reconstruction Agency, 2014]. In Miyagi prefecture the amount of tsunami-related debris was 19 times greater than a normal year's waste while in Iwate prefecture it was 11 times greater [International Bank for Reconstruction and Development, 2012].

The amount of debris washed out by the tsunami in the three prefectures is estimated to be about 5 million tons, 70 % of which deposited on seabed along Japan coasts and the remaining 30% becoming floating debris[89] [Ministry of Environment, 2012]. The debris and tsunami deposits in these prefectures have been stored in almost 1,700 temporary cites, debris account for more than 60% of the total amount, and around two-third of all debris and tsunami deposits are in Miyagi prefecture (Table 11).

What is more, the nuclear accident has contaminated huge areas of lands, property infrastructure, and debris in Fukushima and neighboring prefectures (Map 10). Heavily contaminated areas are located in 101 municipalities of 8 prefectures, and divided into: "Special Decontamination Area" (overlapping with Evacuation Order Area), where decontamination and waste management is done by the Government, and "Intensive Contamination Survey Area", overseen by the local municipalities.

[89] Some debris have been collected or sunk. Therefore floating debris still drifting are less than 1.5 million tons.

Table 11. Amount of total and treated debris and tsunami deposits in Iwate, Miyagi and Fukushima* prefectures (January 31, 2014)

Prefectures	Total amount (10000s tons)	Debris		Tsunami deposits	
		Amount	Treated (%)	Amount	Treated (%)
Iwate	556	400	97	145	93
Miyagi	1,874	1,121	98.7	739	98
Fukushima	349	174	68.4	78	44
Total	2,778	1,694	95.2	961	89

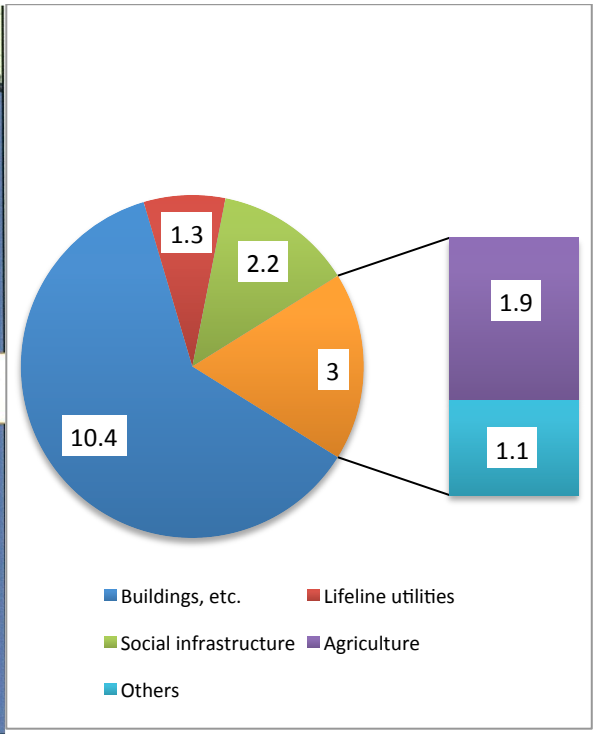
* exclude evacuation area

Source: Ministry of Environment, 2014

Map 10. Special decontamination (red) and Intensive contamination (yellow) areas

Source: Ministry of Environment, 2014

Figure 8. Estimated economic damages of the March 2011 earthquake (trillion yens)



Source: Cabinet Office of Japan, June 24, 2011

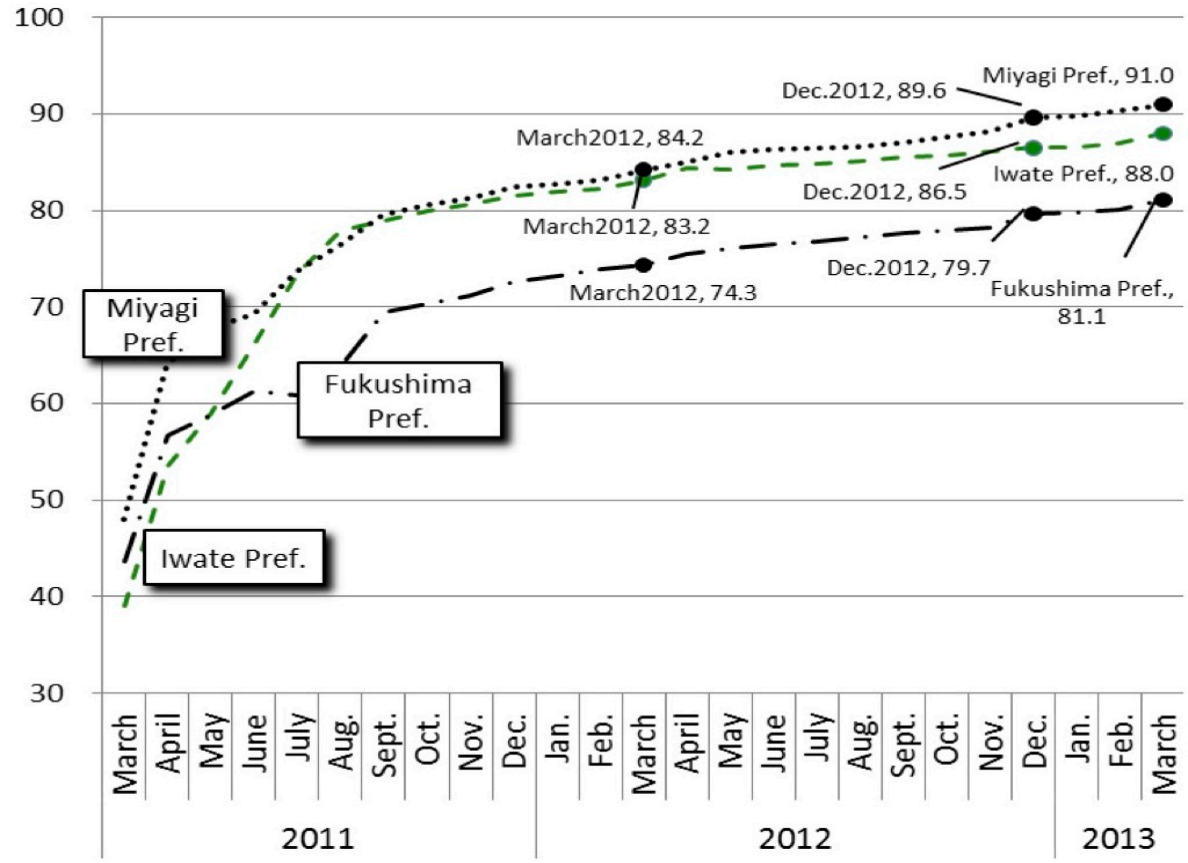
In October 2011, the government announced that it will spend at least 1 trillion yen ($13 billion) to clean up the vast areas contaminated by radiation from the Fukushima nuclear disaster as country faces the prospect of removing and disposing 29 million cubic meters of soil from a sprawling area in Fukushima and four nearby prefectures [Reuters, October 20, 2011].

Furthermore, evacuated zones have become home to an increasing number of wild animals like rats, boars and their offspring with domestic pigs, which have been causing huge (unaccounted) damages to empty houses and farms [NHK World, July 11, 2013, May 6, 2014].

The initial official estimate for the direct economic losses from the March 2011 disaster was about 16.9 trillion yen ($210 billion USD) or 4% of the Gross Domestic Product of Japan[90] (Figure 8). The greatest share of damages (61.5%) was for "Buildings, etc. (Housing, offices, plants, machinery, etc.)", followed by "Others (including agriculture, forestry and fisheries)" (17.7%), "Social infrastructure (river, road, harbors, drainage, and airport, etc.)" (13%) and "Lifeline utilities (water service, gas, electricity, and communication and broadcasting facilities" (7.7%). Anticipated damage in the sector "Agriculture" accounted for 11.24% of the total amount.

Most damages have been concentrated in Fukushima, Iwate, and Miyagi prefectures where there was a significant destruction of the basic infrastructure and the economic activity (Figure 9 and Figure 10). In March 2011 the Index of Industrial Production in the country and the most affected areas dropped considerably – with 15% and 35% accordingly (Figure 11). In March 2011 the Index expressing Status of Activity declined 30% in Iwate prefecture, 40% in Fukushima prefecture and 80% in Miyagi prefecture comparing to the previous month [National Institute for Research Advancement, 2013].

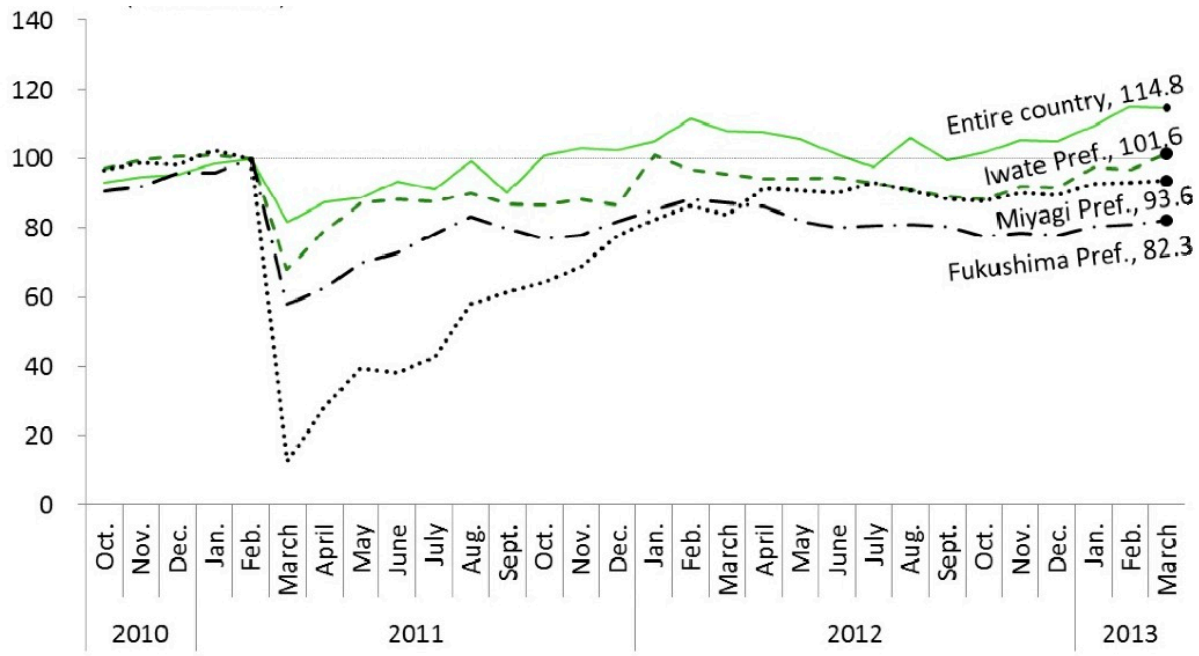
Figure 9. Trends in index for expressing status of recovery of basic infrastructure (February 2011=100)



Source: National Institute for Research Advancement (NIRA), 2013

[90] That is more than twice than the 1995 Great Hanshin Eartquake wich caused damage of approximately ten trillion yen ($102.5) billion or 2.5% of Japan's GDP at the time [Wikipedia, 2014].

Figure 10. Trends in index expressing status of activity (February 2011=100)



Source: National Institute for Research Advancement (NIRA), 2013

Figure 11. Index of industrial production

Source: Reconstruction Agency, 2014

The insured losses from the Great ast Japan Earthquake were estimated at ¥2,750 billion, or 16% of total direct economic losses[91] [Raghieri and Ishiwatari, 2014]. The

[91] Residential assets represented 78% of insured losses. Rice is greatly insured in Japan but insurance almost did not cover rice production losses (disater happened before rice-growing season). In Miyagi prefecture the agricultural insurance scheme has covered damages to green-houses of ¥1 billion.

insurance payouts stemming from the quake had reached ¥1,234.6 billion as of May 2012[92] [Takabe and Inui, 2013]. In addition, ¥360.3 billion (as of December 2012) monetary donations were distributed to the affected by the disaster via the Japanese Red Cross, the Central Community Chest of Japan and local authorities in affected areas.

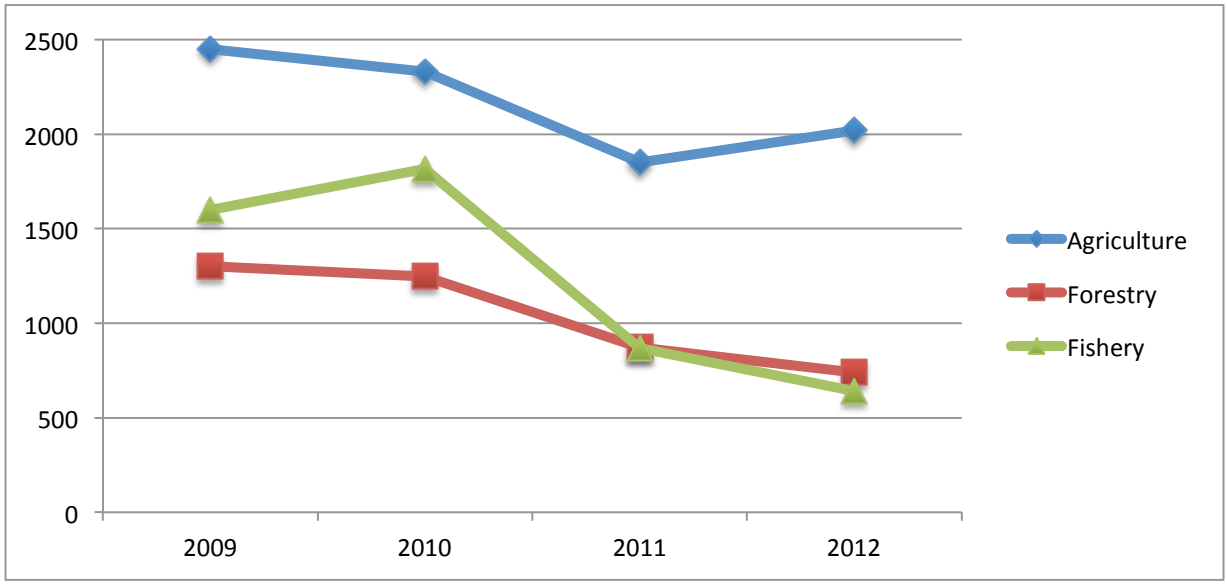
There are approximately 80,000 businesses in the tsunami-affected areas, 740,000 in the earthquake-affected areas, and 8,000 in the evacuation zones of the Fukushima nuclear plant [Tokyo Electric Power Company, 2012]. The most of them have seen their businesses severely destructed after March 2011 [Reconstruction Agency, 2014].

The basic economic indicators demonstrate that considerable part of the local economy in disaster areas have recovered to approximately pre-disaster levels. Nevertheless, many challenges still remain especially for small and middle size enterprises and certain sectors such as agriculture, fishery, food processing etc.

Up-to-date merely 36.6% of the recipients of Group subsidies for recovery and development of facilities (549 groups of approximately 10,000 business operators) report they have recovered sales above the level before the disaster [Reconstruction Agency, 2014]. Similarly, only 63% of damaged by tsunami agricultural lands have been restored for farming and 78% of destructed fishery processing facilities resumed operations.

The overall value of agricultural, forestry and fisheries products in Fukushima prefecture has declined considerably, and there has been no or only a slight recovery in these sectors of the economy (Figure 12). The high level of radiation has caused some Fukushima forests to be abandoned and there is concern about the long-term management of forestry resources [NHK World, May 6, 2014].

Figure 12. Dynamics of values of agricultural, forestry* and fishery* products in Fukushima prefecture



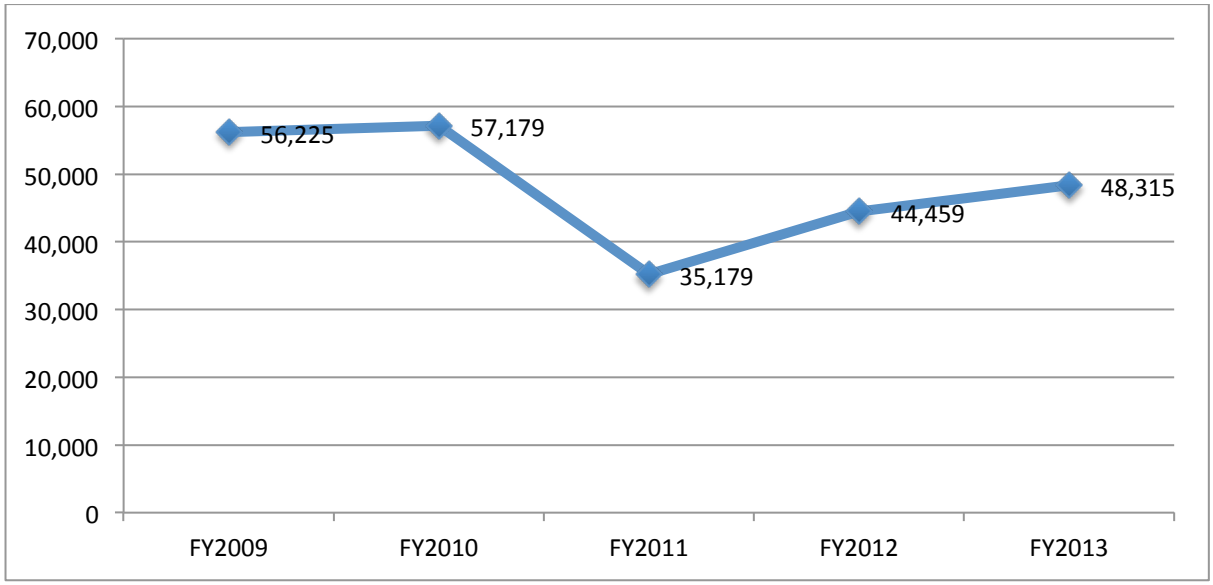
Source: Ministry of Agriculture, Forestry and Fisheries * multiplied by 10

[92] General Insurance Association of Japan designated specific total loss zones, based on satellite imagery, and any total loss claims filed from the area did not require additional confirmation speeding up the payout process. Out of ¥1,200 billion generated by the 741,000 claim payments made, 60% was paid within two months and 90% within five months [Raghieri and Ishiwatari, 2014].

Summer festivals are significant event in Japan in terms of keeping tradition and as attracting tourists and overall economic benefits. Data show that visitor figures for 14 major summer festivals in Tohoku six prefectures fell by 1.01 million or 6.5% from the previous year [The Japan News, July 24, 2014]. Despite that numbers have been rising with 14.96 million visitors in 2013[93], this is still 4.2% fewer than in 2010. In 2013 visitors to the Sendai Tanabata, Morioka Sansa Odori and Soma Nomaoi festivals declined, respectively to 2.06 million (down 12.5%), to 1.3 million (down 3.6%) and 167,000 (down 22.4%) comparing to the pre-disaster period.

Tourism was an important part of the Fukushima economy and the number of overnight stays in hotels and other accommodations dropped more than 65% in March 2011 comparing to the same period of 2010[94] [Tourist Agency, 2014]. There has been some recovery in certain parts of the prefecture (Figure 13) but the overall level is far bellow the pre-disaster period – in December 2013 it was still 26% bellow (comparing to 0.3% up nationwide).

Figure 13. Number of overnight stays in hotels and other accommodation in Naukomi, Fukushima prefecture



Source: Tourist Agency, 2014

By March 2012 as many as 644 companies in 40 prefectures had been forced into bankruptcy by the disaster, including 157 service companies, 150 manufacturers, and 113 wholesalers [The Japan Times, March 11, 2012]. They left behind liabilities of ¥925.4 billion and had employed 11,412 people. April-September 2014 data show that the number of corporate bankruptcies in Japan fell but rose in Tohoku (and Shikoku) for the first time in six years [The Japan News, October 10, 2014].

In order to support firms in Fukushima prefecture, which are under the weight of so-called "double loans", the Corporation for Revitalizing Earthquake Affected Business (a unit

[93] In addition, 6 prefectural capitals of the region have been hosting the Tohoku Rokkon-sai (Festival of the six souls in Tohoku) in rotation since 2011 to support disaster reconstruction efforts which draw 200,000 visitors a year [The Japan News, July 24, 2014].
[94] At the same time the national figure declined around 35%.

of the Deposit Insurance Corporation of Japan) set up a special team (May 2014) to extend support [The Japan News, June 6, 2014]. Firms[95] need enhanced assistance since they have difficulty developing long-term plans for business restoration due to the ongoing nuclear crisis.

Furthermore, land prices[96] in disaster hit prefectures grew or slowed the pace of reduction in the last year[97] as an increasing number of residents moved to higher ground from coastal areas [The Japan News, July 2, 2014]. In Miyagi prefecture the average land price grew 2.4%, marking the steepest growth in the country's 47 prefectures. In Fukushima land prices rose 0.8% rising for the first time in 22 years[98].

Some $30 billion has been paid to 84,000 nuclear accident refugees and around $20 billion to 300,000 tsunami survivors in the Tohoku region [World Nuclear Association, 2014]. The evacuees received JPY 100,000 ($1,030) per month in psychological suffering compensation, which is tax-exempt and paid unconditionally. In October 2013, about 84,000 evacuees received the payments as an average family of four got about JPY 90 million ($900,000) in compensation from TEPCO. The average compensation for real estate was JPY 49.1 million ($490,000), JPY 10.9 million ($110,000) for lost wages, and JPY 30 million ($300,000) as "consolation money" for pain and suffering [Asahi Shinbun, October 26, 2013].

In mid April 2011 a Panel to address compensation for nuclear related damage acting as intermediary[99] established "Guidelines for determining the scope of compensation for damage caused by the accident"[100]. The government and nuclear plant operators also established the Nuclear Damage Compensation Facilitation Corporation[101]. Some JPY 900 billion ($11.5 billion) were released to the company through bonds issued to the Nuclear Damage Facilitation Fund to cover compensation payments[102]. In February 2012 the government approved a further JPY 690 billion ($8.9 billion) in compensation support from the Nuclear Damage Liability Facilitation Fund giving the government voting rights[103]. In the end of July

[95] Principal repayments began in summer 2014 for some afflicted companies that received loans from the government financial institutions.

[96] "Rosenka" or prices of land facing major streets, used to calculate inheritance and gift taxes.

[97] although the average price for the country fell for the 6 straight year (dropped by 0.7% on average in 2013) with exception of the 3 major metropolitan areas (Tokyo, Osaka and Nagoya).

[98] Land prices in evacuation zones have been appraised at zero due to difficulty in conducting on-site surveys.

[99] established within the Ministry of Education, Culture, Sports, Science and Technology, led by Law Professor Yoshihisa Nomi of Gakushuin University, Tokyo.

[100] According to the Law on Compensation for Nuclear Damage and Law on Contract for Liability Insurance for Nuclear Damage the TEPCO liability is exclusive and absolute regardless of fault [World Nuclear Association, 2014]. The government may relieve the operator of liability if it determines that damage results from "a grave natural disaster of an exceptional character" (which it did not do here).

[101] It received JPY 7 billion ($91 million) in public funds and JPY 7 billion from 12 nuclear plant operators, including TEPCO's of JPY 2379 million ($30 million).

[102] a more comprehensive business plan was introduced in March 2012, involving compensation payments of JPY 910 billion ($11.6 billion) annually.

[103] for JPY 1 trillion (about $12.5 billion) paid through the Nuclear Damage Liability Facilitation Fund.

2012 TEPCO sold the government 50.11% of the voting and 25.73% no voting rights shares, and became government-controlled company.

In June 2013 TEPCO requested a further JPY 666 billion ($6.7 billion) in government support through the Nuclear Damage Liability Facilitation Fund, bringing the total amount to JPY 3.79 trillion ($38 billion). More than half of the request (some JPY 370 billion, $3.7 billion) resulted from the re-evaluation of the evacuation zone around the damaged plant and a re-examination of the estimated amount regarding compensation for mental damages, loss or depreciation of valuables such as housing lands and buildings. About JPY 43 billion ($431 million) was due to a higher estimate of compensation coming from damages by "harmful rumors" to the agriculture, forestry, fisheries, food processing and distribution industries[104].

By mid May 2014 TEPCO had paid JPY 3808 billion ($38 billion) in compensation, fairly evenly split between businesses and individuals, based on decisions of the Nuclear Damage Compensation Facilitation Corporation, and covered by loans from the Nuclear Damage Liability Facilitation Fund [World Nuclear Association, 2014]. Some $16 billion was distributed evenly among 85,000 evacuees ($188,200 each person including children). In December 2013 the government raised the upper limit of financial assistance from JPY 5 trillion to JPY 9 trillion ($86 billion).

By the end of November 2013 TEPCO received 2,035,000 applications from individuals and businesses for compensations related to the Fukushima nuclear accidents, and paid a total amount of 3,168.7 billion yen [Nomura and Hokugo, 2013]. Until the end of January 2013 the biggest amount of compensation was paid to "Natural Persons" (48.5%)[105], followed by "Legal Persons and Sole Proprietors" (30.9%), and "Groups Representing Members" (20.6%) such as Agricultural Cooperatives, Fishery Cooperatives, Fukushima Prefecture Residents Health Care Fund[106], and Others [Nomura and Hokugo, 2013].

The greatest compensation payments were for demands from Fukushima prefecture (75%), followed by Kanto region (17.1%), Hokkaido and Tohoku region (4.6%), and Other regions (3.2%). "Mental anguish" and "Damage from incapacity of work" took the largest portion of compensation payments to Natural persons (Figure 14). Most compensation payments to Legal Persons and Sole Proprietors[107] were for "Lost earning" (94.5%), and for applicants from Evacuation Areas (other than agriculture), Tourisms and Service industries (Figure 15).

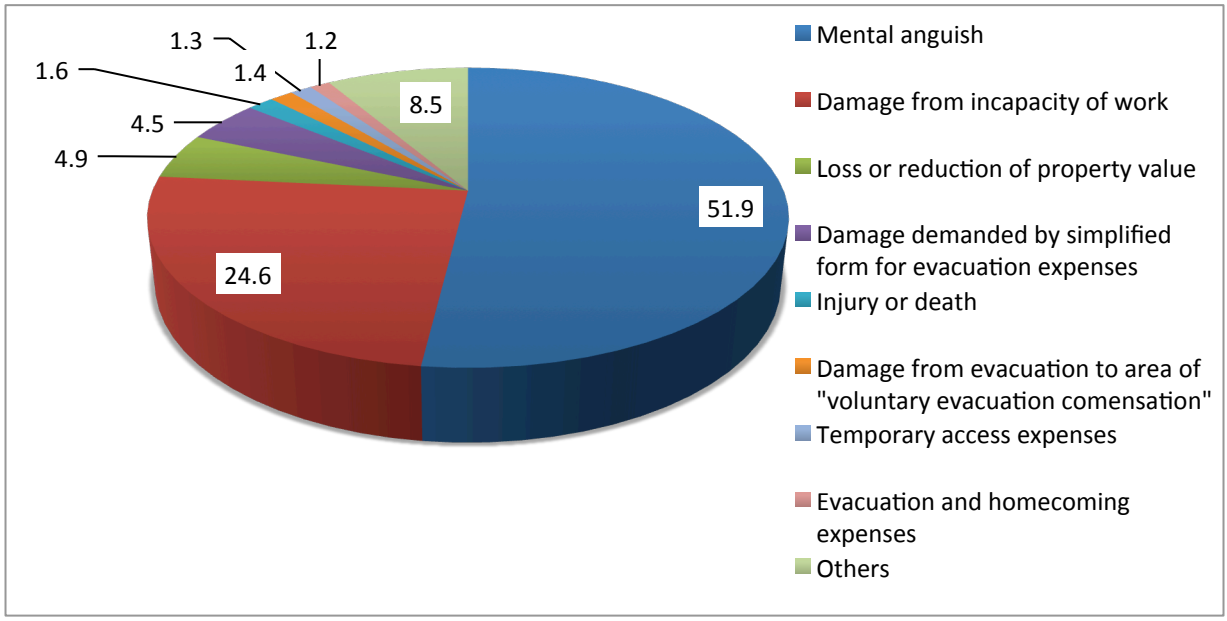
[104] As restrictions on shipment of foodstuffs from affected area continue an additional JPY 240 billion ($2.4 billion) was included to cover for the further compensation claims.

[105] TEPCO has been paying 100,000 yen (USD990) a month to each residents who was forced to evacuate – figure calculated by referring to the approximate 120,000 yen monthly benefit that is paid through automobile liability insurance to hospitalized as a result of traffic accident [Pushpalal et al. 2013]. Local government argue that figure is low and ask for monthly compensation for psychological duress be increased to 350,000 yen.

[106] Fund received by Fukushima prefectural government for financing long-term healthcare of residents.

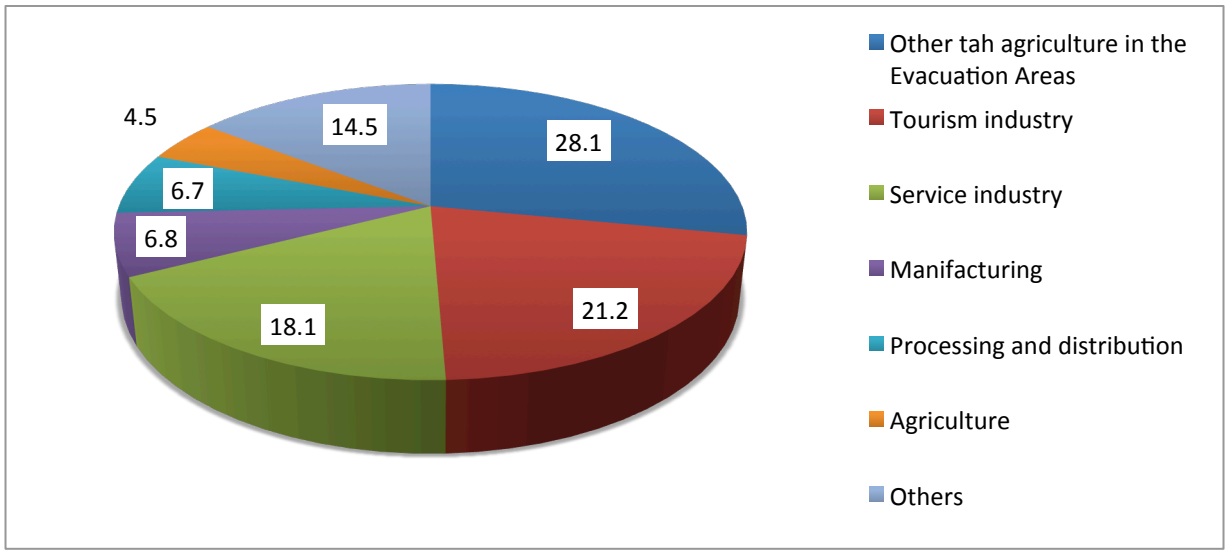
[107] not including payments to farmers, fishermen and others who apply through "Group Representing Victims".

Figure 14. Share of TEPCO payments to Natural Persons by damage categories (%)



Source: Nomura and Hokugo, 2013

Figure 15. Share of TEPCO payments to Legal Persons and Sole Proprietors by damage categories (%)



Source: Nomura and Hokugo, 2013

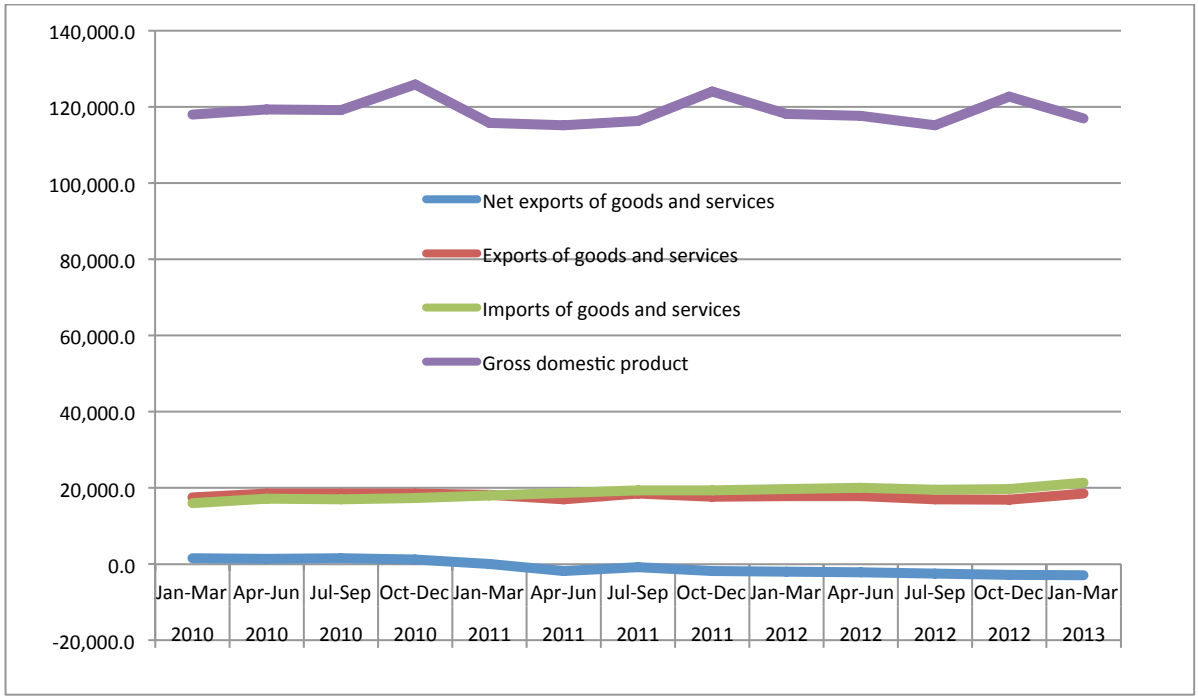
The nuclear disaster and the suspension of nuclear reactors has been also a severe blow for the nuclear industry in the country. For instance, TEPCO logged a net loss of ¥173.26 billion, against the year before profit of ¥437.93 billion, due to a special loss of ¥218.8 billion for compensation for the crisis at Fukushima nuclear power plant [The Japan News, August 1, 2014]. It logged a group recurring profit of ¥52.51 billion in April-June 2014 against a loss of ¥29.49 billion a year before, marking the first profit for the period in 4 years[108]. Meanwhile,

[108] It reflects electricity rate increase under system allowing power firms to pass higher fuel costs for thermal power generation on to customers. Consequently, group sales in the first quarter of fiscal 2014

four other regional power suppliers[109] suffered group recurring losses of ¥74.7 billion, due largely to hefty costs for fuel for thermal power generation with total recurring losses[110].

The macroeconomic impact of the March 2011 disaster has been also significant (Figure 16). Country's real Gross Domestic Product contracted almost 4% during January-March 2011 (comparing to 2010), and Japan has been experiencing a trade deficit as a result of the increased import.

Figure 16. Evolution of GDP, export and import of Japan



Source: Statistics Bureau, MIAC, 2014

Nevertheless, the share of Tohoku region and the three most affected prefectures in Japan's GDP and population is small - 8% and 4% accordingly [Statistics Bureau, 2012]. Besides, the disaster created a big demand for jobs, incentives for investments, and potential for economic growth associated with the recovery and reconstruction businesses (relief, rebuilding, decontamination, innovation etc.).

What is more, there has been a huge government budget for recovery, reconstructions, compensations and development. Following the disaster, the Government approved two supplementary budgets of 6.14 trillion yens for relief and recovery (May and July 2011), and launched a ten-year reconstruction program (focusing on Fukushima, Miyagi and Iwate prefectures) with expended budget of 25 trillion yens for the period 2011-2015 [Government of Japan, 2012; Reconstruction Agency, 2014].

---

rose 9.1%, labor costs grow 18.5% (booked expenses in advance to ease salary cuts from July), while fuel costs fell 1.8% thanks to an improvement in thermal power generation efficiency.

[109] Hokkaido Electric Power Co., Kansai Electric Power Co., Kyushu Electric Power Co. and Okinawa Electric Power Co.

[110] smaller than the combined year before recurring losses of ¥233 billion at nine of the 10 utilities.

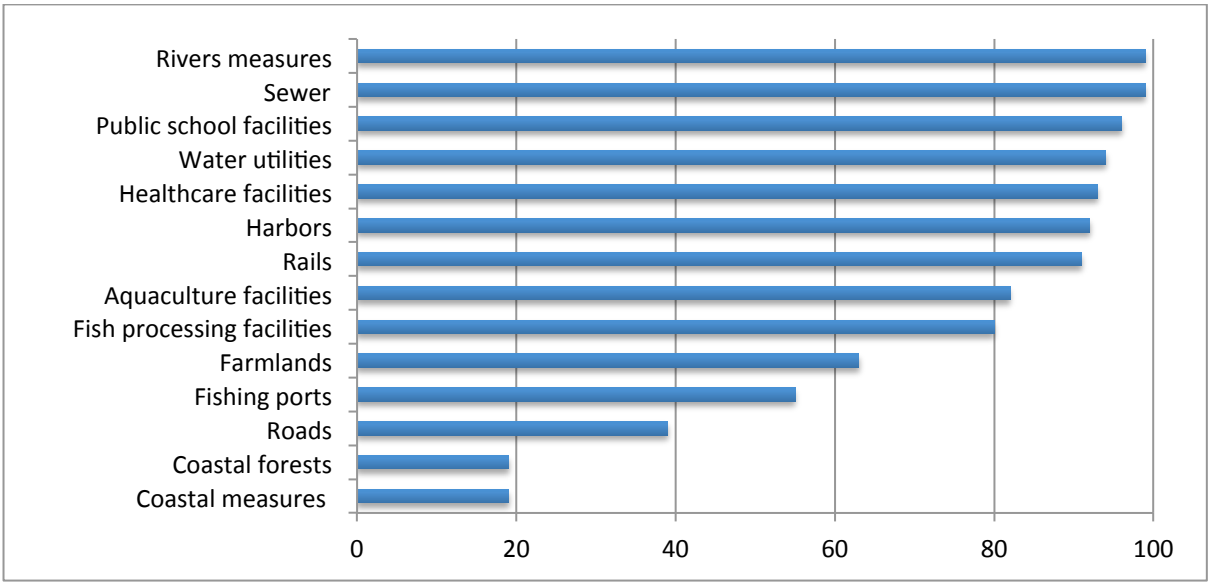
For instance, the government has promoted the "Japan As One' Work Project" as countermeasures against employment during the restoration stage, which resulted in the job placement of over 64,000 people in the disaster-hit 3 prefectures by October 2011 [Ministry of Health Labor and Welfare, 2011]. With the compilation of the Project 580,000 jobs are expected to be generated.

Subsequently, there has been a rapid recovery of infrastructure and economic activities in the country, including the most affected regions. By March 2013 the Index expressing status of recovery of basic infrastructure in Miyagi, Iwate and Fukushima prefecture reached 91%, 88% and 81.1% accordingly (National Institute for Research Advancement, 2013). At the same time the national Activity Status Index augmented by 14.8% comparing to the pre-disaster period, with appositive dynamic in Iwate prefecture (1.6%) and staying still bellow the pre-disaster level in Miyagi (93.6%) and Fukushima (82.2%) prefectures.

There has been a sizeable or complete recovery of damaged lifeline infrastructure in the months after the disaster – e.g. 96% of Electricity, 86% of Gas, 95% of LP Gas, 99% of Fixed line and Wireless phones, 100% of Mail delivery and Gas stations (as of October 2012), 98% of Water and 90% of healthcare facilities (as of March 2012) and 92% of public school facilities (as of March 2013) [Reconstruction Agency, 2014].

Similarly, there has been substantial progress in recovery and reconstruction of long-term infrastructures such as land, transportation networks, utilities, fish processing facilities, etc. (Figure 17).

Figure 17. State of full-scale recovery and reconstruction of public infrastructure after Great East Japan Earthquake (July, 2014)*



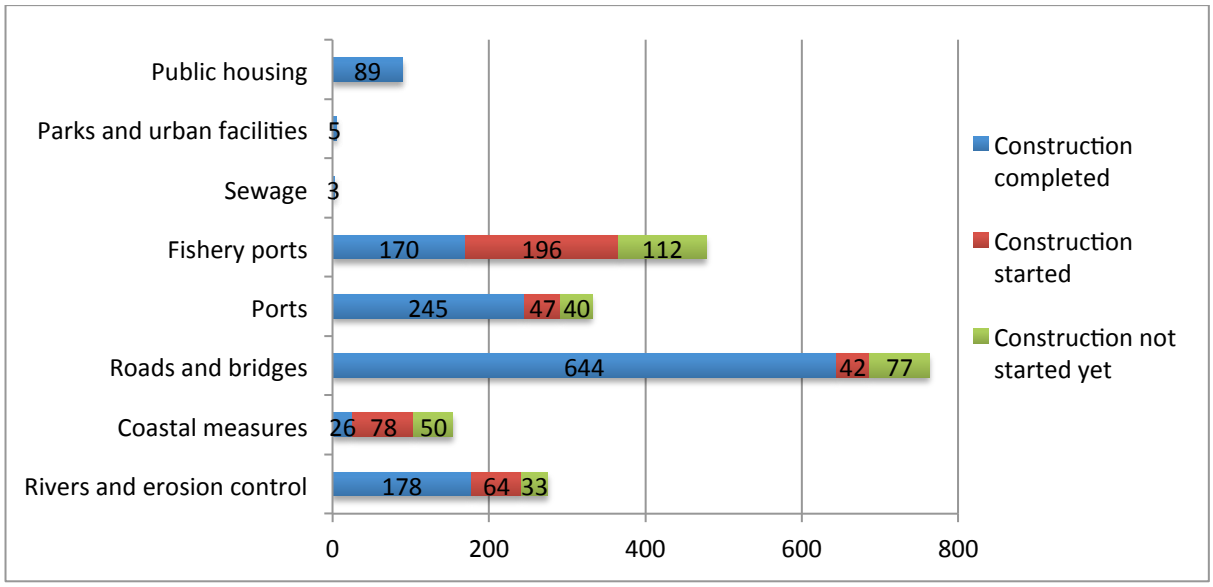
*farmland, and healthcare, school, and fish processing facilities (March, 2014), Aquaculture facilities (December 2012)

Source: Reconstruction Agency, 2014

The progress of reconstruction of different type of public infrastructure has not been similar in different affected areas. For instance, in Fukushima prefecture reconstruction started in 85% of planed cites, and in 65% have already completed (Figure 18). In Aizu and

Nakadori regions progress has been substantial – in 100% and 99% of planed cites (26 and 536 accordingly) construction has been completed. On the other hand, in coastal Hamadori region in a fifth of planed (1,537) cites reconstruction has not started yet [Reconstruction Agency, 2014].

Figure 18. Progress in reconstruction of public infrastructure in Fukushima prefecture, July 1, 2014



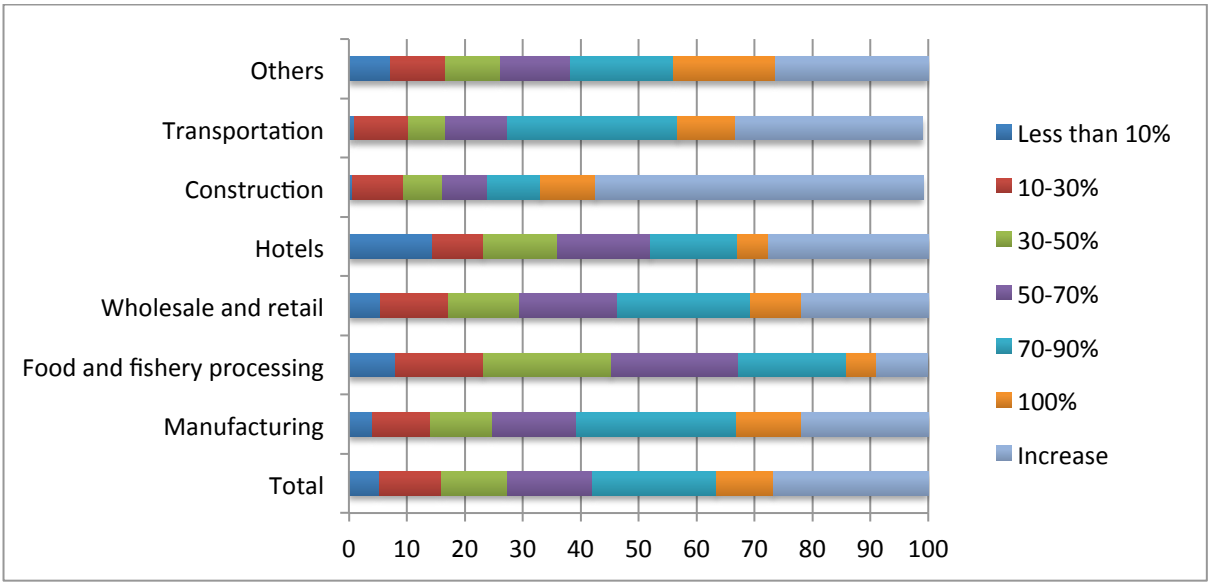
Source: Reconstruction Agency, 2014

There has been also a constant recovery of sales of all industries in most affected prefectures (Figure 19). However, the rate of post-disaster recovery has not bee similar in all sectors of affected industry. There is a fast and above pre-disaster recovery of construction industry. On the other hand, the recovery in wholesale, service, and food processing industries has been slower. For instance, comparing with the same period of 2010 for January-March 2014 the number of guests in hotel rooms in affected 6 prefectures was 14.3% lower, and in most affected 3 prefectures 10.6% lower while there was a growth of 1.4% nationwide [Reconstruction Agency, 2014].

Economy of the three main affected prefectures has been showing a positive employment trend, with the ratio of job offers to jobseekers consistently higher than the national average since early 2012 [Reconstruction Agency, 2014]. For instance, in Fukushima prefecture the later ration jumped from 0.42 in 2010 to 1.24 in 2013. This trend in affected regions is particularly true when it comes to jobs in public welfare, construction, transportation industries, the service sector, as well as certain specialist skills jobs.

Furthermore, there has been a boom in technological innovations and the new sectors such as energy saving, renewable (solar, wind, biofuel) energy, nuclear safety, debris cleaning, processing and disposal, research and development, robotics, ITC, no-soil and solar sharing farming etc. with huge investments of leading players, numerous new comers, joint ventures, etc. [Asiaone News, June 26, 2013; Fukushima Minpo News, November 7, 2014; JETRO, 2013; NHK World, June 12, 2012, June 30, July 8, July 25, 2014; The Japan Times, March 23, 2014].

Figure 19. Percent of sales recovery comparing to pre-disaster state in "Group subsidy recipients", July 2013



Source: Reconstruction Agency, 2014

For instance, academic and corporate experts developed a technology to eliminate 90%-95% of radioactive cesium from fly ash resulting from the burning of combustible garbage[111] in Fukushima prefecture as a demonstration plant for cesium elimination opened in Hirono town [Fukushima Minpo News, November 7, 2014].

Leading telecommunication and internet corporation SoftBank intends to invest in solar and wind power generation in Northeast Japan [NHK World, June 20, 2014]. Similarly, the Tokyo metropolitan government is going to invest 100 million yen in a project to build a mega solar power plant in the Matsukawa district of Fukushima city [Fukushima Minpo News July 1, 2014].

The government has decided to create a research center[112] in Fukushima prefecture operated jointly by members of industry, government and academia, to bring experts together from all over the world to develop improved technologies for decommissioning the crippled reactors at Fukushima nuclear plant [The Japan News, June 20, 2014]. The plan pledges to bring together 200 domestic and overseas experts with knowledge of reactor decommissioning at the joint research center from five countries[113]

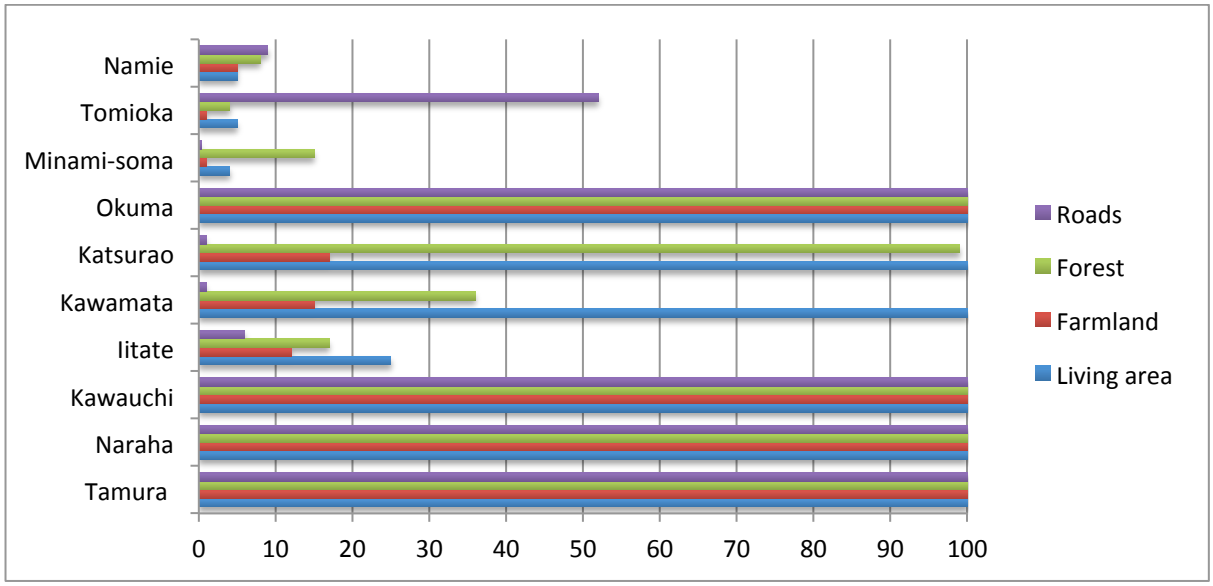
Nevertheless, there have been differences in the progress of recovery between Fukushima, Miyagi and Iwate prefectures. In Fukushima prefecture the overall progress has been lagging behind with regard to the recovery of economic activity, including production, consumption, and distribution [National Institute for Research Advancement, 2013]. In the three prefectures there has been also unlike speed in the infrastructure recovery by individual

[111] In an experiment, the plant reduced radioactive cesium content of fly ash from 5,100 to 309 Bq/kg.
[112] Operations of tentatively called "international joint research center for safe decommissioning" would start in fiscal 2016.
[113] including United States and Russia who were involved in efforts following the 1986 Chernobyl disaster and the 1979 Three Mile Island crisis.

cities, towns and villages. The later have been mostly associated with differences in the recovery of rail systems, treatment of debris, education and medical care.

For instance, in Fukushima prefecture merely 68% of debris and 44% of tsunami deposits outside the evacuation areas has been treated [Reconstruction Agency, 2014]. In the Special Decontamination Area[114] the progress of implementation of planned decontamination work also differ substantially (Figure 20).

Figure 20. Progress in implementation of decontamination work in Special Decontamination Area by September 30, 2014 (per cent)



Source: Ministry of Environment

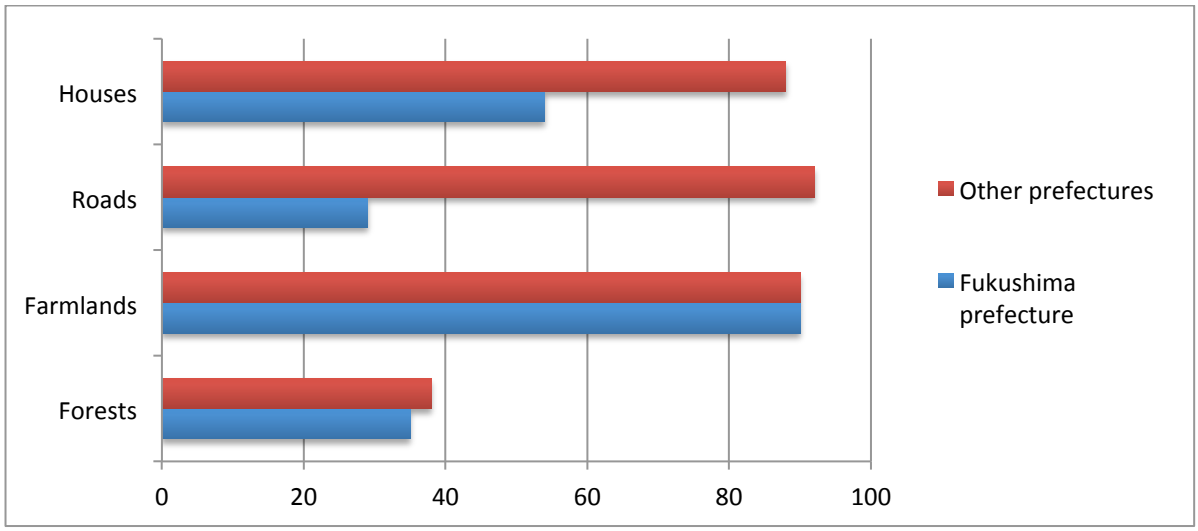
Similarly, there is a considerable difference in the progress of decontamination in Municipality Decontamination Areas[115] in Fukushima and other prefectures (Figure 21). Furthermore, while the decontamination of public facilities (administration facilities, schools, parks and sport facilities, etc.) has been entirely or largely completed[116] reaching the end of full decontamination will likely take few more years [Reconstruction Agency, 2014].

Besides, recent media reports indicate that some of the land along the coastal area flooded by the tsunami remains unused [NHK World, September 11, 2014]. Municipal governments hit by the disaster have purchased land in the inundated areas hoping the financial assistance will help former residents move to higher ground away from the sea. However, according to 25 municipalities in Iwate, Miyagi, and Fukushima prefectures they have so far purchased a total of 2,600 ha[117] but 37% remains untouched because municipalities have no idea how to utilize the land, pieces of land are scattered making it

[114] responsibility of the central government.
[115] responsibility of local governments in 94 municipalities, including 36 in Fukushima prefecture, 19 in Ibaraki prefecture, by 9 in Chiba and Gunma prefectures, by 8 in Miyagi and Tochigi prefectures, 3 in Iwate prefecture, and 2 in Saitama prefecture [Reconstruction Agency, 2014].
[116] E.g. for public facilities, shools, etc. 90% in Fukushima prefectures and 100% outside Fukushima prefectures [Reconstruction Agency, 2014].
[117] for about 2.1 billion dollars.

difficult to put them to use, and businesses hesitate to move into the areas that were once flooded by tsunami.

Figure 21. Progress of decontamination of Municipality Decontaminated Areas, as of March 2014 (percent)



Source: Reconstruction Agency, 2014

There have been also some new challenges associated with the reconstruction and decontamination. The government's employment measures seem have resolved unemployment problem but they have been turning job seekers away from the traditional local industries like fisheries, agriculture, etc. According to the Kesennuma Chamber of Commerce and Industry "local companies are beginning to be restored but the government's emergency employment measures have begun to choke off the local key industries" [The Japan News, March 01, 2014]. In Kesennuma construction workers are now paid about ¥10,000 a day, and those getting jobs via the government's emergency employment program (e.g. patrolling temporary housing units) receive about ¥8,000 a day, while the fishery processing firm pays only about ¥6,000.

What is more, there has been a huge proportion of the unused budget for the reconstruction – it was announced that 35.3% of the ¥7.51 trillion budget set aside in fiscal 2013 to rebuild disaster areas was left unused[118] [The Japan News, July 31, 2014]. The proportion of the unspent funding was almost unchanged from fiscal 2012 (35.2%), indicating that the country has made little progress in overcoming delays in implementing reconstruction projects.

According to the Reconstruction Agency funds were unutilized because it took time to obtain local consent for reviews of reconstruction plans and to acquire land as well as because bidding for many reconstruction projects ended in failure due in part to price hikes for construction materials [Reconstruction Agency, 2014]. The budget implementation rate stood

[118] Reconstruction budget for fiscal 2013 consisted of the special account budget for reconstruction programs and funds carried over from fiscal 2011-2012. Of the total, ¥4.86 trillion was executed. Of the unused funds, ¥1.96 trillion will be carried over to fiscal 2014 and ¥691.7 billion will be used to finance projects other than those originally planned.

at 62.8% for projects to assist disaster victims and at 77.5% for projects to revitalize industries. But the rate was low, at 47% for reconstruction projects related to the nuclear crisis at Fukushima nuclear power plant.

OECD ranked the March 2011 earthquake as the costliest disaster in Japan's post-war history with 3.5% of GDP in property damage not including the costs of nuclear accident (Organization for Economic Co-operation and Development, 2013). There has been a considerable contraction of the real GDP growth in 2011 and 2012 comparing to the pre-disaster projections of the national and international organizations (Table 12).

Table 12. Macroeconomic impact of Great East Japan Earthquake

Growth of Gross Domestic Product	FY2010	FY2011	FY2012
Bank of Japan - January 2011 (%)	3.3	1.6	2
OECD – December 2010 (%)	3.7	1.7	1.3
Real dynamics (%)	1.3	-0.4	-0.3
Change real – projected (percentage points)	- (2 - 2.4)	- (2 - 2.1)	- (1.6 – 2.4)

Source: Bank of Japan, OECD

Recent experts estimates also indicate that the overall macroeconomic impact of the disaster (on stock prices, housing prices, and so on) has not been so huge[119] when compared with the effects of previous crisis such as real estate bubble in 1990 and fall of Lehman Brothers in 2008 [Kawaguchi, 2014]. Most contemporary problems of the Japanese economy have been attributed to other factors (structural problems, inefficient policies, weak yen) rather than the 2011 disaster [The Japan News, April 23, 2014; OECD, 2013].

According to the initial prediction, the March 2011 earthquake is likely to be the costliest natural disaster[120] in the world history [Kim, 2011]. One year after the disaster the direct economic loss from the earthquake and tsunami was estimated to be between 237 and 303 billion USD, and from the nuclear power plant incident around $65 billion [Vervaeck and Daniell, 2012]. Indirect losses were assessed between 185 to 345 billion USD across the earthquake, tsunami and nuclear plant.

According to the initial estimates of property damages and income losses are contrasted with the amounts shouldered by the insurance industry, TEPCO, donors and the government, those directly affected will on average have to come up for about 23% of the overall losses (Table 13). That catastrophe might turn out as the most expensive but the burden for the insurance industry will likely be lower[121] since the low proportion of individuals with earthquake insurance in Japan[122].

Nevertheless, there is still uncertainty about the full costs related to the nuclear accident. The process of compensation of victims, decommissioning of the nuclear plant, and

[119] calculated losses in Net Present Income accounts for 3.5 trillion yen for 2011-2012 or about 1% of GDP [Waldenberger and Eilker, 2014].

[120] Later it was fund out that the nuclear disaster was a "man made" disaster which could have been prevented.

[121] E.g. in the case of the hurricane Katrina (2005).

[122] End of March 2010 only 23% of all private households were insured, including in Miyagi 33%, in Fukushima 14%, and Iwate 12% [Waldenberger and Eilker, 2014].

decontamination, rebuilding businesses and social life in affected areas will last many years and incur enormous costs.

Table 13. Estimated distribution of costs related to the Great East Japan Earthquake

Organizations and type of costs	Amount (billion yen)	Share of B	Share of C
Property and Life Insurances	2,295	9.3	10.2
TEPCO	151	0.6	0.7
Government	16,133	65.7	72
Donations	298	1.2	1.3
Total (A)	**18,877**	**76.8**	**84.2**
Damage through property losses	-16,900		
Costs for cleanup operations	-845		
Income losses 2011	-6,822		
Total losses (B)	-25,412		
Income losses for 2011 and 2012	-4,670		
Medium-term losses (C)	-23,260		
Short-term difference (B – A)	-6,535	23.2	
Medium-term difference (C – A)	-4,383		15.8

Source: Waldenberger and Eilker

For instance, the total number of applications and lawsuits for damages, and the type and requested amount of compensations from TEPCO are not publicly known[123]. According to the recent information TEPCO has paid about ¥3.53 trillion in compensation using government bonds while the total amount of compensation is estimated to be about ¥4.91 trillion [The Japan News, March 12, 2014]. According to the company available funds are not sufficient for compensation of the amount of payouts required [Tokyo Electric Power Company, February 24, 2014]. Nevertheless, the government will eventually pay all TEPCO's debt since it was placed under effective state control since June 2012 [The Japan News, March 27, 2014].

What is more, the estimated amount of compensation has been growing up each time the governmental panel has issued new guidelines. Besides, there have been reported thousands applicants and claimants seeking compensation or resolution of disputes on compensation from TEPCO or authorities through court or other ways [The Japan News, March 12, 2014; The Japan Times, March 13; 2014; NHK World, March, 17, May 8, May 26, May 27, 2014].

For example, in 2014 the Center for Settlement of Fukushima Nuclear Damage Claims[124] made proposals to settle claims filed by groups of residents of Namie Town and Iitate Village [NHK World, October 22, 2014]. However, TEPCO has rejected it saying blanket compensation without consideration for individual circumstances would not ensure equality.

[123] Despite our request to TEPCO we have not been provide with information about the number, type and amount of applications for compensations.

[124] Until end of August 2014 more than 8,000 cases were settled by the Center [NHK World, September 2, 2014].

Increased number of false claims and swindling compensation funds for millions of yens has been also reported[125] [NHK World, June 2, 2014; The Japan News, August 3, 2014].

In addition, there are lawsuits against the central and local governments related to earthquake and tsunami damages. For instance, families of 23 schoolchildren from Okawa Elementary School, Ishinomaki city suits prefectural and local governments for the deaths of their children's claiming that the arrival of tsunami was foreseeable because of issued warning but school did not evacuate children to higher ground [The Japan News, May 19, 2014]. Similarly, a man claims his wife died because the Meteorological Agency initially predicted the ensuing tsunami would be much lower than it actually was (3 minutes after the earthquake) and updated warning did not reach his wife due to the poor condition of the city's address system [NHK World, March 13, 2014].

Recently a district court in Sendai has ruled that the death of a woman five months after the earthquake was related to the disaster[126] [NHK World, December 9, 2014]. The family considered the death to be disaster-related and applied for compensation but the municipal government rejected it. For the first time the court ruled against a local government's decision of this kind stating that the extremely poor living conditions caused by the disaster were a burden to the woman's mind and body and led to her death.

Similarly, a group of residents from a Iitate village is seeking state arbitration for a rise in compensation so all villagers can be entitled to equal damages[127] regardless of radiation levels of areas [NHK World July 22, November 14, 2014]. According to the residents from the two zones with lower contamination the difference is dividing them. They ask the Center for Settlement of Fukushima Nuclear Damage Claims to urge TEPCO to pay equal damages. The residents also seek the payment of consolation money (about 30-thousand dollars per person) since they were exposed to more radiation because the evacuation order was not issued until more than one month after the meltdown. Evacuees also call for around 172,000 dollars per person in compensation for ruining their village lives. About a half of all Iitate residents (2,837) joint the group.

Finally, there are unknown amount of private costs related to dispute and compensation associated with the triple disaster. For instance, about 30 residents of Urayasu City (northeast of Tokyo) whose homes were damaged by massive liquefaction in the March 2011 earthquake[128] filed a lawsuit against the real estate company (Mitsui Fudosan) due to failure

[125] Tokyo police arrested 2 men who under name of a dummy company defrauded TEPCO of 40,000 dollars making a false claim that staffing agency suffered a sales drop because it received fewer job orders from hotels in Fukushima prefecture. Police believe other people were involved as well who submitted fake applications to steal more than 200,000 dollars in total [NHK World, June 2, 2014]. Police have also arrested four people on suspicion of defrauding TEPCO of ¥12 million in nuclear compensation [The Japan News, August 3, 2014]. They included an official of a Tokyo NGO that does paperwork on behalf of clients for claiming damages from harmful rumors - not operating event company in Koriyama faced cancellations from customers due to concerns over radiation exposure.

[126] a 85-year-old remained in heavily damaged house for about a month and died from pneumonia.

[127] Entire village is designated for evacuation, but it is categorized into three different zones, each with a different radiation level and differing amounts of compensation. The evacuees want the current monthly compensation per capita more than tripled to 350,000 yen (3,000 dollars) per month.

[128] Liquefaction caused by the quake damaged about 27,000 houses [NHK World, October 8, 2014].

to reinforce ground when it developed the area more than 30 years ago[129] [NHK World, October 8, 2014].

Central government offered Fukushima prefecture, and the two candidate towns for interim storage facilities of highly radioactive waste (Okuma and Futaba) a total of ¥374 billion (2.2 billion dollars) over 30 years as financial assistance for regional development and restoration of local residents' lives [The Japan News, July 31, 2014; NHK World, July 30, 2014]. First year's payment includes ¥90 billion for the local governments for rebuilding lives of local residents and for regional development (measures to repair damage to public image) while remaining ¥50 billion is for reconstruction of infrastructure in Okuma and Futaba (water supplies, sewerage systems and roads)[130]. In addition, the government will continue to pay for 30 years allowances to areas hosting power plants planning to add ¥1.1 billion to the current ¥6.7 billion a year as subsidy[131] which is normally paid to municipalities hosting nuclear plants and typically used to develop local communities and improve residents' health[132].

(Some) Experts underline the uncertainty related to the total costs of the nuclear disaster since their level has been expanding constantly [Okuyama, 2014]. Early in 2014 the government estimated it would take JPY11.16 trillion and 40 years to clean up the Fukushima site [World Nuclear Association, 2014]. It is largely made up of more than 2.5 trillion yen for decontamination, 1.1 trillion yen for interim storage facilities, 2 trillion yen for reactor decommissioning and contaminated water treatment, and over 5 trillion yen for compensation from TEPCO[133].

Up to date huge challenges in decommissioning the nuclear rectors have been associated with changes in timetables and costs tags. The current timetable calls for the process of removing spent fuel assemblies from the storage pool to begin in fiscal 2017, and removing melted fuel to begin 3 years later. However, the Government and TEPCO officials recently announced that they are planning to delay the start of removing spent fuel units until fiscal 2019 (by 2 years) and the start of removing melted fuel till 2025 (by 5 years) [NHK World, October 30, 2014].

The latest experts estimate to clean up areas designated as uninhabitable[134] is for 6.6 billion US dollars including fees for transportation and storing contaminated soil [NHK World, June 10, 2014]. The 2013 estimated cost of decontaminating other areas were 19.2 billion dollars including spending for setting up the initial storage sites and follow-up

[129] The plaintiffs demanded that the company pay compensation totaling about 7.8 million dollars but the court has turned down residents' claim. Similar lawsuits have been filed elsewhere.

[130] Government plans to pay out the initial ¥140 billion as a lump sum when facilities are constructed so that the local governments can use money flexibly by setting up funds or through other measures.

[131] total ¥7.8 billion a year or ¥234 billion over 30 years.

[132] Local authorities are not satisfied with the amount of money offered and asked government to increase the sum. The government also indicated that it would stop paying subsidies for the offline Fukushima Daichi nuclear plant, located 10 km south of the damaged Fukushima Daiichi, which local people are calling to be decommissioned.

[133] In December 2011 damage costs were forecasted to be "merely" 5.8 trillion yen for things such as compensation for residents, decontamination, and nuclear reactor cooling.

[134] Government has not decided yet whether to conduct cleanup operations in such areas.

checking of radiation levels. The government calculated that building intermediate storage facilities to keep contaminated soil for up to 30 years would cost about 10.4 billion dollars including the funds needed to buy land for such facilities. Finally, the decommissioning of nuclear reactors has just begun and it would take 30-40 years costing 20 billion dollars [NHK World, August 2, 2014].

Experts find the latest Cost Verification Committee's estimate "over-optimistic" and predict that nuclear disaster costs are bound to increase further[135] [Okuyama, 2014]. It is assessed that more and more public funding has been injected but the support for victims is being stopped or reduced. If compensation is conducted in good faith, damage costs could become as high as the annual tax revenue of the nation, or 43 trillion yen [Okuyama, 2014].

Furthermore, some of the economic costs and impacts from the March 2011 disaster could hardly be measured in quantitative (e.g. monetary) terms such as: lost lives and piece of mind, destroyed livelihood and accumulated with many generations capital (community relations, permanent crops, livestock herds, established brands, networks), degradated natural resources (lands, waters, biodiversity, landscape, eco-systems), labor health implications (reduced productivity, increased healthcare costs) etc. [Bachev and Ito, 2013]. Particularly, in the first five months of 2014 police have recorded 90 cases of burglary in 8 municipalities surrounding the crippled nuclear plant, which totaled about 1,200 since 2011 [NHK World, June 12, 2014].

Excessive use of aging nuclear power plants is problematic both in terms of safety and cost [The Japan News, October 20, 2014]. In the wake of the March 2011 crisis, a new rule has been adopted that puts a reactor's operating life at no longer than 40 years in principle[136]. Major utilities have set aside cash reserves to fund decommissioning costs but if a plant closes ahead of schedule and the reserve fund fails to cover decommissioning costs, a utility could face a huge financial burden. What is more, if reactors are decommissioned, host municipalities will be unable to receive subsidies from the central government and there will be negative impacts on local economy.

Finally, the 2011 disasters has led to increased public concerns about disaster preparedness and management efficiency, and fundamental revisions of country's disaster management, nuclear safety and energy policies. The later has been result of the 2011 experience and the post disaster reconstruction and development as well as some recent natural disasters like huge mudslides in Hiroshima (August 2014), unexpected volcanic eruption at Mount Ontake (September, 2014), strong Typhoon Vongfong (October 2014), and a 6.7 eartquake in Nagano prefecture (November 2014).

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[135] E.g. unpecedented construction of ice walls as a temporary method of halting groundwater flow into reactor buildings is under way which will cost ¥31.9 billion [The Japan News, June 6, 2014]. Power consumption of 45.5 million kilowatt-hours of electricity equivalent to that of 13,000 ordinary households, running more than ¥1 billion annually will be needed to keep the underground walls frozen. Implementation of this progect is associated with many dificulties and its efficiency uncertain.

[136] Depending on approval by the Nuclear Regulation Authority, the operation of a nuclear facility could get a one-time maximum extension of 20 years. Of the nation's 48 reactors, seven are about 40 years old.

Recent surveys indicated that 35% of industry sites see liquefaction risk [The Japan News, June 24, 2014], 76% of the public is concerned about aging infrastructure [The Japan News, July 2, 2014], over 70% of schools see risk of tsunami [The Japan News, April 7, 2014], around half of the municipalities within 30 km from nuclear power plants have yet to draw up plans for evacuation in the event of a nuclear accident [NHK World April 19, 2014], some prefectures failed to supply the iodine tablets required for people living within 30 km of nuclear power plants [NHK World, May 9, 2014], less than a half of companies in Tokyo store food and provisions for emergencies in spite of a legal requirement for businesses to prepare for possible large-scale disasters[137] [The Japan News, May 26, 2014], nearly 30% (more than 17,000 districts) in mountainous regions as well more than 30% (about 6,300) of fishing villages in the country could become inaccessible in the event of a major earthquake or other natural disasters [NHK World, October 22, 2014], volcano experts are calling for a review of the Nuclear Regulation Authority's safety requirements and taking into consideration the limitations of volcanic eruption prediction [NHK World, November 3, 2014], etc.

A panel of nuclear experts[138] monitoring reforms at the TEPCO maintains that the utility's nuclear safety culture "has not yet reached desired level in terms of preparing for the unexpected" [NHK World, May, 1, 2014]. TEPCO management problems led to troubles with systems used to purify contaminated water, repeated water leaks, and preparations for cleanup work. The experts recommend that the utility make sure workers are fully aware that they are dealing with a special plant, which caused an accident, and to learn from measures taken at overseas nuclear facilities.

All these have been associated with new public and private measures to modernize infrastructure, enhance safety and disaster preparation, shift to renewable and energy saving technologies, etc.

For instance, the Government set concrete numerical targets to promote the nation's countermeasures to prepare for disasters and reduce damage on a long-term basis [The Japan News, May 16, 2014]. The two plans are compiled based on the basic law (December 2013) to make Japan more resilient against disasters[139] and include measures such as: enhancing information and telecommunications networks, building road networks to enable drivers to take detours in the wake of major disasters and boosting the oil supply system, raise the completion rate of sea embankments from the current 31% (2012) to 66% by fiscal 2016, etc.

Similarly, government obliges local governments to compile evacuation rules that limit the time for operating floodgates and tide gates in coastal areas[140] in the event of tsunami [The Japan News, November 2, 2014]. In addition, multiple nuclear disaster drill has been held in vulnerable regions of the country (including Kawauchi, Fukushima prefecture) under the new

[137] E.g. metropolitan ordinance (April 2013) obliges all companies to store drinking water and food for 3 days for employees as a measure to help those who unable to go home after disater.

[138] independent advisory panel set up after the 2011 accident and chaired by the former US Nuclear Regulatory Commission Chairman Dale Klein.

[139] a basic plan on making Japan disaster ready and disaster resistant, and a 2014 action plan concerning numerical targets of respective measures.

[140] There are about 27,000 floodgates and tide gates nationwide and 75% of them need to be manually closed if quake tremors are detected. In March 2011 eartquake 198 firefighters died or went missing and 30% were working to close such gates.

disaster preparedness guidelines[141], which highlighted existing problems [NHK World, November 3, 2014; The Japan News, November 22, 2014].

The new policy is that in the process of disaster preparation and responses the needs and desires of local people are to be addressed – e.g. in the process of reconstruction, land relocation planning, seawalls building, etc.

For instance, 2011 disaster seriously damaged or destroyed 60% of seawalls with length of about 300 km in Miyagi, Iwate and Fukushima prefectures. The central and prefectural governments are currently pushing a project to build 390 km of new seawalls with ¥800 billion from state coffers [The Japan News, June 23, 2014]. However, many communities are opposed[142] to the project as local residents consider the proposed walls "too high" leaving less land available along the coasts, adversely affecting fisheries, and block ocean views, and affect negatively fishery and tourism industries on which local residents depend. What is more, cost-effectiveness of the seawalls is to be more carefully estimated[143]. Some communities have already lowered the planned height of seawalls, while taking such measures as transferring houses to higher ground and building seawalls in locations further inland.

Some experts suggest that it is important to recover, preserve and expend coastal ecosystems such as coastal forests and igune not only as important ecological and cultural assets but as an effective measure for reducing damage from natural disasters[144] [Ogata and Pushpalala, 2013].

The Cabinet Office has set up a new section dedicated to helping local municipalities prepare for accidents at nuclear power plants consisting of 50 workers from the Secretariat of the Nuclear Regulation Authority and other relevant government ministries and agencies [NHK World, October 14, 2014].

In November 2014 the Diet approved a bill to join an international treaty on sharing the costs of compensation in a nuclear disaster[145] [NHK World, October 24, November 19, 2014]. The government expects the treaty to encourage foreign companies to join the cleanup and decommissioning of reactors at the Fukushima nuclear power plant.

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[141] revised after Fukushima accident. Such drills have been organized every year since the 1999 accident at a nuclear-processing plant in Ibaraki Prefecture.

[142] E.g. in Miyagi prefecture approval for the project is to be received from 40 of 276 communities where the construction of new seawalls is planned. Under its plan, Miyagi Prefecture will raise the height of seawalls from the pre-disaster average of 4 meters to 7.5 meters. However, that height will be insufficient to block gigantic tsunami such as in March 2011, which occurred once in a millennium.

[143] The higher the seawall the more effective it is as a safeguard against tsunami. Higher seawalls are more expensive to construct, ruin scenic views, take a toll on the environment, and entail higher maintenance costs. The life of concrete seawalls is roughly 50 years, which makes rebuilding inevitable at some point in the future.

[144] In 2011 disasters they prove particularly effective in reducing impact of tsunami, preserving houses from damages and debris.

[145] Convention on Supplementary Compensation for Nuclear Damage obliging signatories to set aside 47 billion yen (about 400 million dollars) for compensation in the event of a nuclear accident. If the total damage surpasses this amount, other countries will provide funds to supplement it. The pact stipulates that a lawsuit for compensation can only be filed in a country where a nuclear accident occurred, and liability for damages is concentrated against a nuclear power plant operator.

There has been a response in private sector as well. For instance in October 2014 the Nuclear Risk Research Center was established as a part of the Central Research Institute of Electric Power Industry (run jointly by Japanese power companies) [NHK World, October 1, 2014]. The center's aim is to pinpoint associated risks, including those at plants that have met government requirements to restart, and help power companies fix the problems. According to the Center chief[146] "Japan has been slow to introduce risk analysis because most people think everything that meets government requirements is safe, and such attitudes must change to ensure safety".

The insurance industry is set to raise earthquake insurance premiums by an average 15.5% which is the first hike in 18 years [The Japan News, June 29, 2014]. Meanwhile, the proportion of newly concluded fire insurance contracts in fiscal 2013 (including earthquake damage coverage[147]) rose 1.6 percentage points from the previous year to a record high of 58.1%[148] [The Japan News, August 26, 2014]. Miyagi prefecture saw the highest proportion (85.2%), as the pace of growth was the steepest in Hyogo (3.2 points), and third in Iwate, Tochigi, Kyoto, Tottori, Kagawa and Ehime prefectures (2.6 points).

The Fukushima accident has triggered many anti-nuclear protests in Japan during 2011 [BBC News, 2011; Slodkowski, 2011] and afterwards. The previous Government of Yoshihiko Noda ordered all nuclear reactors to be stopped for safety checks, considered to freeze plans to build new reactors, questioned whether private companies should be running nuclear plants, and focus on reducing dependence from nuclear and promotion of renewable energy[149].

After the 2011 accident all nuclear reactors were shut down for maintenance or refueling, and for the stress tests demanded by the government. Only two were restarted (in the Ohi facility) but shut down on September 14, 2013 leaving all 48 commercial nuclear reactors off-line. Since then the Nuclear Regulatory Authority has received safety-screening applications for 19 reactors at 12 nuclear plants [NHK World, June 10, 2014].

Nuclear power accounted for 30% of the nation's electricity generation before the nuclear crisis while now nearly 90% of the power generated by nuclear plants is being compensated for by thermal power [The Japan News, April 12, 2014]. The shortage of energy, the high energy[150] and fuel import[151] costs, and security risk from relying on imported

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[146] George Apostolakis, specialized in analyzing risks at nuclear plants, served on the US Nuclear Regulatory Commission until June 2014.

[147] Earthquake insurance, offered as an option to fire insurance, covers damage to housing and household goods from temblors, tsunami and volcanic eruptions.

[148] As of the end of March, the number of earthquake insurance contracts in force stood at 15,838,144, up 5.2% from a year before. That is all-time high for the 11th straight year.

[149] Energy White Paper (October 2011) calls for a reduction in the nation's reliance on nuclear power omitting a section on nuclear power expansion in the previous year's policy review.

[150] Electricity rates TEPCO charges households have risen by 40% from before the crisis, while Kansai Electricity Power Co. have increased by nearly 30% [The Japan News, April 12, 2014]. Electricity bills for households have jumped about 20% and for businesses about 30% [The Japan News, May 30, 2014]. According to experts as things stand now, the additional rate hikes are inevitable.

[151] In 2013, imports of fossil fuels including liquefied natural gas as a percentage of GDP stood at 5.7% - higher than in 2008 (5.5%) when the prices of resources soared, and in 1974 (5.4%) during the first oil crisis [The Japan News, June 18, 2014].

energy have been pressing current government to speed up safety inspections and resuming operations of nuclear plants [The Japan News, July 18, November 7, 2014; NHK World, May 13, 2014]. In addition, the Government has been calling for power conservation without setting numerical power-saving targets anymore[152] [The Japan News, May 16, November 3, 2014; NHK World, July 1, 2014].

Power suppliers have been worried about the possibility of electricity shortages and being hit by glitches[153] [The Japan News, May 18, June 30, 2014], while most companies have been expending energy conservation technologies and products [The Japan News, May 18, 2014]. Nevertheless, eight of the 10 regional power utilities, including TEPCO, continue to secure recurring profits[154] due to postponement of equipment renovation and higher efficiency in thermal power operations [The Japan News, November 1, 2014].

The schedule for safety inspections is uncertain and no nuclear reactors restarted by the end of 2014 due to lack of readiness[155], uncompleted formal procedures[156] or strong opposition by local governments and communities, including a court ban[157]. Recent court order against resuming operations at the Ohi nuclear plant could affect other similar lawsuits across the country[158] [NHK World, May 21, 2014].

There have been numerous protests and a lawsuit against reopening Sendai nuclear station in Kagoshima prefecture scheduled to be the first resuming operations [NHK World, May 30, June 1, June 13, 2014]. Recently the hosting city assembly and prefectural government approved the Sendai plant restart, and operations will likely resume early next year after all safety inspections are complete [NHK World, October 20, November 7, 2014].

According to the March 2014 survey, 59% of the respondents opposed to the restart of nuclear plants, outnumbering the 28% supporting the move [The Asahi Shinbun, March 18, 2014]. In all previous surveys (July and September, 2013, January, 2014) the majority of respondents (56%) opposed the restart of reactors.

Furthermore, regarding a nuclear phase-out plan, 77% supported it while only 14% opposed it. Asked about how anxious they feel about the possibility of a serious accident at a

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[152] since summer 2014. Government worries that it will restrict corporate activities and hinder economic recovery.

[153] In fiscal 2013, a total of 169 cases of thermal power plant shutdowns, mainly due to glitches, were reported by 9 of 10 regional power suppliers – that is up 70% from 2010 level.

[154] in April-Setember 2014 TEPCO reported profit of ¥242.8 billion, a second straight profit and even topping the ¥201.3-billion profit before the nuclear accident. Only Hokkaido Electric Power Co. and Kyushu Electric Power Co. suffered recurring losses since they relied heavily on nuclear energy.

[155] Nuclear Regulation Authority criticized the plant operators being not serious enough about improving safety and attitude simply aiming to satisfy screening criteria [NHK World, June 25, 2014].

[156] E.g. formal approval by the local authorities.

[157] Most lawsuits since late 1960s by residents seeking to halt nuclear facilities have been dismissed [NHK World, May 21, 2014]. On May 20, 2014 the Fukui District Court ordered Kansai Electric Power Co. not to restart 3 and 4 reactors at Oi nuclear power plant in Fukui prefecture becouse safety of the idled reactors is not ensured. It was the first court order in Japan to ban nuclear plant operations since 2011 nuclear accident. The lawsuit was filed by 189 local residents in November 2012 claiming that plant operator underestimate of possible earthquakes and reactors lack sufficient cooling systems.

[158] there are now about 30 lawsuits pending against 16 nuclear plants and other nuclear facilities in Japan, including those under construction or in the planning stage.

nuclear power plant other than the Fukushima plant, 36% said they were "greatly" anxious, and 50% were anxious "to some degree".

August 2014 survey also indicated that more than 60% of local governments that host or surround a nuclear power plant[159] are cautious about restarting idled reactors even if they meet new safety guidelines [NHK World, September 8, 2014]. About 67% report they were undecided whether to approve the restart of reactors, about 12% said they will approve or hope to approve in the future, while 8% indicated they will not approve or will never approve[160]. The major reason for opposition or cautious for 30% is because inspections by the nuclear regulating body have not yet finished, for 25% that the central government has not yet dealt with the issue, and for 23% because residents are worried.

The basic energy plan[161] of the new Abe administration defined nuclear energy as "an important base load electricity source" and clearly stated that nuclear power plants will resume operations after safety is confirmed [The Japan News, April 12, 2014]. The nuclear reactors will be restarted since the new safety guidelines (introduced in July 2013) are the strictest in the world and the safety inspections will confirm compliance.

Energy industry reaction has been to maintain nuclear – e.g. in 2014 shareholders meetings of TEPCO, Kansai Electric Power Company and Kyushu Electric Power Company the anti-nuclear proposals of not restarting and scrapping nuclear reactors have been rejected [HNK World, June 26, 2014; The Japan News, June 26, 2014].

Nevertheless, there is strong opposition to restart nuclear power plants by various groups, including some prominent politicians (like Ex-PMs Junichiro Koizumi and Morihiro Hosokawa)[162] suggesting that nuclear power is not safe, it is the most expensive, disposal cites for nuclear waste are not secured, the evacuation routes not secured, and anti-terrorism measures insufficient [NHK World, July 7, September 24, November 2, 2014]. The lack of a single power outage since the nuclear reactors have been offline is evidence that people can live without nuclear energy and calls for more renewables.

Anti-nuclear power groups also criticize the Nuclear Regulation Authority for the conflict of interests of the appointed new Commissioner (Satoru Tanaka) with close ties with the industry compromising the watchdog's neutrality [NHK World, July 8, July 16, 2014].

Experts suggest that further delays in restarting reactors at the nation's nuclear power plants will slow the recovery of the domestic economy, while the resumption of reactor operations could halve Japan's trade deficit [The Japan News, July 26, 2014]. According to estimate, if all 19 reactors[163] resume operations in fiscal 2015 the total nuclear power generation would be less than a half of the output of fiscal 2010. That will reduce the nation's

[159] Included 146 prefectures and municipalities within a 30-kilometer radius of a nuclear power plant.

[160] There is no legal framework for the government to obtain approval from local municipalities to restart reactors.

[161] which serves as a guideline for the government's energy policy.

[162] who launched an organization dedicated to ending Japan's reliance on nuclear power [NHK World, May 7, 2014].

[163] Nuclear Regulation Authority is currently inspecting the safety of 19 reactors at 12 nuclear plants. If all 19 reactors resume operations, nuclear power generation capacity would be 124.3 billion kilowatt-hours.

trade deficit[164] to ¥7.2 trillion, providing certain conditions (such as overseas economic growth) are met.

If 19 reactors resume operations, imports of fossil fuels are estimated to total ¥25.8 trillion in fiscal 2015. This is ¥900 billion lower than the ¥26.7 trillion in fossil fuel imports estimated under the scenario of having just 9 reactors in operation, and ¥1.5 trillion lower than when no reactors operate in the nation. In the latter case, imports were predicted to reach ¥27.3 trillion. Under such circumstances, the cost of power generation is likely to rise to ¥11.2 per kilowatt-hour from ¥8.2 in fiscal 2010, putting additional upward pressure on electricity prices[165]. Moreover, if the price of crude oil rises by $10 per barrel, imports of fossil fuels will increase ¥1.9 trillion, which is likely to lower the nation's gross domestic product by 0.2%. Therefore, the progress of safety inspections at the nuclear reactors will have a significant impact on the Japanese economy[166].

Due to the suspension of nuclear reactors the thermal power generation accounted for 88% of Japan's electricity supply in fiscal 2013, increased by 26 percentage points from 2010 [The Japan News, June 18, 2014]. The nation's greenhouse gas emissions in fiscal 2012 soared about 8% from those in 2010 as utilities discharged about 30% more gases contributing to global warming [The Japan News, May 30, 2014].

The government intends to diversify energy sources aiming to raise the share of renewable (solar, wind, hydro and geothermal) energy in the electricity supply to more than 13.5% of the nation's electricity in 2020, and more than 20% by end of 2030, from about 10% in 2012 [The Japan News, April 4, 2014]. It also started reexamining the renewable energy purchase system making it mandatory for electric power companies to purchase electricity generated by renewable energy sources (solar and wind power) at fixed prices[167] for up to 20 years [The Japan News, July 8, 2014]. Large numbers of applications have been filed for solar power generation, which entails relatively high purchase prices. Since the utilities pass the costs to the consumers the amount in a typical family's utility bill soared from ¥87 to ¥225 a month in 2014[168].

It is estimated that higher power costs have been also hampering pay rise of manufacture industry workers in average lost salary per year ¥52,000 [The Japan News, September 4, 2014]. In order to make up for a maximum 40% increase in electricity costs in comparison to pre-disaster levels, workers could see their annual pay cut by as much as ¥100,000 while if manufacturers deal with the situation by reducing employment as many as 180,000 jobs could be lost.

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[164] which hit a record high of ¥13.8 trillion in fiscal 2013. In January-June 2014 Japan's trade deficit hit ¥7.6 trillion, the worst since such records began in fiscal 1979. The surge is mainly accounted for by growing imports of such fossil fuels as oil and liquefied natural gas.

[165] If no reactors resume operation, the power generation cost will surge to ¥13 – 60% higher than the price in fiscal 2010 - making it difficult to avoid further electricity rate hikes.

[166] NRA has given priority to safety inspections on reactors at Kyushu Electric Power Co.'s Sendai nuclear power plant, and they are expected to resume operations early 2015. Dates for restarting the remaining reactors are unknown and restarting all 19 reactors in fiscal 2015 is considered difficult.

[167] purchase prices have been set at levels more than double those in Europe.

[168] households and businesses will have to pay ¥38 trillion in the next two decades because of surcharges on utility bills [The Japan News, July 8, 2014].

Another problem is that operations have started at only 10% of the approved mega solar power plants[169]. Seven of the nation's 10 major utilities (including Hokkaido Electric Power Co., Tohoku Electric Power Co. and Kyushu Electric Power Co.) are freezing new applications by producers keen to access their grids with electricity generated through solar, wind and other renewable sources since they exceeded the capacity their grids can accept[170] [The Japan News, October 9, 2014]. A major weak point of solar and many other renewable energy sources is that output can fluctuate sharply depending on weather conditions and the time of day. Failure to maintain a steady balance with demand presents the risk of disrupting the frequency and voltage of electricity supplies, which could in turn cause power outages and damage equipment and facilities[171].

Calculations of independent experts also shows that the electricity from nuclear power is the second cheapest energy to produce at ¥8 per kilowatt-hour[172] even after such expenses as costs related to accident compensation were factored the production cost rose to ¥8.4 [The Japan News, October 26, 2014]. Production cost of electricity from renewable energy sources is comparatively high – e.g. large mega solar power facilities generate electricity at ¥30.6 per kilowatt-hour, electricity from wind power cost ¥21.2 per kilowatt-hour, etc. Beside, some renewable energy producers have been gleaning excessive profits while users have borne the financial burden.

The government has limited the role of the Atomic Energy Commission an advisory panel that has served to promote nuclear energy for over half a century[173] [NHK World, April 18, 2014]. The commission no longer will draw up the policy and focus to solving problems related to nuclear power, such as how to deal with radioactive waste and what do to with damaged Fukushima power plant. The number of commissioners has been also reduced (from 5 to 3) and a new code of conduct introduced to ensure neutrality and transparency.

A bill has been enacted for the Nuclear Damage Liability Facilitation Fund's reorganization to allow the state-backed body to provide financial assistance for

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[169] This may be an attempt to increase profits by building facilities at a time when solar panel prices decrease after obtaining approval for undertaking projects when purchase prices are high. Official survey on 4,700 large solar power projects that have yet to begin generating electricity resulted in canceling certification on 144 after considered as inappropriate (The Japan News, July 8, 2014).

[170] If renewable energy providers approved by the government were all operating, they would have a supply capacity of 70 million kilowatts, which is 90% of the government's target (20%). Furthermore, latest survey indicates that combined acceptance capacity of utilities is up to 47% of the total authorized amount of 30 million kilowatts - e.g. Kyushu Electric and Tohoku Electric will only be able to accommodate accordingly about 8 million kilowatts and about 5-6 million kilowatts compared to 18 and 12 million kilowatts to be generated by authorized renewable energy suppliers in their service areas [The Japan News, December 7, 2014].

[171] Greater the use of renewable energy, more adjustments must be made to the supply of electricity generated through such sources as thermal power generation. Greater amount of electricity from renewable could be accepted through installing huge storage batteries and building more transmission lines to share surplus. Implementing later steps on a large scale will come with a price (trillions of yen) but there are not even rules in place for covering such expenses.

[172] After coal (¥7.8). All expenses including the building and maintenance of plants were factored into the costs of energy, including the processing of spent fuel rods in the case of nuclear power.

[173] Commission's role came under review following disclosures 2 years ago that it held secret meetings only with pro-nuclear parties (power utilities and bureaucrats) during compiling the policy.

decommissioning the reactors at Fukushima nuclear plant [The Japan News, May 14, 2014]. The government will take the lead in work to decommission the reactors and contain the radioactive water at the nuclear plant. The body will provide TEPCO with technical instructions on how to proceed with the decommissioning work, monitor whether the utility maintains adequate budget and manpower for decommission, and promote development of related technologies. The government is also planning to review the law on compensation for accidents at nuclear power plants according to which the power companies in principle bear unlimited responsibility for damage payments in the event of an accident [NHK World, June 3, 2014].

The Government has been taking action to increase transparency following the failure to do so in the first days after the nuclear accident. It announced that will publicize interviews with TEPCO and government officials about the accident[174] if they give consent [HNK World, June 5, 2014]. TEPCO shareholders are also asking the government to release interviews since they are important for examining responsibility for the accident, and plan to take legal action if it is turned down [HNK World, June 5, 2014].

[174] A government appointed accident investigation committee interviewed 772 people after the 2011 accident for a report. Until now they have not been disclosed on grounds that they were conducted with understanding that the government would not do so.

5. Impacts on agri-food chains

There have been a huge number of destructed agricultural communities, farms, and agricultural lands and properties from the March 2011 disasters (Picture 5).

Picture 5. Minamisanriki (Shizugawa Ward) before and after 2011 tsunami

Source: Tohoku Chiikizukuri

The total number of damaged Agricultural Management Entities of different type (private farms, corporate entities, cooperatives, local public bodies, etc.) reached 37,700 or around 16% of all Agricultural Management Entities in the affected eight prefectures (Table 14). Reported area of agricultural land damaged by the 2011 disasters in the six coastal and six inland prefectures is around 24,500 ha (Table 15).

Table 14. Number of damaged Agricultural Management Entities by 2011 earthquake (March 11, 2012)

Prefectures	Total number of Agricultural management entities	Damaged agricultural entities		Entities damaged by tsunami	
		Number	Share, %	Number	Share, %
Aomori	3,733	180	4.8	170	4.6
Iwate	35,321	7,700	21.8	480	1.4
Miyagi	47,574	7,290	15.3	6,060	12.7
Fukushima	50,945	17,200	33.8	2,850	5.6
Ibaraki	56,537	1,430	2.5	180	0.3
Tochigi	25,010	1,330	5.3	-	-
Chiba	17,224	1,220	7.1	430	2.5
Nigata	5,311	1,190	22.4	-	-
Nagano	312	210	67.3	-	-
Total	241,967	37,700	15.6	10,200	4.2

Source: Ministry of Agriculture, Forestry and Fisheries

Table 15. Area of damaged agricultural land by the 2011 earthquake (March 11, 2012)

Prefectures	Damaged agricultural land		Tsunami damaged agricultural land		Share of completely restored agricultural land (%)	Share of restored tsunami damaged land (%)
	Area (ha)	% in total cultivated land	Area (ha)	% in damaged land		
Aomori	107	0.1	77	72	94.4	92.2
Iwate	1,209	0.8	725	60	22.2	3.9
Miyagi	14,558	10.7	14,341	98.5	33.3	32.5
Fukushima	5,927	3.9	5,462	92.1	9.3	4.1
Ibaraki	1,063	0.6	208	19.6	90.1	97.1
Chiba	1,162	0.9	663	57.1	100.0	100
Total coastal	24,026	2.7	21,476	89.4	32.9	27.3
Yamagata	1	0.0	-	0	100.0	-
Tochigi	198	0.1	-	0	98.0	-
Gunma	1	0.0	-	0	100.0	-
Saitama	39	0.0	-	0	100.0	-
Niigata	117	0.1	-	0	73.5	-
Nagano	95	0.1	-	0	69.5	-
Total inland	451	0.1	-	0	85.8	-
Total	24,477	1.6	21,476	87.7	33.8	27.3

Source: Ministry of Agriculture, Forestry and Fisheries

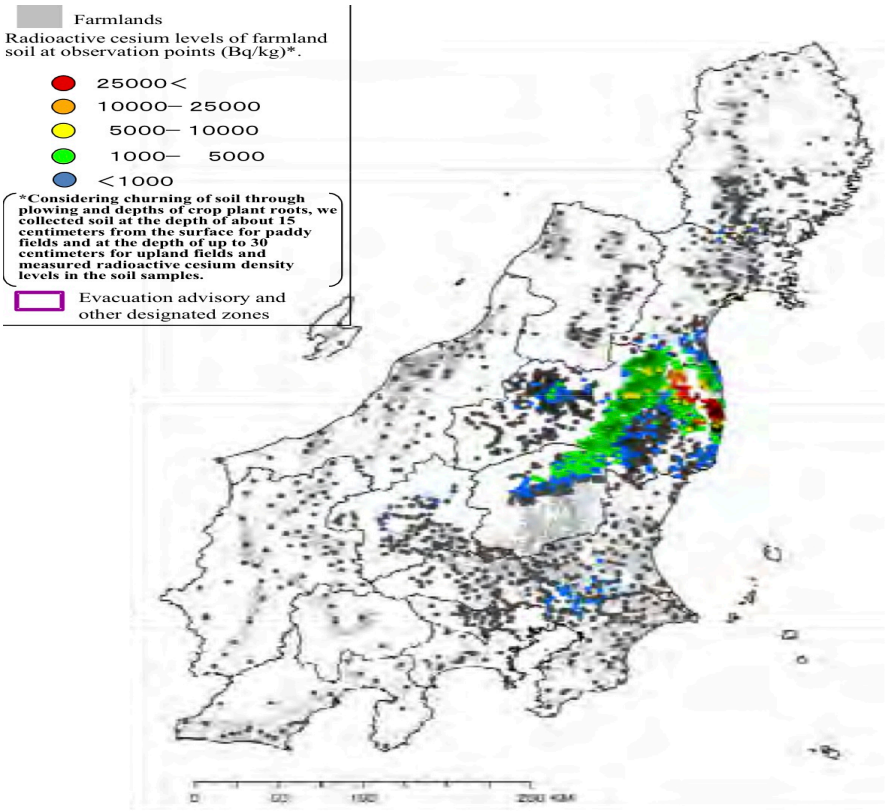
There have been registered damages in 36,092 places including: damaged agricultural land in 18,186 areas, damaged agricultural facilities (mainly storage reservoirs, drains, pumps, shore protection facilities for agricultural land) in 17,317 points, damaged coastal protection facilities for agricultural land in 139 points, and damaged facilities for daily life in farming villages (mainly community sewerage) in 450 points [MAFF, 2014].

Furthermore, there has been radioactive contamination of farmlands from the nuclear accident's fallout (Map 11). Recent survey in the most affected regions shows that contamination with cesium of paddy fields ranges from 67 up to 41,400 Bq/kg and other lands (arable, meadows, permanent crops) from 16 to 56,600 Bq/kg (Table 16).

There has been also enormous destruction of livestock, fruit trees and crops in affected by the disasters regions. The total crop and livestock damages from the 2011 earthquake are estimated to worth 14.2 billion yen [MAFF, 2012]. In Aomori, Iwate and Miyagi prefectures alone the registered livestock damages include 187 dairy heads (171 drowned and 16 crushed or starved), 458 beef cattle (466 drowned and 12 crushed or starved), 5,850 hogs (4,037 drowned and 1,813 crushed or starved), and 4,549,620 poultry (174,800 drowned and 4,374820 crushed or starved) [Tohoku Agricultural Administration Office, 2011].

Damages on farms have been particularly big in areas around the Fukushima nuclear plant, where most agricultural land, livestock and crops were heavily contaminated and destructed [Koyama, 2012, 2013; Watanabe, 2013]. In the most affected evacuation areas farming activity has been suspended or significantly reduced, and majority of livestock and crops destroyed.

Map 11. Farmland soil radiation (Mar. 23, 2012)



Source: MAFF, 2012

Table 16. Share of contaminated with Cs farmlands, as of December 28, 2012 (percent)

Prefectures	Paddy fields					Other farmlands				
	range (Bq/kg)	0-500	500-1000	1000-5000	> 5000	range (Bq/kg)	0-500	500-1000	1000-5000	> 5000
Miyagi	72-1,310	61.9	28.6	9.5	0	110-860	50	50	0	0
Fukushima	50-41,400	39	16.1	40.8	4	40-56,600	34.3	21.2	41.6	2.9
Ibaraki		0	0	0	0	230-560	50	50	0	0
Tochigi	110-1,040	50	41.7	8.3	0	62-2,630	66.7	11.1	22.22	0
Gunma	85-170	100	0	0	0	49-560	95	5	0	0
Chiba	67-120	100	0	0	0	< 16-190	100	0	0	0
Total	67-41,400	43.2	17.8	35.6	3.4	16-56,600	46.2	19.2	32.4	2.2

Source: Ministry of Agriculture, Forestry and Fisheries

According to the officials the number of farm households in the evacuation zones was 5400 and the farming area 11,000 ha, including 73.3% of paddy fields, 25.6% of uplands, and 1.1% permanent crops [Fukushima Prefectural Government, March 2012]. That comprises 8% of the total number of farmers and 9% of the farming area in Fukushima prefecture in 2010. The numbers of beef cattle in the evacuation areas was 10,836, of milk cows 1,980 and of pigs 40,740, accounting respectively for 15%, 12% and 22% of the overall numbers of livestock in 2011. The estimate figure for chickens was 1,589 or 30% of the total number in the prefecture in 2009.

A large scale contamination of crops, livestock and agri-food products by radionuclides has happened as a result of the direct radiation exposure, the fallouts and distributed by wind and rains radioactive elements, the crop and livestock uptakes from leaves, soils, waters and feeds, the diffusion from affected inputs, buildings and equipment, the dissemination through transportation and wildlife, etc.

Up to the Fukushima nuclear plant accident there had been no adequate system for agri-food radiation regulation and inspection to deal with such a big disaster [MAFF, 2011]. On the wake of the accident a number of measures were taken by the government to guarantee the food safety in the country. Within a week from the nuclear accident (March 17, 2011) Ministry of Health, Labor and Welfare introduced Provisional regulatory limits for radionuclides in agri-food products[175] (Table 17).

Table 17. Provisional regulatory limits for radionuclides in agri-food products (Bq/kg)

Products	I-131	Cs-134 + Cs-137
Drinking water	300 (100)*	200**
Milk/Milk Products	300 (100)*	200**
Vegetables/Fish	2000	500**
Cereals/Meat/Eggs	-	500**

*for infants ** values take into account the contribution of radioactive strontium

Source: Ministry of Health, Labor and Welfare

On 29 March 2011, the Food Safety Commission of Japan drew up a report guaranteeing that the ongoing measures based on provisional regulation values are effective enough to ensure food safety for consumption, domestic distribution and exportation. On 4 April 2011 the authorities decided to use the ongoing provisional regulation values for the time being and set up provisional regulation value for radioiodines in seafood on the next day.

During the year after the nuclear accident officials tested 137,037 agri-food samples across the country and detected 1,204 cases (0.88%) exceeding the provisional safety limit in 14 prefectures [Ministry of Health, Labor and Welfare].

Most of the contaminated food samples were in Fukushima prefecture (59.63%), followed by Saitama (10.55%), Ibaraki (7.14%), Tochigi (6.23%) and Miyagi prefectures (5.32%). The share of contaminated items in all inspected samples was highest in Saitama (3.64%), Fukushima (3.33%) and Kanagawa (1.98%) prefectures, and in Tokyo (1.42%).

The majority of highly contaminated items In Fukushima prefecture were vegetables, fishery products and meats, in Ibaraki and Chiba prefectures vegetables, in Miyagi prefecture beef, in Tochigi prefecture vegetables and meats, in Saitama prefecture and Tokyo tea leafs.

More than 3600 fishery products were tested in Fukushima prefecture during the first year after the accident, and 34.7% of them found above 100 Bq/kg [Fishery Agency, 2014]. In the rest of the country from almost 5000 inspected fish samples 4.5% were above safety norm.

The mandatory and voluntary restrictions on shipment covered a number of products from designated areas of affected regions. In addition, there was a ban on rice planting on 8000 ha of paddies in evacuation (95%) and other contaminated areas [MAFF, 2012]. What is

[175] based on intervention exemption level of 5 mSv/y and 50% contamination rate [MHLW, 2011].

more, several municipalities (Minami-shi, Hirono-machi, Kawauchi-mura and Tamura-shi) called for voluntary restraints on planting of paddy rice on total area of 5,600 ha.

In order to meet growing public safety concerns since April 1, 2012 new[176] official limits on radioactive cesium[177] in food items have been enforced in the country (Table 18). Four categories of Drinking water, Infant foods and Milk, and General foods are distinguished, and new safety standards are more stringent than in international ones[178].

Table 18. New Standard limits for radionuclides in food in Japan (Bq/kg)

Food item	Cs-134 + Cs-137
Drinking water	10*
Milk	50*
General Foods	100*
Infant-food	50*

* limit takes into account the contribution of radioactive strontium, plutonium etc.

Source: Ministry of Health, Labor and Welfare

For some raw materials and processed food (like rice, beef, soybean) were set transitional measures and longer periods (until December 31, 2012 or "the best before date") for complete enforcement of the novel safety standards. (Figure 26).

In the last two years the number of (official, collective, private) food inspections has multiplied in the 17 most vulnerable prefectures[179] and around the country. Officially tested food items doubled in 2012, 0.85% of all samples were found exceeding safety limit for radionuclides, and a few highly contaminated items were detected in 4 more prefectures (Aomori, Nigata, Yamanashi and Hiroshima) (Figure 27).

The biggest number of unsafe food items was detected in Fukushima (58.05%), Iwate (10.96%), Tochigi (10.79%), and Miyagi (6.91%) prefectures. The portion of highly contaminated food items was biggest in samples from Fukushima (3.95%) and Iwate (1.03%) prefectures.

Most of the detected items were fishery products, wild animal meats, vegetables and mushrooms. In Ibaraki, Tochigi, Gunma, and Iwate prefectures there were also detected samples of drinking water exceeding safety standard.

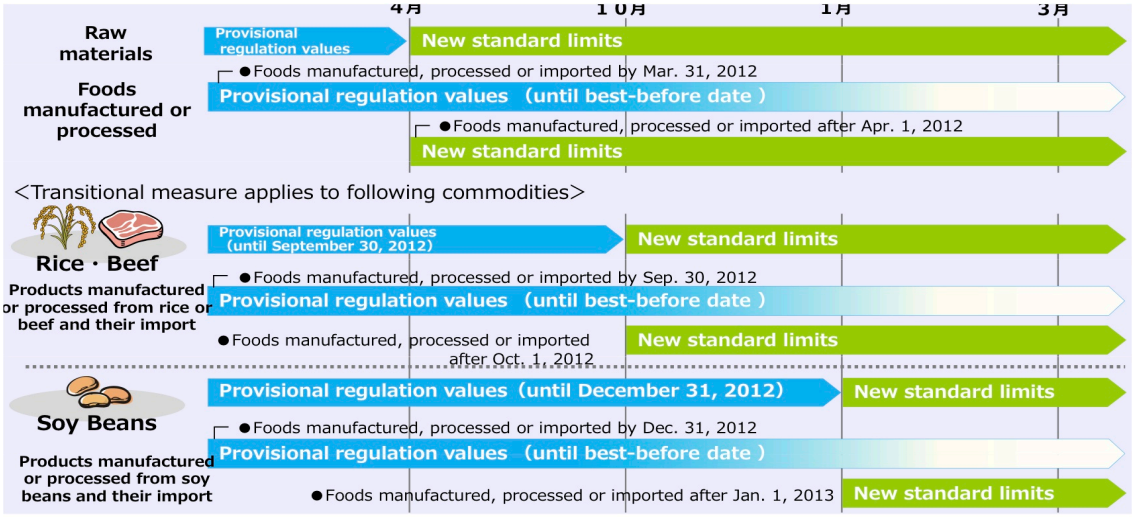
[176] annual maximum permissible dose from radioactive cesium in foods reduced from 5mSv to 1mSv - the same level as Codex GLs [MHLW, 2012].

[177] Standard limits are not established for radioactive Iodine, which has been no longer detected (short half-life), and Uranium, which level is almost the same in the nuclear power plant site as in the nature environment [MHLW, 2012].

[178] e.g. maximum allowed radioactive substances in EU and USA in grains are accordingly 1250 Bq/kg and 1200 Bq/kg, in vegetables 500 Bq/kg and 1200 Bq/kg, in drinking water 100 Bq/l and 1200 Bq/kg.

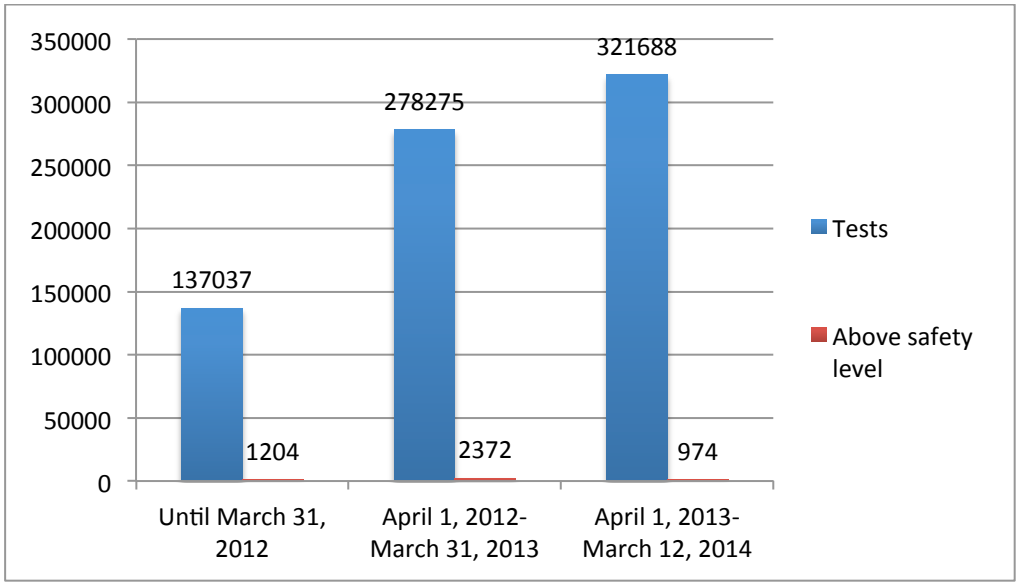
[179] Regular tests on 98 items have been carried out in Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima, Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Yamanashi, Nagano, and Shizuoka prefectures.

Figure 26. Transitional measures for enforcement of new standards for radionuclides in food in Japan



Source: Ministry of Health, Labor and Welfare

Figure 27. Number of radionuclide food tests and items above safety standard in Japan



Source: Ministry of Health, Labor and Welfare

In FY 2013 the number of inspections increased further but only 0.30% of samples were found with level higher than the safety standard[180]. The bulk of highly contaminated items were in Fukushima prefecture (62.42%) followed by Gunma (10.99%), Tochigi (8.42%) and Miyagi (8.32%) prefectures. The greatest segment with highly-contaminated items was detected in samples from Fukushima (1.5%) and Yamanashi (1.18%) prefectures.

Most of the detected items in Fukushima prefectures were fishery products, agricultural products (vegetables, soybean, rice, etc.) and wild animals meat; in Miyagi prefecture agricultural products (bamboo shoot, vegetables, etc.), wild animal meat and fishery products; in Gunma and Tochigi wild anima meats; and in Yamanashi prefecture mushrooms.

[180] No drinking water sample above safety limit was detected.

Official inspections results in the last two years indicate that for all agricultural food products, but mushrooms and wild edible plants, the number of samples with radioactive cesium above safety limits is none or insignificant (Table 19).

Table 19. Results of inspections on radioactivity levels in agricultural products in Japan*

Products	March, 2011 - March 31, 2012			April 1, 2012 - March 31, 2013		April 1, 2013 - March 31, 2014	
	Number of samples	Above provisional limit	Above new limit	Number of samples	Above maximum limit	Number of samples	Above maximum limit
Rice	26,464	39	592	10.4 million	84	11 million	28
Wheat and burley	557	1	27	1,818	0	592	0
Vegetables	12,671	139	385	18,570	5	19,657	0
Fruits	2,732	28	210	4,478	13	4,243	0
Pulse	698	0	16	4,398	25	6,727	59
Other plants	498	1	16	3,094	14	1,613	0
Mushrooms and wild edible plants	3,856	228	779	6,588	605	7,583	194
Tea/Tea infusion**	2,233	192	1,562	867**	13**	446**	0**
Raw milk	1,937	1	7	2,453	0	2,052	0
Beef	91,973	157	1096	187,176	6	208,477	0
Pork	538	0	6	984	1	693	0
Chicken	240	0	0	472	0	385	0
Egg	443	0	0	565	0	418	0
Honey	11	0	1	124	0	66	0
Other livestock	23	0	0	99	1	118	0

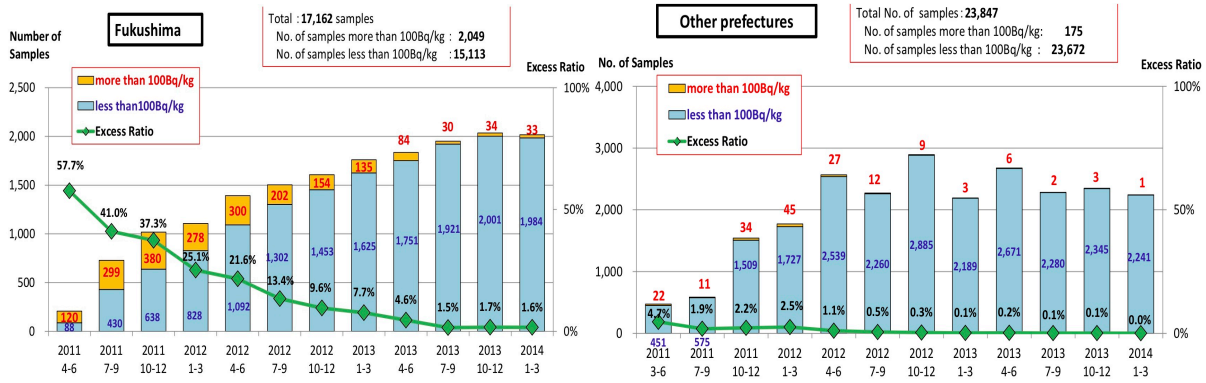
* for crops in 17 northeastern and eastern prefectures, for livestock products all prefectures
Source: Ministry of Agriculture, Forestry and Fisheries

Test data for marine fishery products radioactive contamination also indicate that the number of cases above safety limit has dropped considerably (Figure 28). In Fukushima prefecture, in the months after the accident, the share of highly-contaminated fish was 57.7% but it reduced by half after one year. The portion of samples above safety limit decreased considerably to around 1.5-1.7% in the last three quarters.[181] In other prefectures the share of contaminated fish decreased from 4.7% to less than 1% in 3nd quarter of 2012.

Currently there are still a number of products from certain areas of 17 prefectures, which are subject to mandatory or voluntary shipment restrains[182]. In Fukushima prefecture mandatory and voluntary restrictions cover a wide range of vegetables, fruits, livestock and fish products grown in heavily contaminated areas. In addition, there is still a ban on rice planting on 2,100 ha (almost 3 times lass than in 2013) and overall production management restrictions on 4,200 ha paddies in the evacuation area.

[181] After the 2nd quarter of 2012, monitoring has been focusing on species that have records more than 50 Bq/kg.
[182] more details and updates on requests for shipment restrains and other measures are available at: http://www.maff.go.jp/e/quake/press_since_130327.html

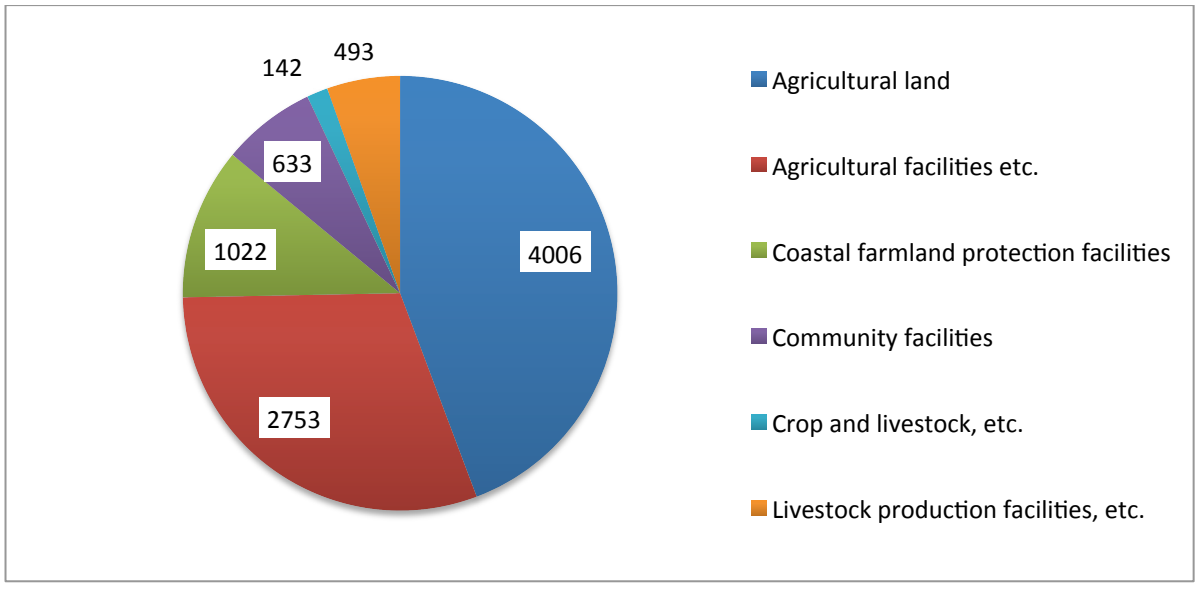
Figure 28. Monitoring results for marine fishery products radioactive levels in Japan



Source: Fishery Agency

The official estimate for the inflicted damage on agriculture by the 2011 earthquake is 904.9 billion yen[183] (Figure 29). The biggest share of the damages is for agricultural land (44.3%) and agricultural facilities (30.4%), followed by the coastal farmland protection facilities (11.3%), community facilities (7%), agricultural livestock etc. (mainly country elevators, agricultural warehouses, PVC greenhouses, livestock bams, compost depos) (5.4%), and agricultural crop and livestock etc. (1.6%).

Figure 29. Damages to agriculture from 2011 earthquake as of July 5, 2012 (100 million yen)



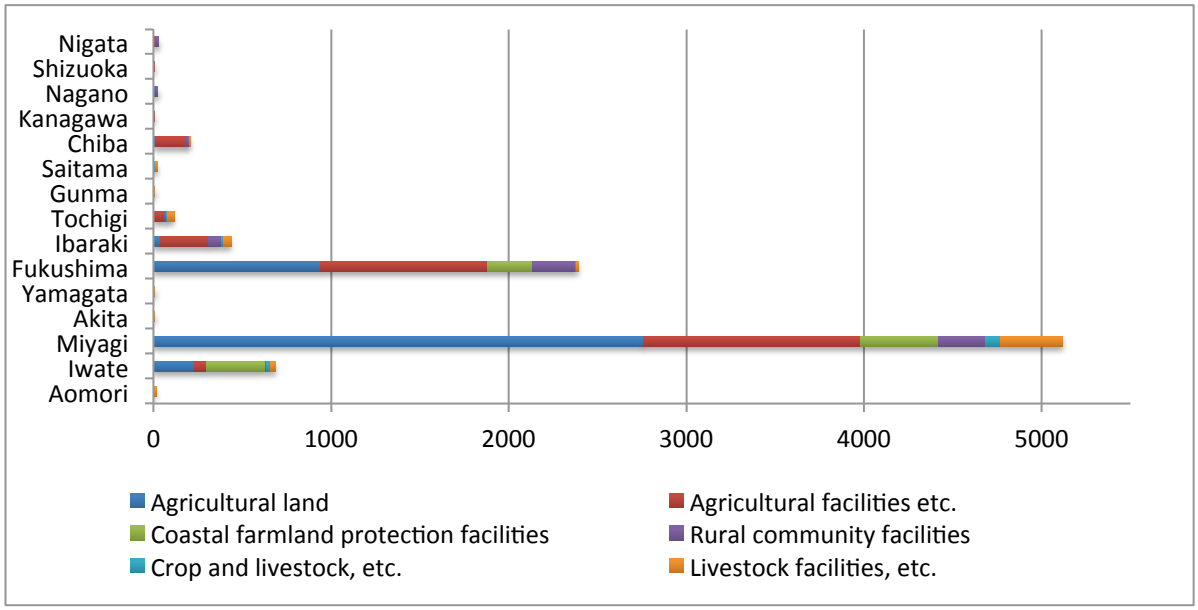
Source: Ministry of Agriculture, Forestry and Fisheries

The greatest amount of damage has incurred in Miyagi prefecture representing 56.5% of the total worth (Figure 30). The second most affected prefecture was Fukushima with

[183] Damage to Sector Agriculture, Forestry and Fisheries (2,426.8 billion yen) is 18 times as large as for 2004 Nigata Chuetsu Easrtquake and about 27 times bigger than for 1995 Great Hanshin Easrtquake [MAFF, 2013].

26.4% of the total damage. Iwate and Chiba prefectures have also incurred considerable damages - 7.8% and 4.8% of the total.

Figure 30. Damages to agriculture in different prefectures from 2011 earthquake as of July 5, 2012 (100 million yen)



Source: Ministry of Agriculture, Forestry and Fisheries

A survey on economic situation of agricultural management entities in the tsunami damaged areas have found out that in 2011 the sales revenues from agricultural products dropped by 68% comparing to 2010 and the agricultural income by 77% [MAFF, 2013]. The biggest decrease in sales and income experienced farmers in Miyagi prefecture, followed by producers in Iwate and Fukushima prefectures (Figure 31). Severe blows on sales and income were registered by producers in the three dominant type of farming in the region as those specialized mainly in facilities vegetables saw the highest decrease in sales and income (86% and 76% accordingly), followed by the rice and open field vegetable producers [MAFF, 2014].

There have been some improvements in sales and incomes in all areas but in 2013 they were still far bellow the 2010 level – 24% and 36% accordingly [Ministry of Agriculture, Forestry and Fisheries, 2014]. The fastest recovery has been registered in Miyagi farms' sales and income (49% and 48% increase), followed by the Iwate (23% and 32% increase) and Fukushima (21% and 13% increase) producers' results. The slower growth of income compared to sales (in Iwate and Fukushima prefecture) was due to the higher costs associated with the post-disaster cleaning and rebuilding.

There has been a good progress in recovery of sales and income of rice and vegetable farms but in 2013 their levels was still considerable lower than in 2010. The fastest income growth was registered by the rice producers (54%) due to restoration of farmland and augmentation of sales (62%). The slower pace of post-disaster recovery in the facility grown vegetables was caused by the prolonged farmland restoration and the high (facility) rebuilding

costs after the land restoration is complete and operation resumed [Ministry of Agriculture, Forestry and Fisheries, 2014].

Figure 31. Evolution of agricultural sale and income of agricultural management entities in tsunami-damaged areas (2010=100)

Source: Ministry of Agriculture, Forestry and Fisheries

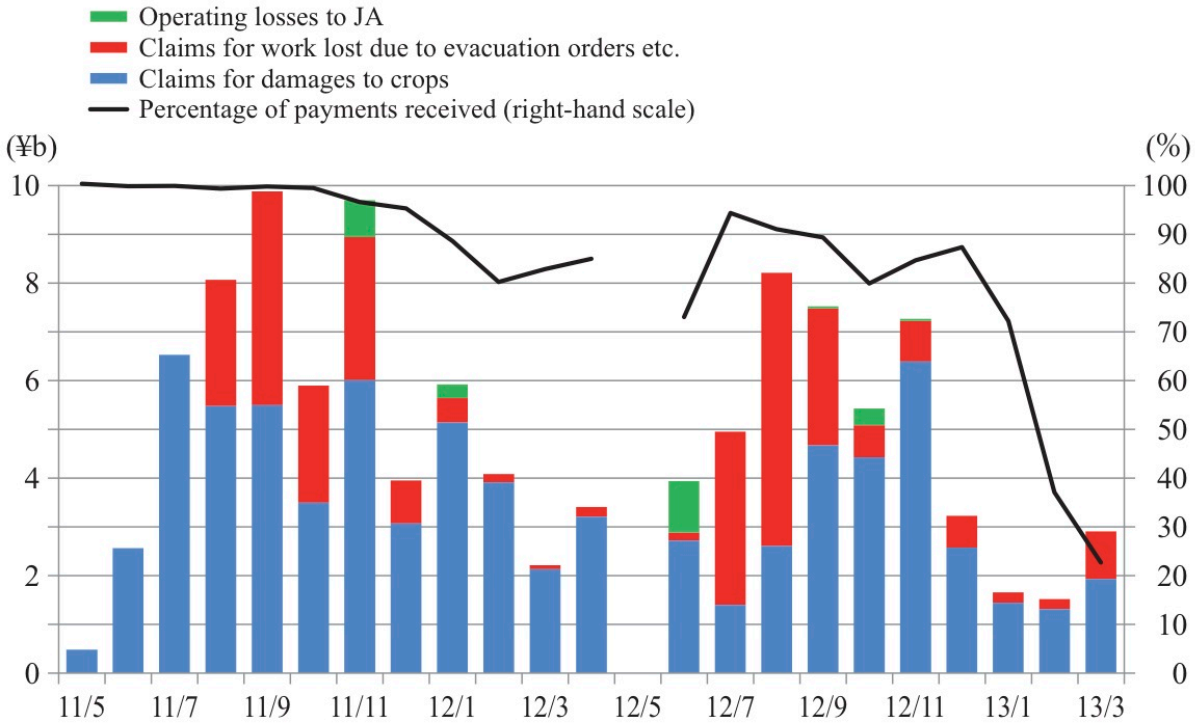
In the first year after the disaster there was augmentation of the agricultural output value in 69.8% out of the 43 tsunami-damaged municipalities. In the rest of the affected municipalities there was no progress (11.6%) or even a reduction (18.6%) in the agricultural output, including in 58.3% of the damaged municipalities in Iwate prefecture, a half in Aomori prefecture, 26.7% in Miyagi prefecture, 16.7% in Ibaraki prefectures, and zero in Fukushima and Chiba prefectures [MAFF, 2013].

There are official estimates on some of the damages from the Fukushima nuclear disaster as well. After the nuclear accident, the Gross Agricultural Product in Fukushima prefecture shrunk by 47.9 billion JPY [MAFF]. Furthermore, there has been agriculture-related damages amounted to 62.5 billion JPY (by May 2012). The annual loss from the nuclear accident in the prefecture is estimated to be around 100 billion JPY [Koyama, 2013].

Some of the direct damages to farms production and marketing have been specified with the compensation claims of farmers to TEPCO. By mid April 2013 demand compensation though the Fukushima Taskforce was 109,3 billion yen, while the received compensation were 97,2 billion yen or 89% of the demand (Figure 32). Most of the claims have been for lost work due to evacuation orders and for crops damages.

Until May 2012 the amount of compensation demands reached 62.5 billion yen with a greatest portion of claims being for the untilled land (compensation for suspension of work) horticulture and livestock damages (Table 20). The amount of money received as compensation for the same period accounted for 73% of the claimed damages.

Figure 32. Claims for damages against TEPCO by the Fukushima Prefecture JA Group



Source: Fukushima Prefectural Union of Agricultural Cooperatives

Table 20. Breakdown of Fukushima Prefecture Union Compensation Claims (100 million yen)

Claims	On May 1, 2012		On May 1, 2013	
	Value	Share in total (%)	Value	Share in total (%)
Rice	11	1.8	32	2.9
Horticulture	130	20.8	264	24.2
Fruit	62	9.9	75	6.8
Milk	18	2.9	20	1.8
Livestock disposal	99	15.8	100	9.2
Other livestock damages	85	13.6	162	14.8
Pasture	27	4.3	50	4.6
Untitled land (for work suspension)	163	26.1	325	29.8
Business damages	30	4.8	64	5.8
Total	625	100	1,092	100

Source : Central JA Union for Fukushima Prefecture

The progress in compensation payments has been slow and uneven due to the delays in TEPCO's review process and demands for further documentation, lack of sufficient funds for satisfying all claims, multiple disputes, etc.

Besides, there has been no amelioration in the payments of compensation due to the lack of funding and multiple disputes. TEPCO continues to receive claims for damages of farmers and agri-food business from around the country. However, up to date total amount of claims received by and paid to different affected agents is not easy to find.

According to JA almost 100,000 farmers lost about 58 billion yen ($694 million) by March 1, 2012 or 25% of production [Takada and Song, 2012]. Published information for TEPCO payments to Groups Representing Victims for 2011-2012 shows that Agricultural Cooperatives received 280,400 million yen [Nomura and Hokugo, 2013]. The greatest share of the groups agricultural payments went to Fukushima (29.8%), Ibaraki (13.8%) and Shizuoka (10.4%) prefectures.

Nevertheless, all these assessments do not include important "stock damage" (material funds, damage to production infrastructure, contamination of agricultural land, facilities for evacuation, and usage restrictions on machinery) as well as the loss of "society-related capital" (diverse tangible and intangible investments for creating production areas, brands, human resources, network structure, community, and cultural capital, ability to utilize resources and funds for many years). According to experts the later losses are quite difficult to measure and "compensate" [Koyama, 2013].

Likely wise, much of the overall damages from the 2011 disasters on farmers livelihood and possessions, physical and mental health, environment, lost community relations etc. can hardly be expressed in quantitative (e.g. monetary) terms. Many farms livelihood and businesses have been severely destructed as a result of loss of life, injuries and displacement, and considerable damages on property (farmland, crops, livestock, homes, material assets, intangibles such as brands, good reputation, etc.), related infrastructure, and community and business relations.

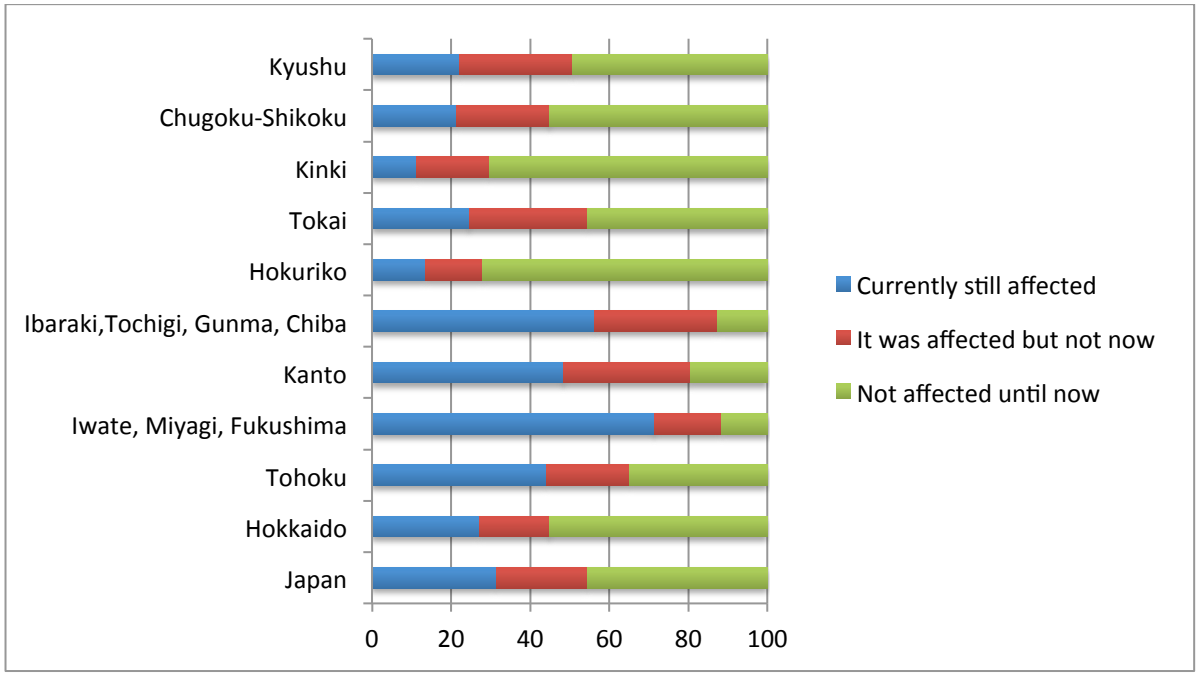
What is more, thousands of farmers in Fukushima and neighboring regions have been continuing to suffer enormously from the radioactive contamination of farmlands and agricultural products, the official and/or voluntary restrictions on production and shipments, and the declined markets and prices for their products [JA ZENCHU, 2012; Koyama 2013a, 2013b; Ujiie 2011 and 2012; Watanabe, 2011; Wataname 2013].

There has been a significant short and longer-term negative impact of the triple disaster on farm management entities in the most affected prefectures and beyond. According to a survey disaster affected negatively almost 55% of Japanese farms (Figure 33). A 2012 survey has found out that the most severely affected have been farmers in Tohoku and Kanto regions, and the least affected in Hokuriko and Kinki regions. In the worst hit Iwate, Miyagi, Fukushima, Ibaraki, Tochigi, Gunma, and Chiba prefectures more than 88 89% of all farms "are still affected" or "were affected in the past" from the earthquake, tsunami and nuclear accident.

Among different sectors of agriculture the most farms have been affected by the disasters in beef and facility flowers production (Figure 34).

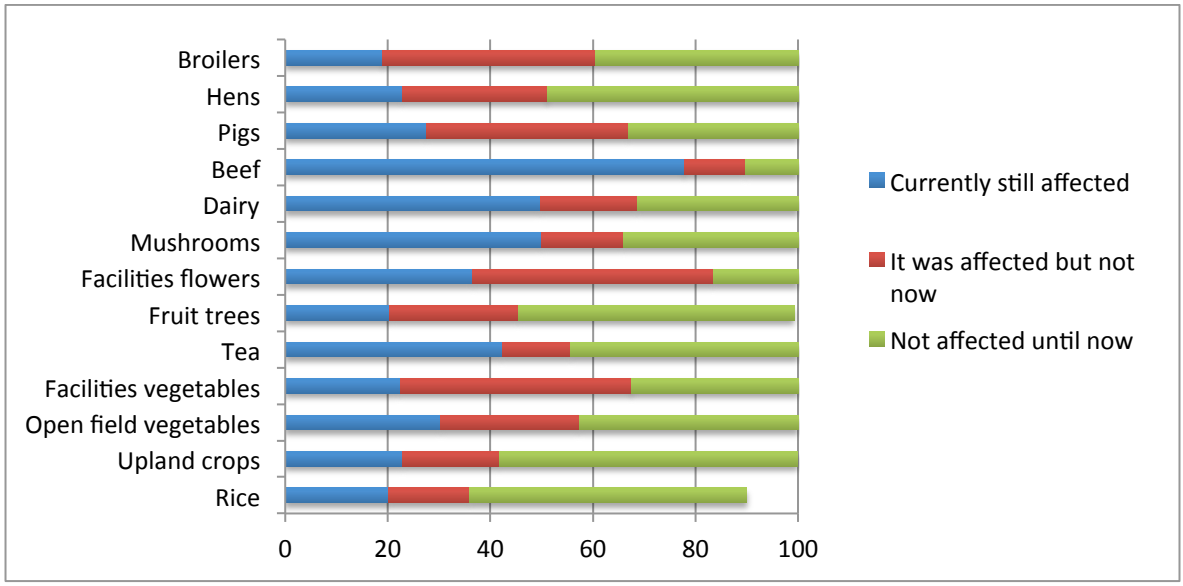
The major reasons for the negative impacts of the triple disasters have been "decline in sell prices" and "harmful rumors" while the damaged inputs supply and production affected less farms (Table 21). What is more, for farmers still affected by the disasters the importance of the first two factors increased considerably in 2012 comparing to the disaster year.

Figure 33. Adverse effect of Great East Japan Earthquake on farm management in different regions of Japan (March 2012)



Source: Japan Finance Corporation

Figure 34. Adverse effect of Great East Japan Earthquake on farm management in different subsectors of Japanese agriculture (March 2012)



Source: Japan Finance Corporation

Table 21. Reasons for those who are currently adversely affected in different regions (August, 2011; January 2012)*

	Damage to production		Damage input supply		Damage to distribution		Decline in sell prices		Harmful rumors	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Japan	24.5	23.2	41	27.1	44.4	33	65.8	74.4	52.8	60.5
Hokkaido	12.6	14.1	55.9	39.7	34.4	31.3	63.5	79.8	44.1	46.4
Tohoku	46.3	38.2	51.5	25.2	60.8	41	55.2	65.8	58.3	72
Kanto	34.1	26.1	28.8	17.6	45.2	27.8	69.6	72.8	72.9	76.1
Hokuriko	12.4	14.8	47.6	29.6	40	24.1	44.8	63	45.7	55.6
Tokai	7.6	7.3	30.5	18.2	41.9	34.5	86.7	87.3	35.2	43.6
Kinki	5.4	11.4	25	28.6	29.3	25.7	73.9	77.1	44.6	28.6
Chugoku-Shikoku	6.3	9.7	31.7	23.9	33.7	29.2	72.6	80.5	38	50.4
Kyushu	8.6	9.1	27.9	29.9	40.5	32.5	77.5	86.8	37.5	36

Source: Japan Finance Corporation *multiple answers

There has been a great variation in the importance of different factors affecting producers in individual sectors of agriculture (Table 22). For instance, "damaged production" has been a major factor for the most broilers producers, "damaged input supply" for the majority of pigs, upland crops, and open field vegetables producers, while "declined sell prices" and "harmful rumors" impacted farmers in all sectors. Furthermore, in 2012 the impact reduced sell prices further increased for most subsectors, while of the harmful rumors for all producers.

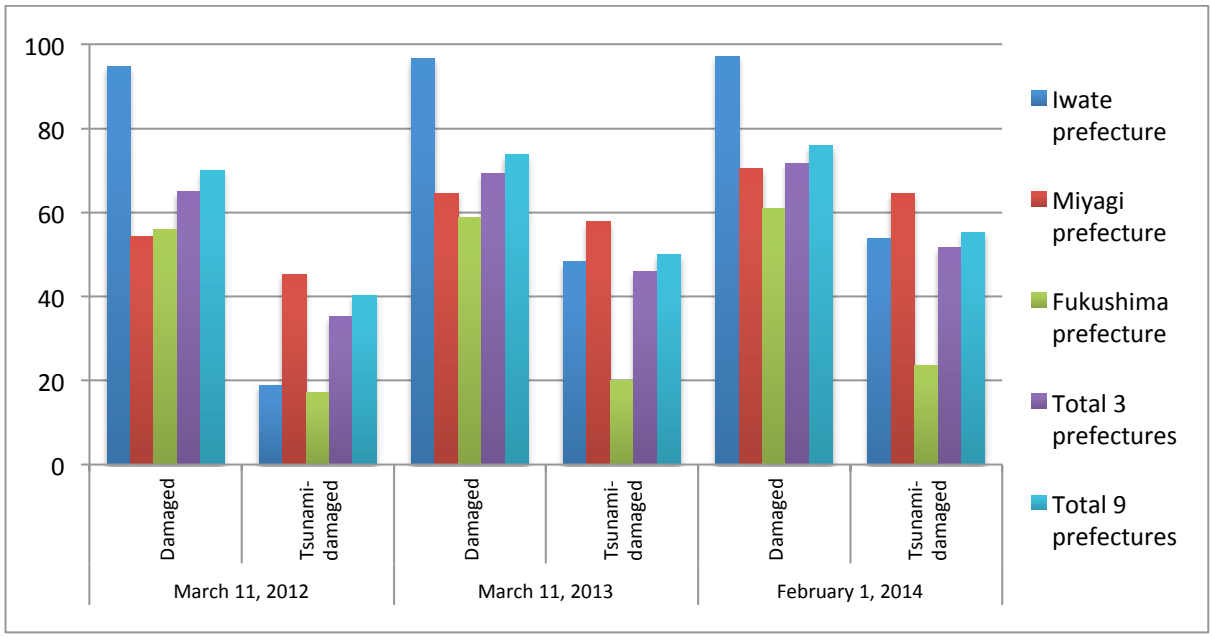
Table 22. Reasons for those who are currently adversely affected in different subsectors (August 2011; January 2012)

	Damage to production		Damage input supply		Damage to distribution		Decline in sell prices		Harmful rumors	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Rice	26.3	27.4	48.8	32.3	36.7	33.5	41.2	55.9	53.7	67.9
Upland crops	10.4	16.3	63.6	55.6	32.9	34.1	50.3	73.3	41	49.6
Open field vegetables	9.2	19.9	41.4	43.8	38.5	42.5	81	70.5	51.7	54.8
Facilities vegetables	28.3	32.7	24	35.6	41.9	36.5	78.7	65.4	48.4	54.8
Tea	13.5	13.4	8.7	15.9	40.4	34.1	69.2	67.1	80.8	87.8
Fruit trees	14.7	21.3	35.3	20	42.2	41.3	56.9	65.3	49.1	61.3
Facilities flowers	15.5	19.8	26.8	25.2	52.1	27	88.7	88.3	14.6	19.8
Mushrooms	23	38.3	27	36.2	48.6	31.9	77	76.6	44.6	57.4
Dairy	32.3	26.3	50	21.2	42.9	29.8	71.8	84	57.1	58.2
Beef	22.4	18.4	29.5	10.5	55.9	35.6	96.7	94.8	87.4	80.8
Pigs	49	22.8	66.9	16.5	56.6	15.2	35.2	75.9	34.5	53.2
Hens	37	18.2	47.8	12.1	45.7	24.2	28.3	78.8	41.3	27.3
Broilers	67.7	72.7	90.3	45.5	51.6	18.2	6.5	36.4	6.5	63.6

Source: Japan Finance Corporation *multiple answers

One year after the disasters around a third of damaged agricultural land was completely restored, including 27% of the tsunami damaged farmlands. During the same period about 90% of tsunami-afflicted farmland was cleaned of rubble, a large part of agricultural infrastructure reconstructed (including 100% of major draining pumping stations and 7.3 km priority restoration zones of coastal farmlands, and 92% of the rural community sewages) [MAFF, 2012]. Consequently, 70% of all damaged farms in 9 prefectures and 40.2% of tsunami damaged farms in 6 prefectures and 40% of resumed farming (Figure 35).

Figure 35. Share of agricultural management entities, which resumed farming (percent)



Source: Ministry of Agriculture, Forestry and Fisheries

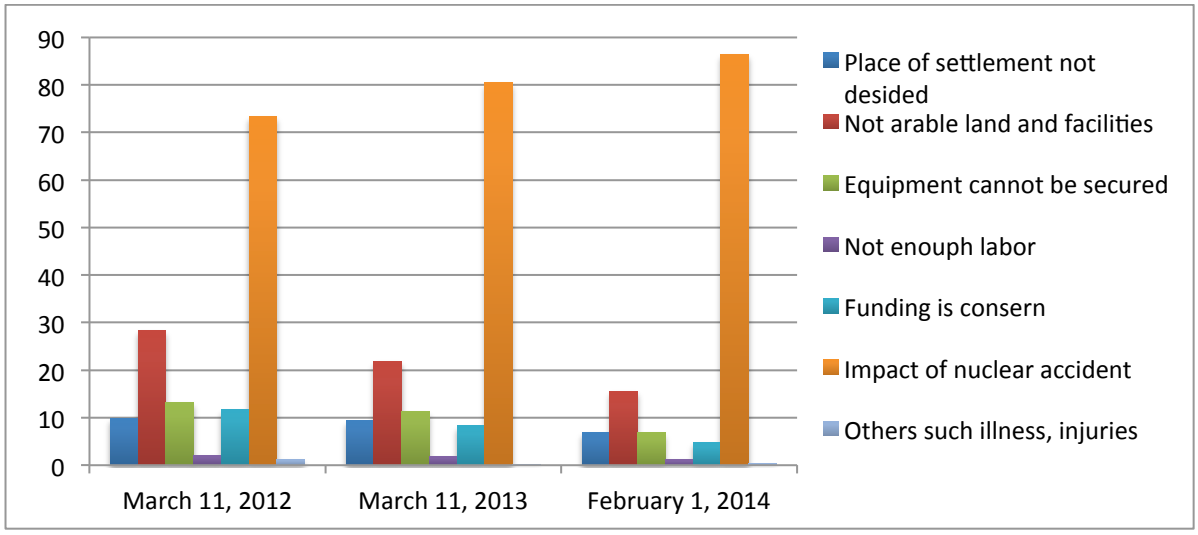
By March 2013 restoration and salt removal on 38% of the tsunami-damaged farmland was completed and they were available for farming (with restoration on another 63% ongoing) [MAFF, 2013]. That was close to the target in the 3 years plan for complete restoration of tsunami-damaged farming set by the Basic Guidelines for Reconstruction of Agriculture and Rural Communities after the Great East Japan Earthquake. The latest figures indicate that 63% of tsunami damaged agricultural land has been made again available for farming [Reconstruction Agency, 2014], and more than 55% of the affected farms resumed operation.

The biggest progress in restoration of the damaged farms has been achieved in Iwate prefecture and for the tsunami damaged farms in Miyagi prefecture. On the other hand, in Fukushima prefectures restoration of operations in damaged farms has been progressing slowly. Until June 2014 merely 29.9% of the tsunami-damaged farmland has been restored and become resumeable for farming, 82.3% of damaged agricultural facilities have been restored, and 60.9% of agricultural management entities resume operations [MAFF, 2014]. Similarly, merely 69.3% of the planed agricultural lands (paddy, upland, orchards and pastures) from the Municipality decontamination area have been actually decontaminated

[Reconstruction Agency, 2014]. Moreover, some parts of heavily contaminated areas remain almost untouched and probably require a long time before farming can be resumed.

Major reasons for "not resuming farming" in the three most affected prefectures have been the impact of nuclear accident, unavailable arable land, facilities and equipment, undecided place of settlement, and funding problems (Figure 36). Moreover, importance of most of these factors has been decreasing due to progression in reconstruction, returning of evacuees, restoration of farmlands and public support measures. On the other hand, the significance the nuclear crisis as a reason deterring effective resumption of operations by majority of farms has been increasing.

Figure 36. Reasons for not resuming farming in Iwate, Miyagi and Fukushima prefectures, multiple answers (% of farms)

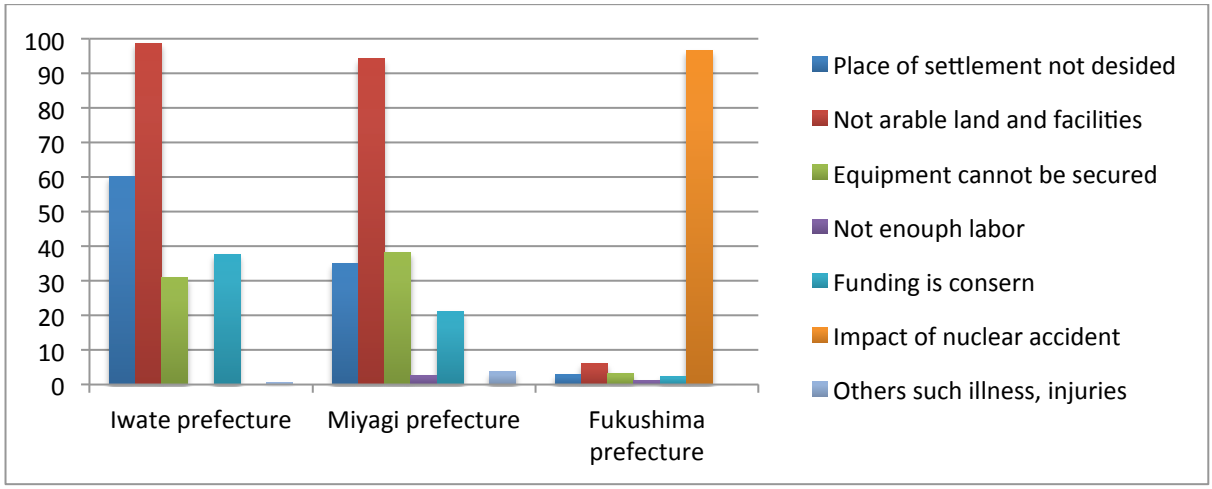


Source: Ministry of Agriculture, Forestry and Fisheries, 2014

Most critical factors for "not resuming farming" for majority of farms in Iwate and Miyagi prefectures have been unavailable arable land and facilities (Figure 37). Other important factors for a significant number of farms in these prefectures are that farmers have still not decided on the place of settlement (affecting 60% of damaged farms in Iwate prefecture), funding of farming activities is an issue, and equipment can not be secured. On the other hand, the most important obstacle to restart operations for the most Fukushima farmers has been the "impact of nuclear accident".

There is no official statistics on whether farmers have been able or not to harvest any produce on officially restored land in affected prefectures. However, there are reports that some of already desalinated and restored tsunami-damaged farmland is still unproductive. For instance, farmers have been unable to harvest any soybeans in a 30-hectare area out of planted nearly 45-hectare field in Rokugo, Eastern Sendai [Ishikawa and Ishikawa, 2014]. According to farmers remained high salt concentration in the farmland soils might have been reason for that.

Figure 37. Share of farms with diverse reasons for not resuming farming, multiple answers (%)



Source: Ministry of Agriculture, Forestry and Fisheries, 2014

After March 2011 the food industry in the disaster regions and throughout the country was also seriously affected by the production drops, business suspensions, distribution ruptures, etc. due to damaged plants, rolling blackouts, packaging material production shortages, gasoline shortfalls, etc. [MAFF, 2011]. Regular surveys on food industries dynamics reviled that 71% of the country's food companies were "affected" by the March disasters, including more than 35% "still affected" at the beginning of 2014 (Figure 38).

The strongest hit were food-industry companies in Tohoku's most affected regions (Iwate, Miyagi and Fukushima prefectures) (92.5%) and in Northern (84.6%) and Southern (82.3%) Kanto region.

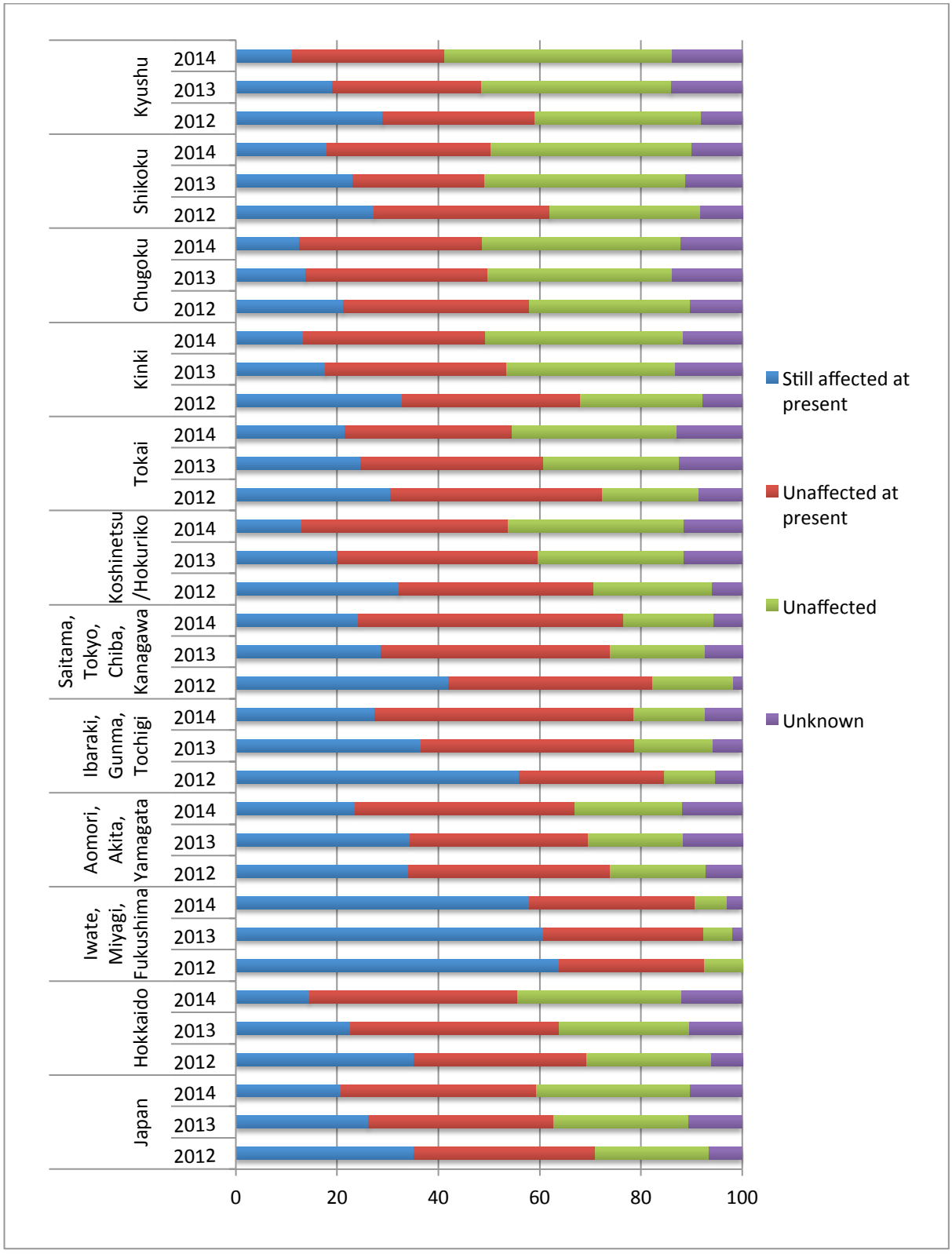
Similarly, 57.9% of country's food companies have been negatively affected by the Fukushima nuclear disaster as about 35% still affected in the beginning of 2014 (Figure 39).

The most severely affected have been the companies in Northern Kanto (83.4%) and in Tohoku's Iwate, Miyagi and Fukushima prefectures (81.9%).

There is difference in the adverse impact in different subsectors of food industry. According to 2014 survey the earthquake and tsunami have affected negatively the selling prices, procurement of ingredients and raw materials, and demand from trade partners of a good number of food industry companies [Japan Finance Corporation, 2014]. Disasters affected uniformly strong the Procurement of ingredients and raw materials of the majority of companies in all subsectors. In addition, disasters affected the Demand from trade partners of many companies in Wholesale trade, and the Sales volume, number of consumers, and the Price of ingredients and raw materials in Restaurants business.

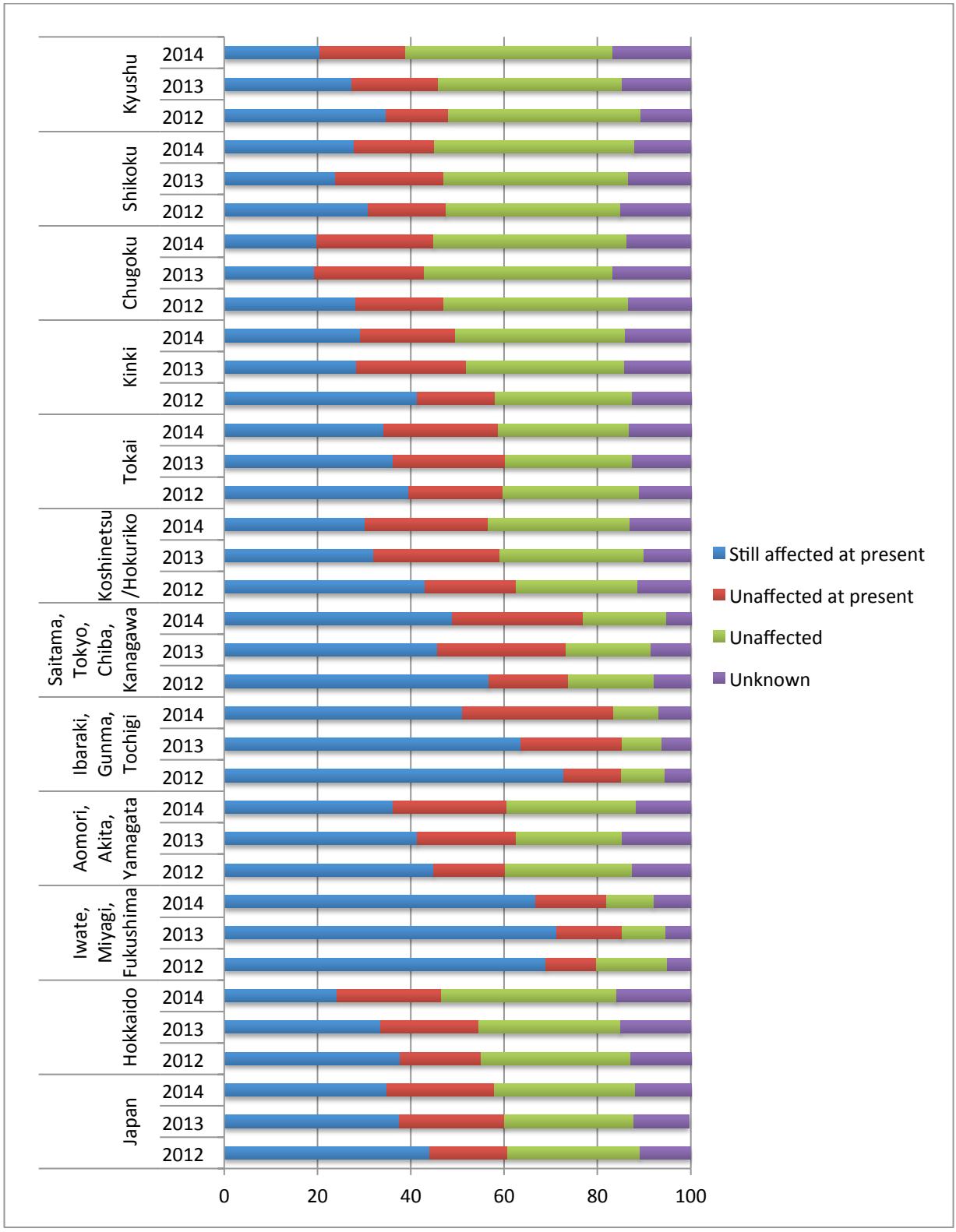
Fukushima nuclear disaster has also affected mostly Demand from trade partners, Sales volume, and Procurement of ingredients and raw materials of many food companies. However, while most food Manufactures and Wholesale traders suffered mainly from the decrease in the demand of trade partners, for the most the Restaurants operators and Retailers the Procurement of ingredients and raw materials has been predominately affected by the nuclear accident.

Figure 38. Earthquake-tsunami disaster effects on food industry in Japan (January, 2012, 2013, 2014)



Source: Japan Finance Corporation

Figure 39. Impact of Fukushima nuclear power plant accident on food industry in Japan (January, 2012, 2013, 2014)



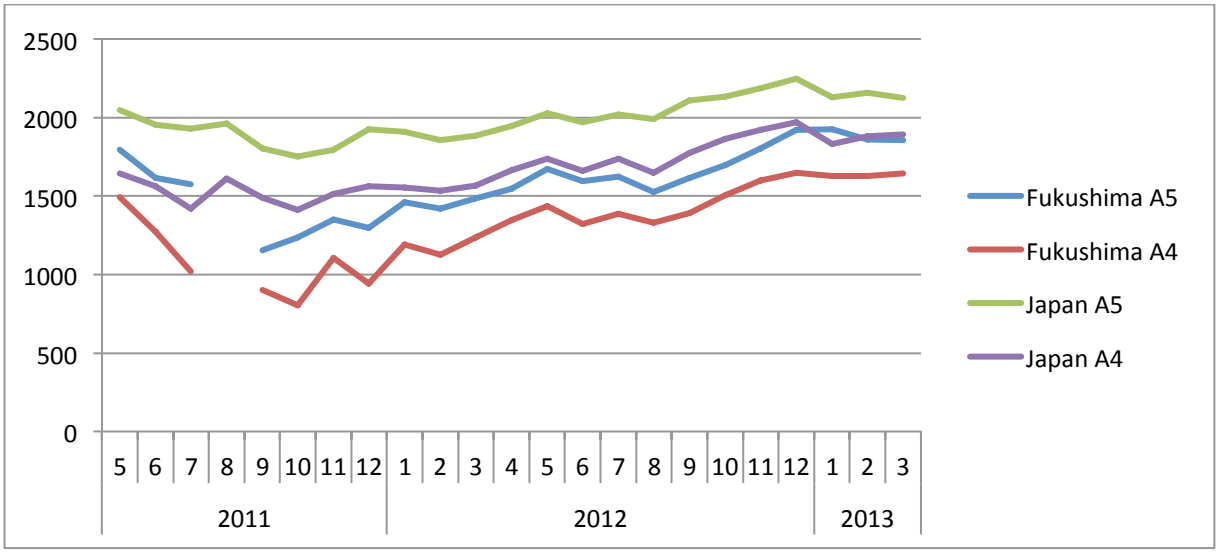
Source: Japan Finance Corporation

Due to genuine or perceived health risk many Japanese consumers stop buying agricultural, fishery and food products originated from the affected by the nuclear accident

regions ("Northern Honshu"). Even in cases when it was proven that food is safe some wholesale traders, processors and consumers restrain buying products from the contaminated areas [Futahira, 2013; Koyama, 2013; MAFF, 2012; Watanabe 2011, 2013].

After the nuclear accident, there was a considerable decline in absolute and relative prices of affected farm products and products from the contaminated regions. Fukushima prefecture has lost its comparative advantage to other farming regions. For instance, there was a considerable decline in the wholesale prices of beef cattle in Fukushima prefecture and in Japan after the accident (Figure 40). The prices in the country have been recovered and there has been gradual recovery of beef prices in Fukushima prefecture as well. Nevertheless, prices for different categories of beef are still 12-13% lower in Fukushima comparing to Japan. There have been similar trends for rice and vegetables as well [Watanabe, 2013].

Figure 40. Evolution of wholesale prices for beef cattle in Fukushima prefecture and other parts of Japan (yen per kg)



Source: Central JA Union for Fukushima Prefecture

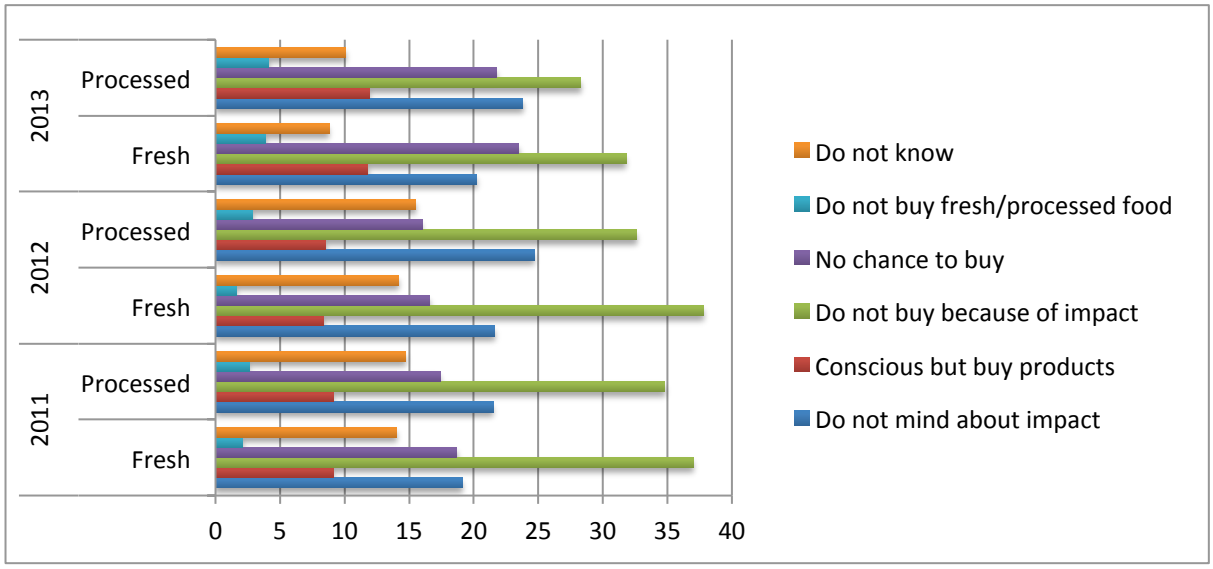
There has been significant change in the purchase behavior of a great number of consumers after the March 2011 disasters. The July 2011 survey found out that a good share of consumers decreased the purchased amount of fresh (10.6%) and processed (9.8%) food, ornamental flowers (21.6%), confectionary (15.2%), etc. [Japan Finance Corporation]. On the other hand there is an increase in purchase mineral water (17.6%). These changes were more dynamic in the worst affected East Japan than in the other parts of the country.

In the months after the earthquake, the item most emphasized by the consumers at the time of purchase of fresh food was "production location" and for processed food the "origin of raw materials" [Japan Finance Corporation]. However, for the majority of consumers there was not change of the place to buy fresh (88.5%) and processed (89.1%) food comparing to the pre-duster period [Japan Finance Corporation, 2011].

The consumer attitude to purchase food products from the affected by the nuclear disaster regions has evolved in post disaster years (Figure 41). Currently, relatively more and more consumers do not mind the impact of the nuclear disaster when purchase agri-food

produce. Nevertheless, still significant share of consumers do not buy fresh (31.8%) and processed (28.3%) products from that regions because of the impact of the nuclear disaster.

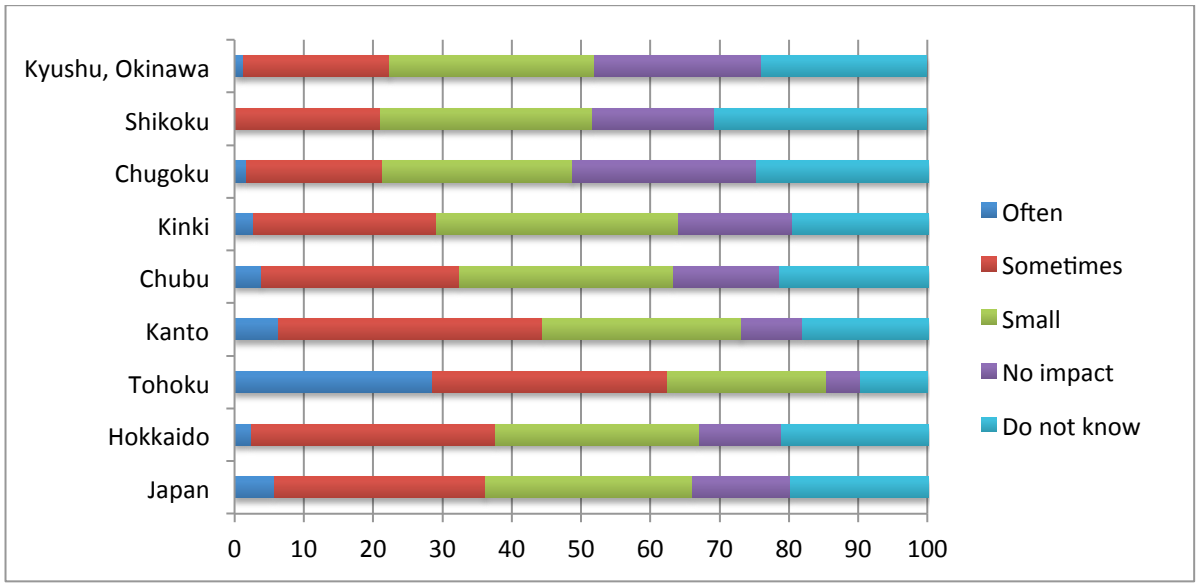
Figure 41. Awareness when purchase fresh and processed food from the region after Fukushima nuclear power plant accident (July 2011, January 2012, January 2013)



Source: Japan Finance Corporation

Recent data indicate that a good portion of Japanese consumers (36.5%) "often" or "sometimes" purchase purchase foodstuffs from affected by the 2011 disasters areas (Figure 42). The latest figure is much higher in Tohoku region then in the other parts of the country.

Figure 42. Purchase of (processed goods and agricultural products) foodstuffs produced in areas affected by the Great East Japan Earthquake (including eating out) (January 2014)



Source: Japan Finance Corporation

Nevertheless, for a great proportion of the consumers it is important to select the region of agro-food products and they purchase "rarely" or "not at all" from the affected regions.

Many consumers in the affected regions and throughout Japan have seen their direct procurement (e.g. prices) and transaction (information, search, assurance etc.) costs for supply of needed safe agri-food relatively from alternative regions, countries or guaranteed sources increased [Bachev and Ito, 2013]. However, there are no detailed studies on these effects of the nuclear disaster yet. Nevertheless, some research proves that a major way to minimize the transaction costs for supply of radiation safe product from a big number of costumers is to use "origin of product" selective governance [Uijie, 2012]. A segment of consumers went even further to purchase only from the "guaranteed sources" like some Tokyo residents using direct sales contract to buy rice from Kyushu farms [Kakuchi, 2013]. On the other hand, some Fukushima farmers see growing new crops (like cucumbers) and opting for direct sales to customers (rather than supermarkets) as a way to recover operations.

Some experts argue that both producers and consumers are victims of the "reputation damage" [Koyama 2013]. According to 2013 survey 26.1% of the consumers do not even know that inspections of radioactive contamination are being conducted [Consumer Affair Agency, 2013]. In order to facilitate communication with consumers, promote and recover Fukushima agricultural products numerous initiatives have been undertaken by farmers, agricultural organizations, NGOs, authorities, business, retailers etc. such as: direct sells by farmers, on spot radiation tests, recovery markets, Farmers' Document and Farmers Café events, government "Eating for support" initiative, joint ventures with shops, promotion complains with participation of top officials, celebrities, journalists, and farmers in big cities, international fairs etc. [Fukushima Minpo News, January 27, 2014; Inoue, 2014; The Japan News, March 8, 2014; Koyama, 2013; NHK World, May 17, September 21, 2014; MAFF, 2014].

Fight against "harmful rumors" that led to plummeting prices and sales of farm products have been also a high priority for local and national authorities. For instance, Fukushima prefecture is spending about 1.7 billion yen ($16.6 million) this fiscal year to fight rumors about radiation - fourfold budget increase over the previous year [Inoue, 2014].

Dynamics of demand has been a result of lack of sufficient capabilities in the inspection system, inappropriate restrictions (initially covering all shipments in a prefecture rather than from contaminated localities), revealed rare incidences of contamination in generally safe origins, low confidence in the official "safety" limits and inspections, lack of good communication, harmful rumors ("Fu-hyo"), and in certain cases not authentic character of traded products [Bachev and Ito, 2013]. The "reputation damage" has been particularly important factor for the big agri-food producing regions like Fukushima, Ibaraki etc. which products have been widely rejected by consumers [Futahira, 2013; Fukushima Minpo News, May 11, 2014; Koyama, 2013; Watanabe, 2013].

The 2011 disasters also affected considerably the international trade with agricultural products. Around 40 countries imposed restrictions on agri-food import from Japan after the nuclear accident, including major importer such China, United States, Indonesia, Malaysia and South Korea. The European Union required food and animal feed from 12 prefectures to be checked prior the export to prove that radioactive iodine and cesium levels do not exceed

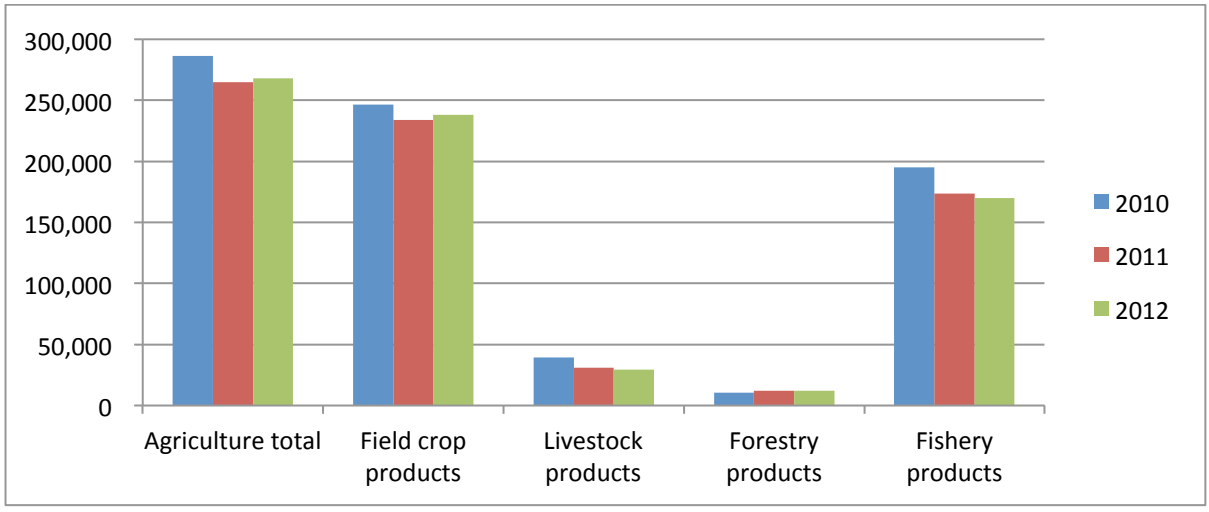
EU standards. In addition, agri-food items from 35 other prefectures had to be shipped along with a certificate of origin to verify where the products were produced.

Few months after the nuclear crisis some countries (like Canada, Thailand) lifted or eased restrictions on Japanese food imports. Rice exports to China with government-issued certificates of origin and produced outside the prefectures Chiba, Fukushima, Gunma, Ibaraki, Niigata, Nagano, Miyagi, Saitama, Tokyo, Tochigi and Saitama became possible in April 2012. In October 2012, EU also substantially eased import restrictions from 11 prefectures but kept restrictions for products from Fukushima prefecture. Radioactive material tests certificates are usually required [MAFF, 2014]. By March 1, 2013 as many as of 10 countries completely lifted radionuclide related restrictions on food products from Japan including Canada, New Zealand, Malaysia, Mexico, Peru, Chile, Columbia, Guinea, Myanmar, Malaysia and Serbia [Reconstruction Agency, 2014].

Due to the foreign countries' import restrictions and the experienced damages, the value of Japan's farm and livestock product exports declined substantially - in April-December 2011 the export plunged by 40.9 billion yen (11%) from the year before [MAFF, 2012]. Furthermore, in January-March, 2012 the value of country's export of agricultural products was 89 million (12.77%) lower than for the same period before the disaster.

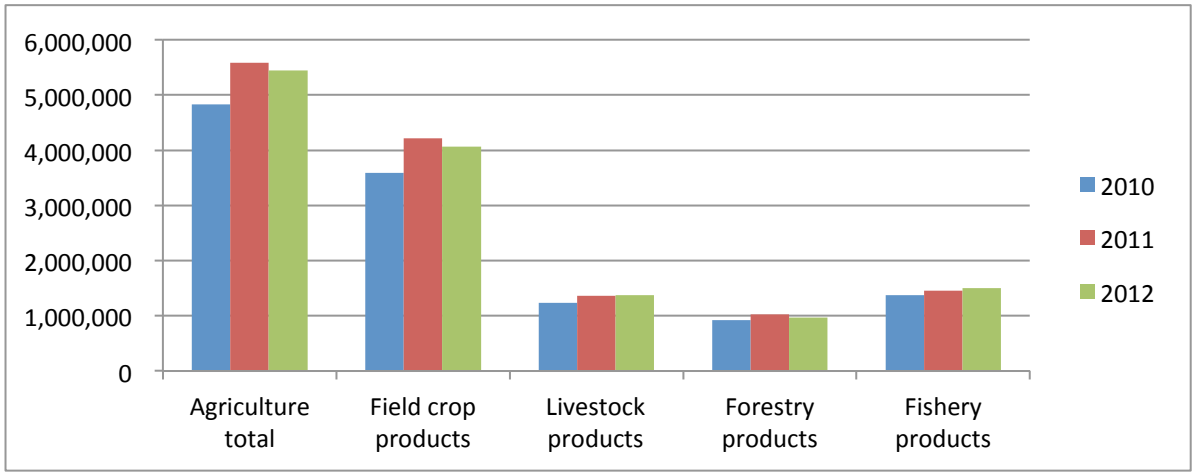
Consequently, there was a considerable decease in the overall agricultural (including fields crops and livestock products) as well fishery products export in 2011 (Figure 43). At the same time, there was a significant increase in the import of agricultural, forestry and fishery products as imports of farm products jumped 16% to 5.58 trillion yen in 2011 (Figure 44).

Figure 43. Dynamics of agricultural, forestry and fishery export of Japan (million yen)



Source: Statistical yearbook of MAFF

Figure 44. Dynamics of agricultural, forestry and fishery import of Japan (million yen)



Source: Statistical yearbook of MAFF

In April-December 2012 it was registered a 5.98% growth in the export of agricultural products of the country [MAFF, 2014]. Moreover, a slight augmentation of the annual exports of agricultural and field crops products was reported but the export value was still bellow 2010 level. The overall import of agricultural and crop products decreased but it was still above the pre-disaster levels. At the same time fish products exports continue to enlarge.

There have been also positive effects on product, technological and organizational development and innovation in agriculture and related industries. The enormous public funding as well as the novel business possibilities (and restrictions) have created new opportunities for revitalization and expansion of farming and agri-business in the most affected regions and beyond trough technological and organizational modernization.

There have been huge incentives for investment in soil decontamination, emergency aid, agri-food safety, production recovery and modernization, product and technologies innovations and diversification, agri-food marketing, reconstructing of business and infrastructure, other public and private research and development projects. All they have been opening up more entrepreneurial, employment and income opportunities for agricultural and general population, and diverse form of business and non-for profit ventures.

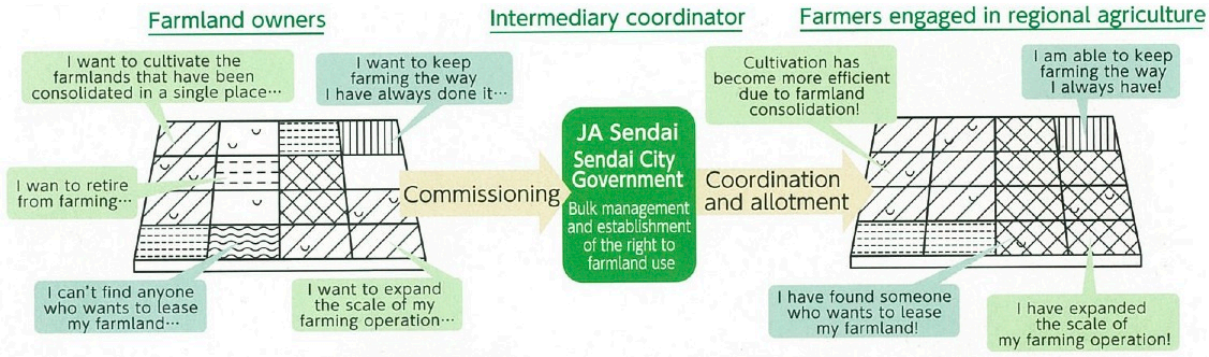
According to experts there are many companies (especially from outside of affected areas) wanting to lease in abandoned farmland and start large-scale corporate farming. That will let consolidate and enlarge farm size, introduces large-scale machineries and innovations, explore economies of scale and scope, increase investment and efficiency, diversify and improve competitiveness of farming enterprises.

In a line with new policies for agriculture (decentralization, liberalization, land consolidation, etc.) and intention to use Tohoku reconstruction as “a model for the entire country” new approaches for accumulating farmlands have been also reviewed. The goal is to promote land accumulation by leasing farmlands to current or future farm operators.

For instance, since April 2013 the Sendai city in collaboration with the JA Sendai introduced a new approach to “bulk management of farmland” (Figure 45). Sendai city and JA Sendai act as intermediary by implementing bulk lease management practices of farmlands in the relevant areas so that borrower farmer are able to cultivate land that have been

consolidated in a single place according to the scale of their farming and the status of operations.

Figure 45. Bulk management approach for farmland consolidation in Sendai



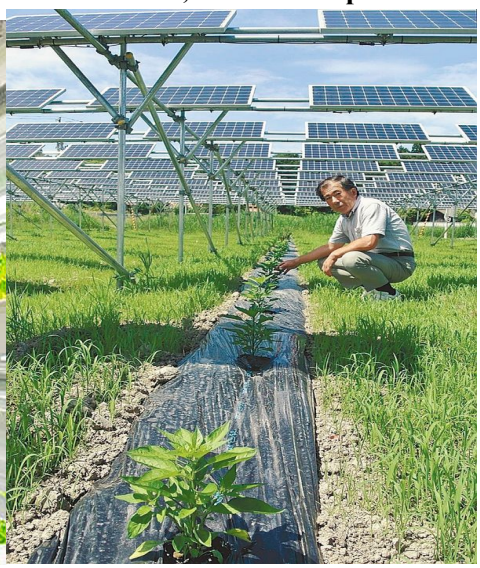
Source: City of Sendai, 2014

The experience with reconstruction Sendai agriculture shows a good result – e.g. the East Sendai District Farmland Consolidation Project covers 1,979 ha out of the 2,244 ha of the total District area [City of Sendai, 2014]. The ratio of consent by the landlords for farmland consolidation is 94.6%.

Furthermore, new technologies have been widely experimented and introduced in disaster areas. For instance, a large futuristic vegetable plant has been recently opened led by Fujitsu Ltd. (Picture 6). Aizuwakamatsu Akisai Vegetable Factory uses renovated 2,000 m^2 idle semiconductor-manufacturing clean (free of environmental contaminants and pests) room facility of the company in Aizuwakamatsu, Fukushima Prefecture [Fukushima Minpo News, 26 January 2014]. Production technology is chemical-free and completely controlled to maintain optimal growing and atmospheric conditions.

Picture 6. Aizuwakamatsu Akisai Vegetable Plant, Factory, Fukushima prefecture

Picture 7. Solar sharing project in Odaka district, Fukushima prefecture



Source: Lisa, 2014

The factory produces low-potassium leaf lettuce on a demonstration basis handling the whole process of production ranging from seed sowing to shipment. Initial daily output of 1,800 heads of leaf lettuce is to be boosted to a maximum 3,500. Production space will be also expanded (by 1,000 $m^{2)}$ in the future. About 30 people are employed as staff is expected to increase as output grows. The product, containing 86% less potassium on average, is intended for people suffering from chronic kidney disease requiring dialysis. It is also kid-friendly since a low nitrate level makes it less bitter and more appealing to children.

Another prospective technology invented in Japan is "solar sharing" - a process in which farmers generate solar power on the same land where they grow crops. Farmers in Fukushima prefecture have been testing that new technology and hope to sell power to help improve farmland or cover losses in income caused by radiation fears [Asiaone News, June 26, 2013]. In Minami-Soma, the prefectural government has begun a model project (Picture 7). A 2,000 square meter piece of farmland in the city's Odaka district is an example of solar sharing. On the farmland, 500 solar panels, each 70 centimeters by 1.6 meters, are installed atop 1.9-metre poles. Below the rows of panels, eggplants, chili peppers and produce are grown on an experimental basis.

Other innovations have been also experimented. For instance, Dutch bio-farming company Waterland International and a Japanese federation of farmers made an agreement in March 2012 to plant and grow camellia on 2000 to 3000 ha [The Mainichi Shimbun, Aril 4, 2012]. The seeds will be used to produce bio-diesel, which could be used to produce electricity. The affected region has a big potential for production of clean energy since some 800,000 ha could not be used to produce food anymore. Experiments have been carried out to find out whether camellia was capable of extracting cesium from the soil since experiment with sunflowers had no success.

Increasing applications of ICT in agriculture have been also reported leading to precision technologies, higher farming productivity, efficient use of resources, enhanced food safety, and improved relations with counterparts and consumers [NHK World, July 15, 2013].

6. Environmental impact

The March 2011 disasters have had enormous environmental impacts [Kontar *at al.*, 2014; ME, 2013; NASA; Urabe *et al.*, 2013; UNSCEAR, 2014; WWF, 2013].

There have been numerous surface ruptures, ground cracks, mass movements (rock falls and landslides), land uplifts and subsidence, alterated landscape and seacoast in affected by earthquake and tsunami areas. Furthermore, a huge amount of rubble and debris have been created after the disaster. Most of these damages and waste have been "trivial" and once the infrastructure is repaired, none of them will matter at all [McNeill, 2011].

What is more, the large-scale reconstruction plans for the affected areas have included appropriate measures for rebuilding and better disaster protection of communities, cleaning and recycling of debris, and recovery and conservation of natural environment [Iwate Prefecture, 2011; Sendai City, 2011; Fukushima Prefectural Government, 2012; Government of Japan, 2014].

The earthquake and tsunami have caused huge destructions of soils, landscape, natural flora and fauna, and entire coastal ecosystems. Unknown number of wildlife have been killed, injured or displaced. Large land areas have been damaged by the seawaters, salinity and other pollutants, and become unsuitable for farming and natural habitats.

Tsunami badly affected about 1,718 ha of coastal disaster-prevention forests in 253 sites situated over an extensive area from Aomori to Chiba [Ministry of Environment, 2012]. In Rikuzentakata, Iwate the destruction left nothing but a single tree out of a coastal protection pine forest with more than 60,000 trees planted two century ago [National Aeronautics and Space Administration, 2011]. In addition, many traditional Igune were destructed by tsunami and consequently cut because they were composed by badly damaged by salt water Japanese cedar [Ogata and Pushpalala, 2013].

One year after the tsunami, the landscape near the mouth of the Kitakami River[184] remains irrevocably altered, farmland north and east of nearby Nagatsura become river bottom, the river mouth widened, and water from Oppa Bay crept inland, leaving only a narrow strip of land and new islands near the river mouth [National Aeronautics and Space Administration, 2012].

Similarly, tsunami tide swept away all fishing weirs and hatcheries in Kido River which boast large numbers of returning salmon on Honshu island[185] [Fukushima Minpo News, April 16, 2014]. A trial study in 2013 has found out that both fish born before the and after disaster are returning[186] to rivers significantly altered by the tsunami [NHK World, November 20, 2014]. Only a third of salmon born before the disaster made their way

[184] in March 2011 wide swaths of floodwater covered the north and south banks of the river channel, and sediment fills the river's mouth. Research suggests that waves from the tsunami traveled nearly 50 km upstream from the mouth of Kitakami River [NASA, 2012].

[185] on April 15, 2014 Naraha fisheries cooperative released young salmon into the river for the first time since the disaster. It is considering rebuilding hatcheries and resuming egg collection/hauling in fall 2015 in hope to restart release of self-hatched young salmon in spring 2016 [Fukushima Minpo News, April 16, 2014].

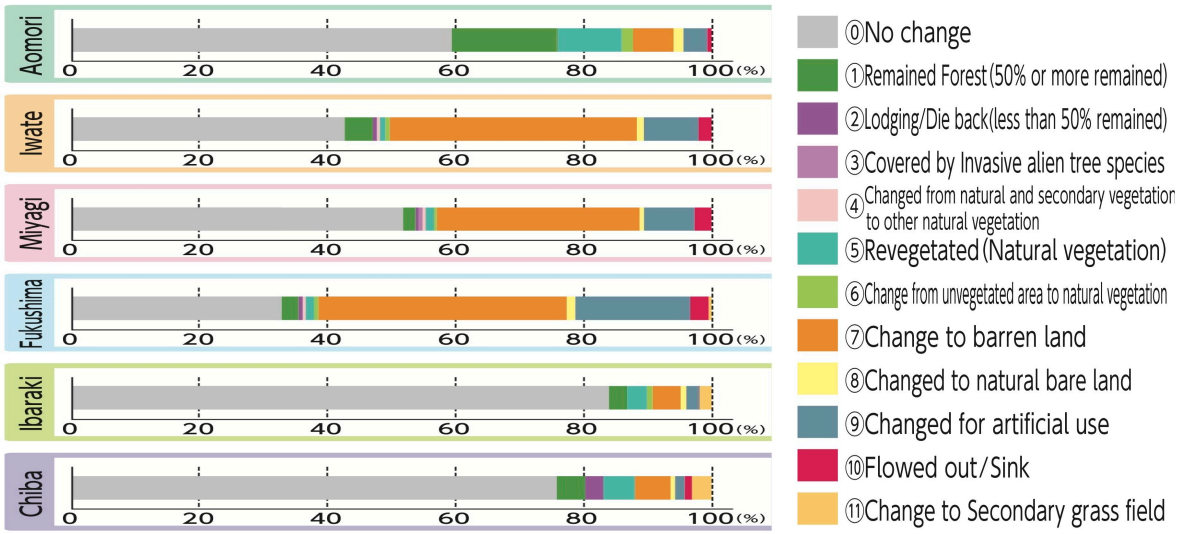
[186] Salmon usually returns to its river 3 to 5 years after birth.

upstream while 38.88% never entered rivers since environs changes (riverbeds and embankments) may make it difficult to find a way back.

A study has found out that soil liquefaction in the March 2011 earthquake was more widespread than previously thought [The Japan Times, Match 6, 2014]. Nearly 9,700 zones in 189 municipalities across 13 eastern and northeastern prefectures experienced soil liquefaction due to the earthquake, and while reclaimed land along coastlines was especially susceptible, it also occurred inland along rivers and land developed for housing.

Monitoring of the changes in vegetation in areas submerged by the tsunami along the Pacific coastline shows that "Changed to barren land" areas (where weeds grow abundantly in damaged areas) occupies the greatest share - around 30% of the total area (Figure 46). This is followed by "Changed for artificial use" such as developed lands and debris storage areas etc. (10% of the overall area). After the disaster "Changed to barren land" occupies a significant portions in Iwate (40%), Fukushima (40%), and Miyagi (30%) prefectures while "Flowed out/Sink areas" are seen in about 5% of the land in these prefectures.

Figure 46. Vegetation changes in areas submerged by March 2011 tsunami (percent)

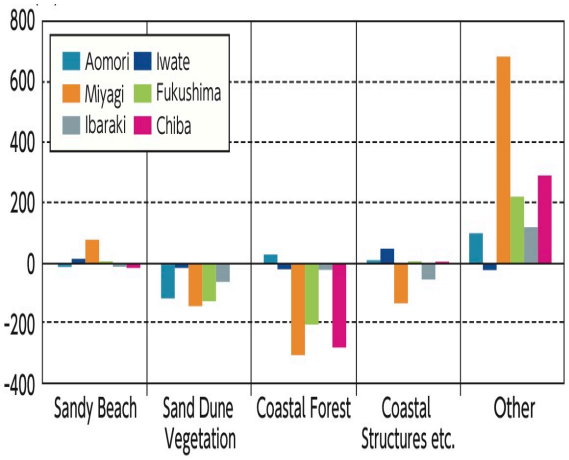


Source: Biodiversity Center of Japan, Ministry of Environment, 2013

In other prefectures "No change" areas are prevailing. However, in some places like Sosa City and Yokoshiba-Hikari Town of Chiba prefecture "Remained Forest" and "Lodging/Die back" areas occupied the greater share.

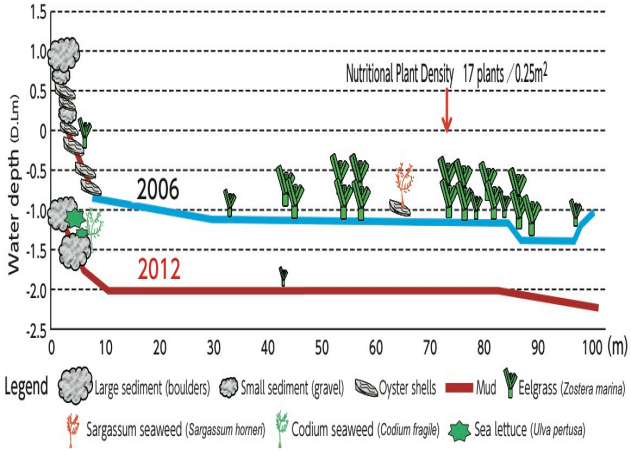
Monitoring on changes in the sandy and muddy beaches due to the tsunami also indicates that "Sand dune vegetation" and "Coastal forest" were vastly reduced and mostly were transformed through man-made developments or changed into "Barren lands" included under "Others" (Figure 47). "Sand dune vegetation" in Aomori prefecture, "Sand dune vegetation" and "Coastal forest" in Miyagi prefecture, and "Coastal forest" in Chiba prefecture were changed to "Others" by almost the same extent in terms of the area.

Figure 47. Changes in areas of beaches due to March 2011 tsunami (ha)



Source: Biodivercity Center of Japan, 2013

Figure 48. Distribution of seaweed Algae in Mangokura lagoon in 2006 and 2012



Source: Biodivercity Center of Japan, 2013

Natural environment survey in Matsukawaura Lagoon has found out a trend toward recovery of species numbers and population densities of benthic animals, forest bird species declined due to the elimination of coastal forests, while some water bird species showed an increase in numbers [World Wide Fund, 2013]. Besides, a large amount of water springs is observed due to ground subsidence, suggesting the possibility that a sandy environment will be sustained.

In Shizugawa Bay rocky-shore denudation was still observed despite the decrease in algae-eating animals such as sea urchins [World Wide Fund, 2013]. In surveyed two bays there are new kinds of places functioning as habitats for living creatures including remaining driftwood and concrete rubble, swamp environments that appeared on land due to ground subsidence, and unused rice fields.

Monitoring of the marine environment has found out a great disturbance of Zostera forest caused by the tsunami (Figure 48). For instance, in Mangokuura lagoon, Ishinomaki City, the ground was seen to have subsided by about 0.9-1.5 meters, becoming muddy as sludge accumulated, distribution area of the Zostera was drastically reduced, and their population growing from the coast up to about 100 meters out at sea was exterminated.

The study of Sendai Bay and the Sanriku Ria coast showed that 30–80% of taxa indigenously inhabiting intertidal flats disappeared after the tsunami [Urabe et al., 2013]. Among animal types, endobenthic and sessile epibenthic animals were more vulnerable to the tsunami than mobile epibenthic animals like shore crabs and snails.

At the same time, some species reallocated or increased their population after tsunami. For examples, Scopimera globosa and Grandidierella japonica not seen before the disaster in Gamo lagoon, Sendai city have been observed and their population increased [Biodiversity Center of Japan, 2013]. Other study have also confirmed that tsunami not only took away many benthic taxa from the intertidal flats but also brought in some taxa from elsewhere [Urabe et al., 2013].

Enhanced habitats in the seawater have been also reported due to reduced fishing after disasters [Biodiversity Center of Japan, 2013]. For instance, estimated number of chub

mackerel in waters near Kinkasan is now 2.6 times higher and there are 80% more adult fish than in the summer of 2010 [The Japan News, March 29, 2014].

The study on marine pollution has found out that PCBs (polychlorinated biphenyls), HBCDs (brominated flame retardants) and PBDEs (polybrominated diphenyl ethers, brominated flame retardants) were detected in all analyzed marine life [World Wide Fund, 2013]. High concentrations of HBCDs were detected in some specimens and PCB concentrations in Pacific cod were found to be about four times higher than before the earthquake and tsunami disaster. A positive correlation was seen between trophic level (level in the food chain) and concentration of PCBs, HBCD and PBDEs, suggesting bioconcentration throughout the food chain.

The radiation contamination after Fukushima accident has also affected the natural environment. Experts suggested similar to the Chernobyl accident biological anomalies in plants and animals such as population decease, mutations, etc. [Akimoto, 2014; ISHES, 2011; Nakanishi and, Tanoi, 2013]. For instance, a study on the effects of radioactive contamination following Fukushima disaster demonstrated that the abundance of birds was negatively correlated with radioactive contamination, and that among 14 species in common between the Fukushima and the Chernobyl regions, the decline in abundance was steeper in Fukushima [Møller et al., 2012]. A year after the nuclear disaster scientists found ("unexpected") mutated butterflies suggesting that mutations have been passed down from the older generations.

Other studies have also reported a link between elevated radiation levels after nuclear disaster and abnormalities in insects such as pale grass blue butterfly [Hiyama et al., 2012]. Radioactive isotopes originating from the Fukushima nuclear reactor were found in resident marine animals and in migratory Pacific Bluefin tuna, which caused a worldwide public anxiety and concern [Fisher et al., 2013]. Diverse studies on sea and fresh water fish in vast areas suggest that concentration of Cs has not decreased suggesting additional uptake [Buesseler, 2014; Mizuno and Kubo, 2013].

The United Nations assessment on the effects of nuclear accident on non-human biota inhabiting terrestrial, fresh-water and marine ecosystems concluded that radiation exposure have been high in the most contaminated areas, and there are risks for individuals of certain species, but it is geographically constrained with no long-term effects on populations [United Nations Scientific Committee on the Effects of Atomic Radiation, 2014]. Nevertheless, experts warned for follow up assessments of exposure and trends in marine environment.

More recent scientific models suggest that radiation exposures to wildlife within 100 km of the power plant were not high enough to cause a long-term harm such as prevent populations of plants and animals from reproducing and surviving [Strand et al., 2014].

Nevertheless, there have been some impacts on wildlife in contaminated areas. For example, evacuation zones have become home to an increasing number of wild animals like rats, boars and their offspring with abandoned domestic pigs, etc. [NHK World, July 11, 2o13, May 6, 2014]. There have been reported changes in population, areas of habitation, behavior and eating habits of these wildlife. For instance, the wild monkey (Japanese macaques) population is rapidly increasing in Odaka Ward of Minami-Soma, which is under an evacuation advisory, and said to have reached about 390 or three times its pre-crisis level [The Japan News, August 22, 2014]. The monkeys and other animals found in evacuation

advisory areas (such as wild boars and raccoons) believed to be expanding habitats taking over areas formerly inhabited by people.

During the year ending in March 2014 the average radiation level in Fukushima forests fell to 0.44 microsieverts or more than a half compared to two years ago [NHK World, May 6, 2014]. The amount of radioactive materials in new leaves is about one fifth of those contained in leaves that started growing before the disaster. According to forecasts the forest radiation will drop to around 30% from the current level over the next 20 years. Officials say that workers' fear of radiation has led to abandonment of some forests and that is causing concern about long-term management of forestry resources.

Recently it has been found out that most of the radioactive cesium that leaked from the Fukushima nuclear plant settled in a common mineral that comes from granite [NHK World, November 11, 2014]. According to scientists it is important to identify how the element exists in the soil predicting that most of the radioactive cesium in Fukushima soils is likely to be found in black mica. That finding is expected to encourage others to develop ways to remove it from contaminated lands[187].

The first assessments of "health effect" on farm and domestic animals and plants in the most affected areas have been also completed. Many of the farm livestock in the contaminated area has been slathered or died. However, a farmer M.Yoshizawa kept 360 cows[188] alive at his 80-acre spread inside the nuclear evacuation zone in defiance of a government kill order [Uncanny Terrain; Fackler 2014]. The farmer could monitors effects of prolonged radiation and there are reports that white spots on the fur and skin are appearing on some of his Japanese black cattle [CAN, August 2013; Fackler 2014].

The first study of cattle abandoned in the evacuation area[189] and euthanized indicates that in all examined specimens deposition of Cs 134 and Cs 137 was observed [Fukumoto, 2013]. Organ-specific deposition of radionuclides with relatively short half-life was also detected such as Silver-110m in the liver and Te 129m in the kidney. A linear correlation was found between radiosesium concentration in peripheral blood[190] and in each organ as the resulting slopes were organ dependent with the maximum value obtained for skeleton muscles (Figure 49). The levels of rediosesium in the organs of fetuses and infants were 1.19 fold and 1.51fold higher than in corresponding maternal organs. Radiosesium concentration in organs was found to be dependent on the feeding conditions and the geographical locations location where cattle were caught.

Radioactive Ag110m was detected in all the liver samples and no relation was found between the activity concentration in blood and liver. The data indicate that the liver is the primary target organ that accumulates silver.

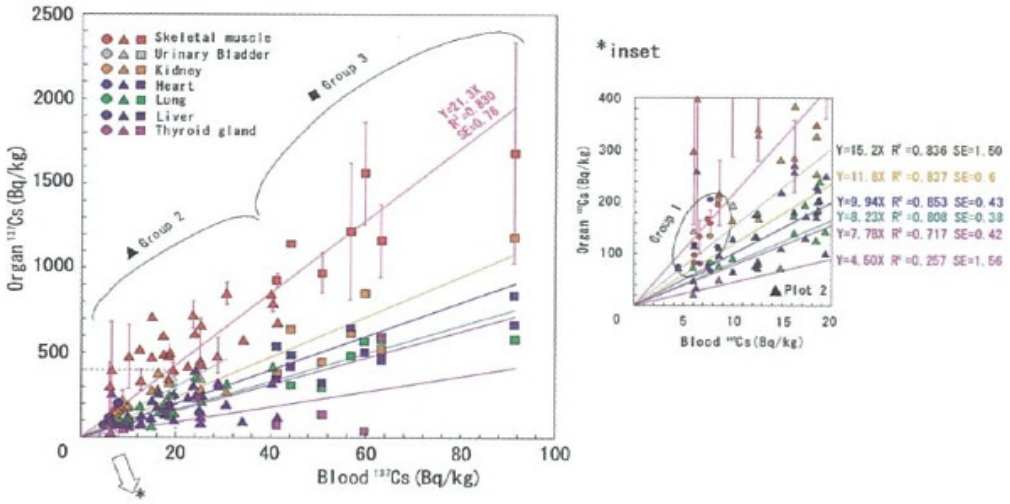
[187] Scientists still don't know how the radioactive cesium chemically combined with minerals in soil around the plant.

[188] more than half are ones that others left behind.

[189] 79 cattle, including 3 fetuses from pregnant cattle and 3 mother-infant pairs, all obtained between August 29 -November 15, 2011.

[190] Thus the activity concentration d Cs in organ can ne estimated from that of blood.

Figure 49. Cs analysis of different groups cattle* from evacuation area



*Group 1 and 3 Minamisoma, Group 2 Kawauchi. Group 1 kept in stall barge after the accident, fed with radionuclide-free pasture grass and contaminated rainwater. Group 2 and 3 allowed to graze freely on contaminated grass.

Source: Fukumoto, 2013

As far as Te129m is concerned it was detected in 62% of cattle examined. Its deposition in kidneys suggests that Te132[191] also accumulated in kidney shortly after the nuclear accident. These results suggest that monitoring of Te132 and I131 warrants more attention in terms of assessing health risk to the thyroid.

The study have expended to measurement of radioactivity in animals other than cattle. It was found that the radioactivity in each organ was higher in swine than in cattle but its transfer to organs from the blood was higher in cattle than in pigs. Therefore, bio distribution of radioactivity substances is species-specific and that further study is necessary to assess the effect of radionuclides in humans. The study has also revealed that the problem is not only radioactive caesium but also other radionuclides.

Analyses of this type[192] are extremely valuable for the assessment of environmental pollution, bio distribution, metabolism of radionuclides, dose evaluation and the influence of internal exposure as well as likely consequences for humans from long-term exposure[193].

It is estimated that the Great Japan Earthquake generated more than 20 million tons of debris[194] in the three most affected prefectures, of which about 5 million tons is estimated to have been washed out by the tsunami [Prime Minister of Japan and cabinet, 2014]. A major

[191] with half-life 3.2 days and decay product I132.

[192] The team collected tissue samples from different animals (cattle, swine, Japanese macaque, wild pigs, horses) which are currently being examined.

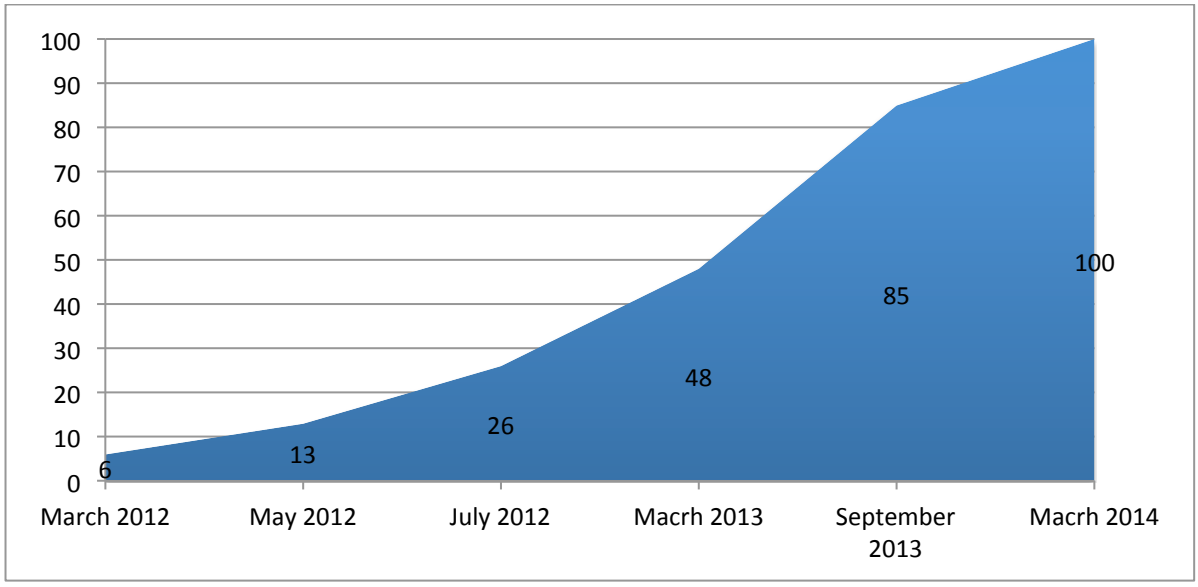
[193] The amount of radioactivity concentration does not reflect biological effects but it is the first clue for understanding the biological effect of radiation.

[194] tsunami washed out collapsed houses, cars, woods, ships, aquaculture facilities, fixed fishing nets, cargo containers, etc. More than 90% of floating debris is parts of collapsed houses and driftwoods, which are difficult to sink.

portion of the later (3.5 million tons) is considered to have deposited on seabed along Japan's coast, and remaining 30% become floating debris. Since 2011 some 1.5 million tons of debris has been collected or sunk, and the amount of floating debris still drifting is considered to be less than 1.5 million tons.

By March 2014 processing of all disaster debris and tsunami deposits were completed with exception of some (Evacuation) areas of Fukushima Prefecture [Reconstruction Agency 2014]. The official data indicate that almost all disaster debris were removed (99%) as treatment and disposal of 97% of them completed (over 80% recycled) (Figure 50). Similarly, around 96% of the tsunami deposit were removed and processing of 92% finished (almost all recycled). Approximately 85% of debris and nearly all of the tsunami deposits can be recycled, and materials used in public works projects in disaster-affected area [Ministry of Environment, 2014].

Figure 50. Processing rate of disaster waste in coastal municipalities (percent)



Source: Reconstruction Agency

The major issues associated with the cleaning have been the availability and selection of storage sites, methods of incineration, decisions about recycling, and waste treatment and disposal [International Bank for Reconstruction and Development, 2012].

Debris swept away by tsunami are still drifting in the Pacific Ocean with much of it washing ashore in North America [The Japan News, March 22, 2014]. According to the officials western U.S. coastline will continue to see debris for years to come contaminating seawater and beaches. It is estimated that about 400-thousand tons of the 1.5-million tons of debris adrift in the Pacific Ocean could reach the US and Canada by October 2014 [NHK World, May 5, 2014].

There have been found shellfish and algae native to Japan on debris that has already washed ashore causing concern about the creatures' possible impact on ecosystems [NHK World, May 5, 2014]. Japan's Environment Ministry has launch a 3 years study (starting July 2014) to find out whether the 2011 tsunami debris carries living organisms from Japan and what is their possible impact on ecosystems on North America's west coast.

Recently the International Atomic Energy Agency (IAEA) sent marine experts[195] to Japan to report their analysis of the seawater off the coast of Fukushima nuclear plant, and compare results from Japanese and IAEA laboratories to assess accuracy of Japanese data [NHK World, November 1, 2014]. The IAEA has been advising Japan to disclose comparative analysis of the results of more than one institution to enhance transparency and ease concerns of neighboring countries.

A large-scale decontamination of soils, waters, infrastructure, property etc. has been going on involving central and local authorities, private and collective organizations, individual and communities efforts, etc. Consequently, a good progress has been achieved in cleaning up residential and natural environment in many places.

A pilot work for forest decontamination in 4 Fukushima localities[196] started in September 2014 (for completion March 2015), covering a forest area tens of hectares wide in each selected municipality [Fukushima Minpo News, July 31, 2014]. The demonstration work seek to lay the groundwork for resuming forestry business and reducing anxiety among evacuees hoping to return to hometowns as well identify effective methods of decontamination and ways to minimize workers' exposure to radiation.

According to some experts the undertaken large-scale decontamination by the authorities and at grass-room level[197] would create new environmental problems such as: huge amounts of radioactive waste, removal of top soil, damage to wildlife habitat[198] and soil fertility, increased erosion on scraped bare hillsides and forests, and intrusion by people and machinery into every ecosystem scheduled for remediation etc. [Bird, 2012].

September 2014 data indicate that in temporary storage sites (in Kotakizawa, Jikenjo, Shin-Baba, Baba, Goshi and Ogita districts) where removed soil has been collected and stored, the air dose rate at the entrance of the sites shows no difference after removed soil is stored, and radioactive materials has never been detected from leachate or groundwater under the sites [Ministry of Environment, 2014].

In July 2014 TEPCO reported that it recovered about 80% of a radioactive substance that leaked with contaminated wastewater in 2013[199]. The substance with the highest concentration in the water was radioactive strontium with an estimated 45 trillion becquerels of radioactivity [HNK World, July 2014]. Most strontium has been recovered by collecting soil soaked with the contaminated water while remaining 20% likely seeped into soil below tanks and other facilities. According to TEPCO the substance remains in the soils and it is highly unlikely that it was carried into the sea by underground water.

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[195] From Environment Laboratories in Monaco who collected samples in September to examine the effects of radioactive materials on the ocean's ecosystem.

[196] 30 ha in Tamura city's Miyakoji district (evacuation order lifted in April, 2014); 10 ha each in Minamisoma city's Odaka district and Iitate village's Nimaibashi district; and 30 ha in Kawauchi village's Modo district (last three districts are designated as areas preparing for lifting of evacuation orders). Locations are privately owned where the central government is to undertake decontamination.

[197] E.g. in Iitate-mura villagers have been carrying decontamination actions and trials with support of a recovery group "Resurrection of Fukushima" [NHK World, December 9, 2013].

[198] Including negative impact on some species on the Fukushia prefecture's Red List of endangered or threatened species (such as "vulnerable" grassland butterfly and the Japanese peregrine falcon).

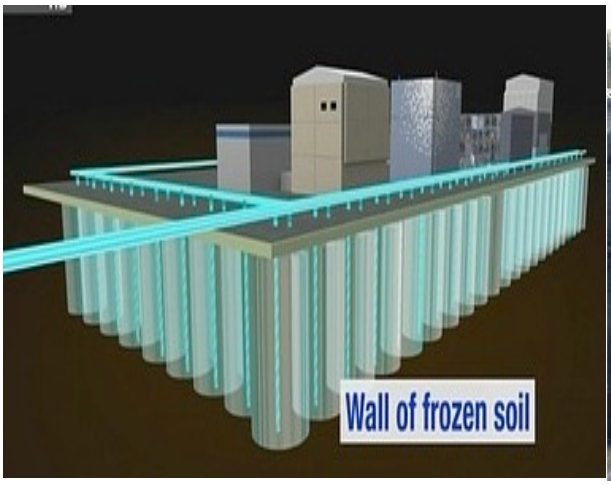
[199] In August 2013 about 300 tons of wastewater contaminated with radioactive substances leaked from a storage tank at the plant.

TEPCO recently revised its storage plan[200] with planning to build additional tanks to store 100,000 tons of radioactive water at the nuclear plant. Tanks at the cite can store about 480,000 tons of radioactive water, but 90% of the 1000 storage tanks are already full [NHK World, April 4, 2014]. Company expects the amount of contaminated water to be less than 800,000 tons by March 2016. More tanks are added in case the planned one are not enough or preventative measures (including frozen underground walls) do not work as well as planned [NHK World, July 14, 2014].

In April-November 2014 TEPCO tried to freeze radiation-contaminated water in underground tunnels in order to prevent water used to cool melted-down fuel to leak out of reactor buildings into tunnels where it mix with ground water, seep into the ground and end up in the sea[201]. In November the company gave up that plan (water did not freeze) and announced that underground tunnels containing radioactive water will be blocked off by newly developed cement[202] [NHK World, November 21, 2014].

A separate and larger project has been underway to freeze soil and create a wall of ice 1.5 km stretch around the four reactor buildings (Picture 8). TEPCO plans to lay 1,500 meters of pipes around the four reactor buildings hoping to complete the construction work by the end of March 2015 and start circulating refrigerant of minus 30 C[203]. The ice walls are intended to prevent groundwater from coming into the reactor building basements, which are filled with highly contaminated water from operations to cool the overheating reactors. The work has been delayed due to a suspension in freezing the water in the tunnels as part of the work areas overlap.

Picture 8. Wall of frozen soil in Fukushima plant



Source: NHK World, July 23, 2014

Picture 9. Bags with contaminated soils

Source: Yomiuri Shinbun, December 9, 2014

[200] Previous plan included building tanks to store 830,000 tons of water by the end of March 2015.

[201] Utility tunnels between the 2 and 3 reactors and the sea are estimated to hold a total of 11,000 tons of radiation-contaminated wastewater. TEPCO hopes to remove wastewater from tunnels around all reactors in fiscal 2014 [NHK World, June 16, 2014].

[202] latest plan will not affect the larger project to freeze soil and create a wall of ice around reactors.

[203] so that two-meter thick frozen soil walls will be created within a few months.

There has been also many technical problems such as failures in cooling systems, multiple leakages, high radiation at the plant cite, delays and/or changes in plans, etc. [NHK World, April 4, April 13, May, 31, June 4, June 9, June 10, June 19, June 22, July 8, October 22, October 30, 2014]. All that has been coupled by high uncertainties on state of affairs and risks, and likely effects of undertaken actions.

For instance, the effects of the groundwater bypass operation[204] intended to reduce the amount of radiation-tainted water at the plant has been apparently having limited effects [The Japan News, June 28; NHK World, July 25, 2014]. In the first 2 months water levels at observation wells near the reactor buildings[205] dropped by only around 10 cm at most. Water levels tend to rise after rains and it is vital to reduce the amount of rainwater infiltrating the soil but little progress has been made due to a delay in land leveling[206]. It has been also found that Cesium in groundwater rises at plant after storm as well water near the embankment was more than 3 times higher (251,000 becquerels of cesium per liter) the level before heavy rainfall from Typhoon Phanfone [NHK World October 15, 2014].

Similarly, some experts warns that there is no reason to place overly high expectations on the ice walls [The Japan News, June 6, 2014]. There are fears associated that if soil is not frozen evenly it could cause subsidence, or if the ice walls melt due to problems with cooling functions, there could be a widespread danger of radioactive water flowing outside the buildings. It is essential to carry out several measures in parallel. The amount of contaminated water has increased by 300-400 tons a day and sooner or later there will be no more sites available for the construction of storage tanks at the plant.

Experts have also pointed out the need to purify contaminated water before discharging it into the ocean [The Japan News, June 6, 2014]. Advanced Liquid Processing System (ALPS) introduced for that purpose has continued to malfunction[207]. Recently TEPCO has unveiled an improved system (sophisticated ALPS) for decontaminating radioactive water[208] planning to put 3 systems into full operation in December 2014 treating 2,000 tons of water daily [NHK World, October 16, 2014].

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[204] groundwater is pumped up from wells near the plant's 1 to 4 reactors before it flows into the basements of the reactor buildings and mixes with high-level radioactive water there. It is temporarily stored at tanks and then released into the sea after radiation checks. Company began to pump up groundwater in early April, and the release of pumped-up water started in late May as more than 8,600 tons of groundwater have been released into the Pacific so far [The Japan News, June 28, 2014]. The fishermen's federation (regardless of differences in opinions) accepted the plan [NHK World, March 31]. Water bypass operation, once fully implemented, will reduce the the daily buildup up of highly radioactive water at the plant to 100 tons down from roughly 400.

[205] 3 wells located 70 to 150m from the reactor buildings.

[206] Current plan is to cover soil near the wells with asphalt by the end of March 2015 to keep rain from seeping into the ground [NHK World, July 25, 2014].

[207] Current system is supposed to be capable of treating up to 750 tons of water daily with its 3 processing lines but its operation has been plagued by trouble. A second version of system started trial operations in September 2014.

[208] The new system can process more than 500 tons of water a day with only one line and it is expected to leave less radioactive waste and be less prone to glitches.

TEPCO has showed a system to remove radioactive substances from tainted underground water before releasing it into the sea. The utility plans to discharge well water from around reactor buildings at the facility to stem the buildup of contaminated water[209]. The officials say the system removed most radioactive materials to undetectable levels in trial runs but its plan has met opposition from local fishermen [NHK World, October 16, 2014].

One of the TEPCO's engineers properly described the progress as "trial and error continues" since dealing with new technology and equipment, making mistakes, and are unknown results [NHK World, July 4, 2014].

Furthermore, the process of decommissioning the nuclear reactors is at the beginning stare and is expected to last 30-40 years[210] and associated with many challenges such as lack of experiences, available technologies, uncertainties and risks, public concerns, lack of disposal cite, etc. [NHK World, August 2, 2014]. For instance, there is a lots of uncertainty related to the state and schedules of operations – e.g. it is extremely difficult to remove melted fuel from the No.1 to No.3 reactors. Operation schedule is to start work at the No.1 and 2 reactors in fiscal 2020, and at the No.3 in fiscal 2021, but workers still do not know where or in what state the fuel lies as a result of the meltdowns at the 3 reactors [NHK World, October 22, 2014].

In October 2014 it was announced that the decommissioning of Fukushima reactors may be further delayed [NHK World, October 16, October 22, 2014]. The work was to begin in July 2014, but have been delayed after radioactive dust from the plant was blamed for contaminating rice paddies when the operator removed debris from the plant's No.3 reactor in August 2013[211].

The No.1 reactor building has a cover to prevent massive amount of radioactive material from spreading. TEPCO began drilling holes in the ceiling and spraying chemicals inside to stop dust from spreading, planning partially to remove the cover in late October. The operator hopes to begin full-scale dismantling of the cover in March 2015 and complete the task in about a year[212]. The government and TEPCO set a timetable for removing fuel out of the storage pool at the No. 1 reactor from the reactor building after April 2017, but delays are also likely.

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[209] About 300 tons of underground water is flowing into the buildings daily. Tainted water is believed to be leaking into the sea with underground water.

[210] With first stage (removal of 270 tons of fuel from 3 melted reactors) around 20 years and disposal and dismantling another 15 years. Decommissioning work has progressed fastest at the No.4 reactor where nearly 90% of the fuel rods have been removed and work is to end in 2014. Removal of fuel from the No.3 reactor building is to begin in fiscal 2015, and work at the No.1 and 2 buildings in fiscal 2017. Radiation levels remain extremely high in the No.2 building and there is no specific schedule for fuel rod removal there [NHK World, October 22, 2014].

[211] Recently the Nuclear Regulation Authority announced that it is highly unlikely that radioactive particles from the Fukushima nuclear power plant contaminated rice fields [NHK World, October 31, 2014]. Removal work released dust particles with 110 billion becquerels of radiation with relatively large diameters of several micrometers. According to the authority such particles had an environmental impact only in the plant compound and rice paddy contamination may have come from river and ground water [NHK World, October 31, 2014].

[212] debris removal is planed to begin before October 2016.

Last but not least important, up to date, it has been difficult to secure cites for long-term and permanent disposal of radioactive waste [NHK World, April 7, June 15, 2014; The Japan News, March 8, 2014]. Until now contaminated soil, leaves, and mud removed during decontamination work, and other radioactive waste have been stored at temporary sites across Fukushima prefecture (Picture 9) at more than 70,000 locations [The Japan News, December 9, 2014].

According to expert there are 3 million tons of tainted biomass in Fukushima and its disposal is a big challenge [The Japan Times March 23, 2014]. In addition, there have been collected a huge amount of contaminated soils, debris, incinerated ash, mud from sewage, straw, etc. located in Tokyo and 11 other prefectures. In the end of March 2014 there are a total of 143,689 tons of materials defined by the Government as "designated waste" [213] [The Japan News, July 9, 2014]. The later contain radioactive substances measuring more than 8,000 Bq/kg, and according to law[214] should be handled in the prefecture where it originated under the responsibility of the central government.

A site for the final disposal of radioactive waste has not been chosen yet. There is a government plan to build interim storage facilities in Okuma and Futaba to store contaminated soil, waste and ash from burned contaminated materials[215]. These sites are to operate for up to 30 years but residents of candidate places continue to suspect that they will eventually be used for final disposal facilities and insist for safeguards [NHK World, May 27, June 8, 2014]. Some residents are also against since the storage facilities would harm the towns' image and make it difficult to restart farming due to consumers concerns about safety of agricultural products [NHK World, June 2, 2014]. Besides, some residents complained about the offered price, saying it's not enough to rebuild their lives[216] elsewhere but government has no revised the planned purchase prices [NHK World, October 14, 2014].

Meanwhile, Government is proceeding with the plan seeking residents' understanding while briefing residents about safety measures related to transportation and storage of radioactive wastes [NHK World, May 28, June 7, June 15, September 30, 2014]. Late August 2014 the prefectural government and the host towns formally accepted the construction of storage facilities on their territories [Fukushima Minpo News, August 31, 2014].

In November 2014 both Houses of the Diet approved Fukushima waste bill for the construction of temporary storage facilities[217] for radioactive waste near the crippled nuclear plant [NHK World, November 4, 19, 2014]. The bill obliges the government to ensure to ensure the waste is safely stored in the facilities and complete within 30 years the final

[213] containing radioactive substances measuring more than 8,000 Bq/kg.

[214] on special measures concerning the handling of pollution from radioactive materials.

[215] They will able to accommodate enough waste to fill Tokyo Dome more than 20 times and will dispose waste containing up to 100,000 Bq/kg of radioactive materials. Government plans to purchase 16 square km of land in the area and start transporting radioactive soil to the facilities in January 2015.

[216] Government plan to purchase land at around half of its value before the nuclear accident as compensation for housing would depend on the age of buildings [NHK World, September 30, 2014]. Landowners who decline to sell but allow usage of plots would be paid 70% of the purchase price. Prefecture would cover the difference between pre-disaster value and the amount of compensation.

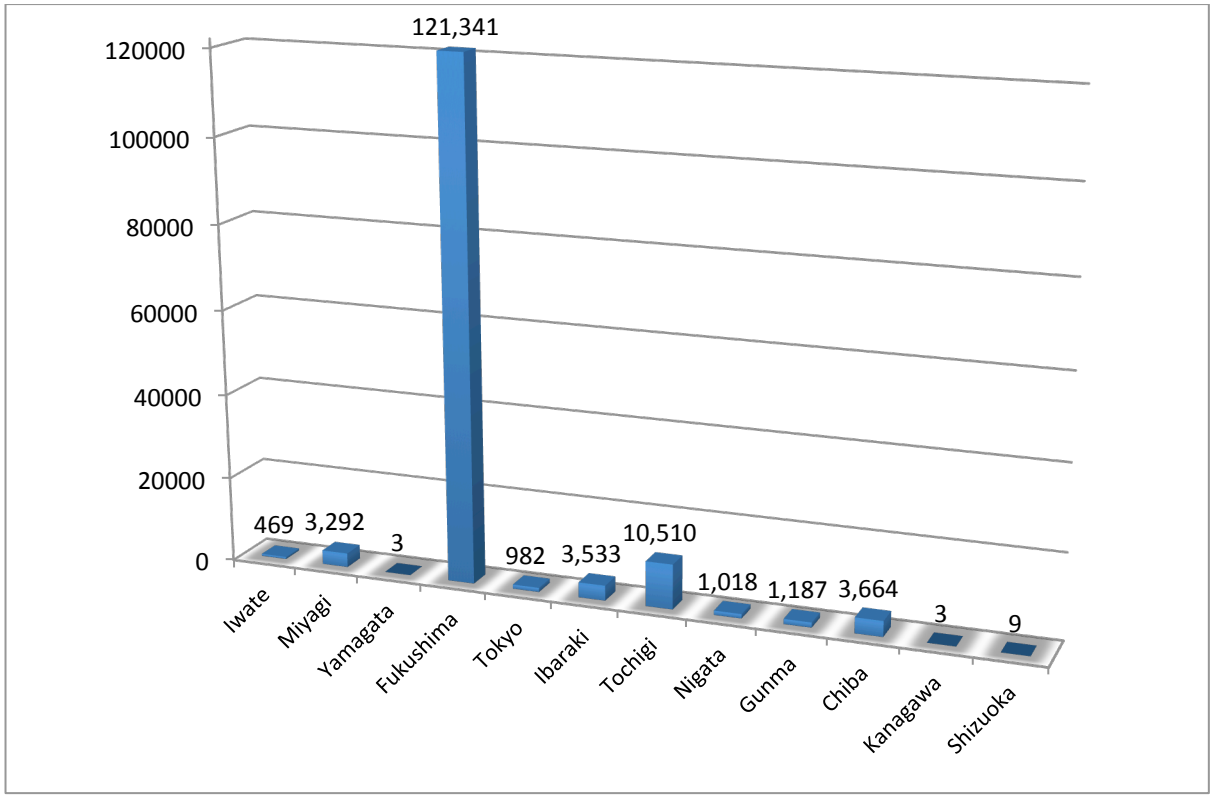
[217] The government acquires all shares in a state company (Japan Environmental Safety Corporation) that will run the business of storing nuclear waste

disposal of radioactive waste (including contaminated soil) after moving it outside Fukushima prefecture.

Furthermore, the government announced it will set superficies (surface) rights for land allowing landowners to keep property rights for the land[218] to be used for building temporary storage facilities [NHK World, July 28, 2014; The Japan News, July 29, 2014]. In addition, 820-million dollars of grants will be handed over directly to the 2 towns as a part of the 3 billion dollars in subsidies that will be given to the prefecture and municipalities to help rebuild communities and peoples' lives [NHK World, August 26, 2014].

A little progress has been also made in deciding on final disposal facilities locations for handling more than 146,000 tons radioactive waste from the Fukushima nuclear crisis in Tokyo and 11 other prefectures (Figure 51). For instance, up to date one of the warehouses storing rice straw (supposed to be used as livestock feed) covered in sheets of silver foil to protect against the sun's rays, stands in area of farming paddy in Tome, Miyagi Prefecture[219] [The Japan News, September 12, 2014].

Figure 51. Amount of Designated waste in Japan, June 30, 2014 (tons)



Source: Ministry of Environment

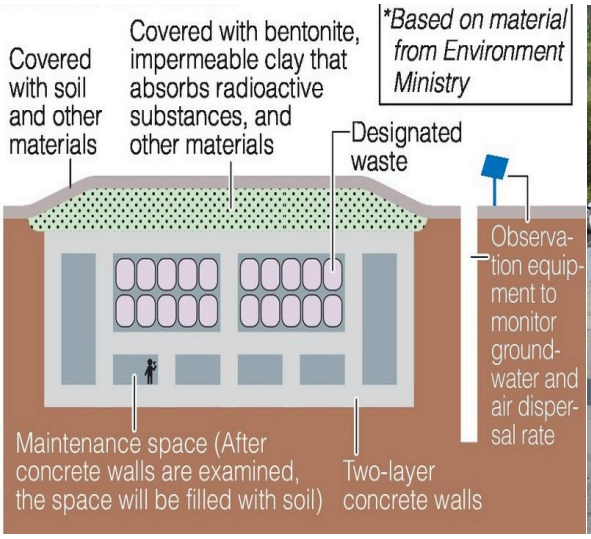
[218] Initially, the government planned to buy land for the temporary facilities to ensure stable management but some landowners refuse to sell. Local communities claim attachment to ancestral land and fear that temporary facilities would become final disposal sites if the land is nationalized.

[219] City government initially explained that the warehouses would be kept in the farmer's vicinity for only two years (until January 2014).

The central government[220] plans to construct a safe concrete double-walled structure underground to contain buried designated waste (Picture 10). Waste will be put into containers and bags, which will then be stored inside a concrete double walled structure to be buried underground, and after being buried that the structure will be covered with a second layer of concrete and soil[221] [The Japan News, July 9, 2014].

The government has been considering locations to newly build final disposal in five prefectures (Miyagi, Tochigi, Ibaraki, Gunma and Chiba) because there are large amounts of "designated waste"[222] [The Japan News, July 9, 2014]. Local residents have been strongly opposing to the construction of facilities due to fears about radiation, environmental threat, and risk that agricultural products will become unsellable (Picture 11). In 2014 the Environment Ministry officials held meetings with officials from Miyagi prefecture and the three "candidate" municipalities (Kurihara, Taiwan and Kami) on one of which territory it aims to construct the final disposal facilities but all municipalities opposed.

Picture 10. Plans for final disposal facility for designated radioactive waste



Source: Ministry of Environment

Picture 11. Kami residents against construction of final disposal facilities

Source: The Yomiuri Shimbun, July 9, 2014

There are nine temporary storage facilities for designated waste on the premises of the Teganuma sewage treatment facility in Chiba prefecture. Each of them stores 526 tons of designated waste generated in Matsudo, Kashiwa and Nagareyama in the northwestern part of the prefecture. Since the later do not have adequate storage facilities, the prefecture accepted

[220] The central government is responsible for the disposal of "designated waste" in each prefecture.

[221] Amount of additional radioactivity along the borders of facilities' premises is expected to be less than 0.01 millisievert a year and "health risk negligible" (average radiation dosage in nature is 2.1 millisieverts per year).

[222] Material from the Fukushima Daiichi nuclear accident that has radiation levels exceeding 8,000 Bq/kg. For prefectures with small amounts of designated waste plans are to bury the waste underground in existing disposal facilities [The Japan News, September 12, 2014].

their waste at the sewage facility on a "temporary basis", with a time limit set for the end of March 2015 [The Japan News, July 9, 2014].

In Tome, storing Miyagi prefecture's largest amount of designated waste (like straw), the difficulty of securing storage sites has led to some waste being stored by individuals. Much of the radioactive waste in Nasu-Shiobara, Tochigi prefecture is also temporarily stored on private property. Local officials and people in these places fear that if situation is prolonged for a long period of time waterproof sheets used to store designated waste will deteriorate. Residents near the sewage facility in Chiba prefecture filed a lawsuit demanding the elimination of the storage facilities.

The government needs to create the disposal facilities[223] because storage is reaching capacity in 5 prefectures [NHK World, July 30, 2014]. In response to the failure of previous administration to select cites "without consulting local residents", the current government revised the process as municipal councils were set up in every prefecture to decide on selection methods while taking into consideration local residents preferences [The Japan News, July 9, 2014].

Up to now only three prefectures (Chiba, Tochigi and Miyagi) decided on their selection process of candidates. The government was able to propose the candidate sites in Miyagi Prefecture (Kami, Kurihara and Taiwan) but local opposition is strong, and final decision is not made and planned field surveys blocked by residents [NHK World, October 24, 2014].

The government has also chosen a state-owned property in Shioya town, Tochigi prefecture as a possible final disposal site for radioactive waste [NHK World, July 30, August 18, 2014]. The local government and citizens have been opposing saying it will have a negative effect on natural water resources and local agricultural and food products[224]. The mayor suggested a counterproposal on radioactive waste[225] calling for all radioactive waste to be stored at an intermediate facility in a no-entry evacuation zone on the Daiichi plant compound [NHK World, November 7, 2014].

Recently government allocated ¥5 billion in 2014 fiscal year's budget to five prefectures (Miyagi, Tochigi, Ibaraki, Gunma and Chiba) to carry out regional developments and take measures to counter harmful rumors hoping it will help win understanding of local residence.

The Atomic Energy Agency is reported to be looking at the direct disposal of spent nuclear fuel instead of reprocessing it[226] [NHK World, July 29, 2014]. The government has long maintained the policy of reprocessing all spent nuclear fuel[227] and conducted few studies about disposing it as waste. A basic energy plan adopted in April 2014 upholds the nuclear

[223] They are for sewage sludge, incinerated ash, and other waste contaminated with more than 8,000 Bq/kg of radioactive materials.

[224] In September 2012, the ministry chose a state-held forest in Yaita City as the prefecture's candidate site but the plan faced criticism and it had to start the selection process again. In October the mayor of Shioya and the leader residents group handed petition to the Minister - population is 12,000 but the petition was signed by about 173,000 from across Japan [NHK World, October 29, 2014].

[225] state should pay sufficient compensation to Fukushima and dispose radioactive waste in one place.

[226] Agency's draft report says it is technically possible to directly dispose of spent nuclear fuel at a low radiation level. If spent nuclear fuel is buried 1,000 m underground for 1 million years, the radiation level at the earth's surface will peak in 3,000 years, at 0.3 microsieverts per year.

[227] extract plutonium and reuse it as fuel at nuclear power plants.

fuel recycling policy but for the first time it called for studies on ways to directly dispose of spent fuel without reprocessing it [NHK World, July 25, 2014].

A series of challenges led to the later move: a reprocessing plant in Rokkasho Village, Aomori prefecture has suffered numerous troubles being unable to start full operation more than 20 years since construction began; nuclear power plants have accumulated 17,000 tons of spent nuclear fuel; fast breeder reactor Monju, Fukui prefecture is designed to use recycled plutonium but facility has been plagued by troubles[228] and its future is uncertain.

The agency's analysis is expected to lead to greater discussions on how to deal with the stockpile of spent nuclear fuel and wastes. Spent nuclear fuel is known to have higher radiation levels than high-level radioactive waste, and compared to reprocessing, direct disposal would mean more than a 4-fold increase in nuclear waste volume. Besides, the government lacks any prospect of finding a place that would accept a nuclear dumpsite.

Top officials at the Nuclear Waste Management Organization of Japan charged with the selection and construction of the final disposal facilities, were replaced recently in view of the planned restart of nuclear power plant operations. Since 2002 the Organization charged with the selection and construction of the final disposal facilities has been asking municipal governments to indicate willingness to accommodate the final disposal facilities [The Japan News, July 23, 2014].

Until now only one local government (Toyo, Kochi prefecture) has announced its candidacy (2007) but its efforts have been buckled under opposition from local residents. In December 2013 the central government switched to a policy in which it would play a leading role in narrowing down prospective candidate sites beforehand and then requesting two or more municipal governments to accommodate the facilities.

The central government plans for radioactive waste to be mixed with glass, and the vitrified waste to be stored in metal containers buried at least 300 m deep underground[229]. Some in the government voiced a cautious view that presenting candidate sites before the local elections next spring will cause disarray, and the candidate sites will most likely be presented after that [The Japan News, July 23, 2014].

All these difficulties and uncertainties make it difficult to access the full environmental impact of the March 2011 disasters, and require a long-term monitoring of effects on the individual components and entire ecosystems [ISHES, 2011; ME, 2012a; UNSCEAR, 2014; WWF, 2013].

A 2014 government report points out that the release of radioactive materials following the Fukushima nuclear accident remains Japan's biggest environmental problem [NHK World, June 6, 2014]. What is more, Japan emitted the largest amounts of greenhouse gases on record[230] in the fiscal 2013 (a climb of 1.6% since 2012) blamed on the increased use of fossil fuels (including coal) since the 2011 nuclear disaster [NHK World, December 5, 2014].

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[228] including a fire and failed inspections.

[229] Final disposal facilities are to be about 6 sq. km to accommodate at least 40,000 metal containers. Existing amount of spent nuclear fuel is equivalent to 25,000 such metal containers (stored at nuclear plants and other sites). Many nuclear plants already have no more room to store spent nuclear fuel.

[230] 1.395 billion tons - most since comparable data are available (1990) and 1.3% up from the 2005 levels. By 2020 the target is to cut emissions by 3.8% from the 2005 levels.

At the same time, people's enthusiasm for power saving fades down from increased willingness to save power after rolling blackouts following Fukushima crisis. Recent survey shows that 60.7% of respondents wanted to save power, set air conditioning temperatures at appropriate levels or take other measures to curb global warming (down from 71.9% in June 2012 survey) while purchasing environmentally friendly products was cited by 36.9% (down from 47.4%) [The Japan News, September 25, 2014].

Conclusion

The unprecedented triple disaster in Northeast Japan in March 2011 was among the worst in the Japanese and world history. The earthquake, tsunami and Fukushima nuclear accident have had immense impacts on diverse aspects of people life in the most affected regions, the rest of the country, and beyond. Agriculture, food industry and food consumption have been among the worst hit.

The excellent individual and community disaster preparedness, and well-established national system of disaster management, have been a major reason for the adverse impacts to be much lower that it would have been elsewhere in a similar disaster. Furthermore, a superior disaster recovery experience, good organization, and enormous public support from government, other organizations, volunteers, etc. have allowed a rapid recovery and a successful reconstruction of a great part of devastated regions and sectors. For home country of one of the book coauthors (Bulgaria) a recovery from such a disaster certainly would have taken decades.

Almost four years after the disaster there are still a number of challenges associated with the recovery and reconstruction in Tohoku region and elsewhere. They are mostly related with a big number of evacuees with destructed life and businesses (temporary accommodation, health problems, lost relations and employment, etc.), continuing outmigration from the badly affected areas, slow pace of rebuilding of devastated infrastructure, housings and businesses, prolong decontamination process in some places, on-going crises in Fukushima nuclear plant, consumer reluctance to visit and buy products of affected regions, etc.

In addition, the 2011 disasters have considerably aggravated some already existing problems of the rural regions such as: aging and shrinking population, lack of labor and young entrepreneurs, low competitiveness and efficiency, income and services disparities, etc. Subsequently, the speed and extent of disaster recovery and post-disaster reconstruction differ quite substantially among individual agents, (sub)sectors, and (sub)regions. Besides, there are great uncertainties associated with the long-term social, health, economic, environmental, policy etc. consequences of the 2011 disasters.

On the other hand, the disasters have had positive impacts on the development of certain (more resilient, adaptive) sectors in the most affected regions and some (traditional, prospective) sectors in other parts of the country. The post disaster recovery and reconstruction have also given opportunities and induced considerable policies and institutional modernization in various (energy, agricultural, security) sectors, and improve disaster prevention and management, food safety information and inspection, technological and product innovation, jobs creation and investment (including in “new” areas such as research and innovation, ICT, renewable energy, robotization), farmlands consolidation and enhancement, infrastructural amelioration, organizational restructuring, etc.

Not least important, the failures of government bureaucrats to foresee, prevent, communicate, and deal with the March 2011 disaster and its consequences have thought individual agents to take decentralized actions – self-recovery and reconstruction, community and business initiatives, private and collective safety checks and decontamination measures,

voluntary shipment restrictions, new production and marketing methods, movements for fundamental policies change, etc.

This study was just an attempt to assess the overall impact of the March 2011 disasters Understandably the research is incomplete due to the "short" period of time after the disasters, insufficient and controversial data, difficulties to adequately assess longer term implications, etc. Therefore, more future studies are necessary to evaluate and update the "known" impacts of the 2011 disasters. Besides, further in depth "micro" studies are needed to fully understand and estimate the impacts of the disasters in each location and community, type of enterprises and productions, and component of supply chain, etc.

There are a number of major lessons that can be learned from the study of the March 2011 disasters' impact on and post disaster reconstruction of agri-food sector in Japan.

First, the triple March 2011 disaster was a rare but a high impact event, which came as a "surprise" even for a country with frequent natural disasters and well-developed disaster risk management system like Japan. Therefore, it is necessary to "prepare for unexpected", and design, build and test a multi-hazard disaster risk management for the specific conditions of each country, region, sector, etc. Accordingly appropriate measures and sufficient resources (funding, personnel, stock piles, shelter cites, transportation means) have to be planed for the effective prevention, early warning, mitigation, response, and post disaster relief and recovery from big disasters and accidents. Besides state resources it is important to mobilize huge private, community, NGOs, and international capabilities, expertise and means. For instance, a public-private partnership is necessary to properly identify and designate available public and private resources (accommodations for a longer stay, relief supply, etc.) in case a big disaster occurs and evacuation needs arise.

Second, the risk assessment is to include diverse (health, dislocation, economic, behavioral, ecological, etc.) hazards and complementary, (food, supply, natural, biological) chain, spin offs, and multilateral effects of a likely (natural, man made, combined) disaster. Modern methods and technologies are to be widely employed (mass and social networks, computer simulation, satellite imaging, etc.) for effective communication, preparation of disaster maps, assessment of likely impacts, planning of evacuation routs, relief needs, and recovery measures, secure debris and waste management, etc. It is crucial to involve multidisciplinary and multi-stakeholders teams in all stages of risk management to guarantee a holistic approach, "full" information and transparency, adequate assessment of risks, preferences and capabilities, and maximum efficiency.

Third, the risk management system is to be discussed with all stakeholders, and measures taken to educate and train individuals, organizations and communities for complex disasters and all contingencies. The individual responsibilities are to be well-specified and effective mechanisms for coordination of actions of authorities, organizations, and groups at different levels put in place and tested to ensure efficiency (speed, lack of duplication and gaps) during emergency. Individual and small-scale operators dominate in the agri-food sector of most countries around the world, and their proper information, training, and involvement is critical. The later is to embrace diverse agri-food and rural organizations, consumers, and population of each age group, which all commonly have no disaster management "culture", knowledge, training, and plans (particularly for large disasters like earthquakes, tsunamis, nuclear and industrial accidents).

Forth, it is necessary to modernize the specific and overall formal institutional environment (property rights, regulations, safety standards, norms) according to the needs of contemporary disaster risk management. A particular attention is to be put on updating agri-food safety, labor, health, and animal welfare standards, and ensure adequate mechanisms, qualified agents, and technical instruments for effective implementation and enforcement. Establishment of an accessible cooperative, quasi public or public agricultural (crop, livestock, machineries, building, life and health) insurance system, including assurance against big natural, nuclear etc. disasters is very important for many countries for rapid recovery of affected agents and sectors. Modernization of the out of dated (often informal) lands, material, biological and intellectual property registration and valorization system is also important for effective post disaster compensation, recovery and reconstruction. That is particularly true for the great number of subsistent and "semi-market" holdings dominating the agro-food sector around the globe, which usually suffer significantly from disasters (often losing all possessions) but get no market valuation, insurance and/or public support.

Sixth, it is important to set up mechanisms to improve efficiency of public resource allocation, avoid mismanagement and misuse of resources as well as reduce individual agents' costs for complying with regulations and using public relief, support and dispute resolution (e.g. court) system. That would let efficient allocation of limited social resources according to agents needs and preferences, intensify and speed up transactions, improve enforcement (of rights, laws, standards) and conflict resolution, decrease corruption, and eventually accelerate recovery and reconstruction. In this respect it is obligatory to involve all stakeholders in decision-making and control, increase transparency etc. at all levels and stages of disaster planning, management, and reconstruction. In the case of a post-disaster evacuation it is essential to secure proper (police, voluntary group) protection of private and public properties from thefts and wild animal invasion in disaster and evacuation zones.

Seventh, different agents and elements of agri-food chain are affected unlikely from a disaster and have dissimilar capability to recover. Most farming assets (multiannual crops, irrigation facilities, building, brands, biodiversity, landscape) are interlinked with the land, and if the later is damaged a rapid recovery (rebuilding, relocation, alternative supply) is very costly or impossible. Similarly, smaller-scale and highly specialized enterprises, small-member communities and organizations, and visitors and tourists to the disaster regions, are all more vulnerable and have less ability to protect, bear consequences and recover. All that require differential public support (intervention, compensation, funding, assistance) to various types of agents it order to provide emergency relief, accelerate recovery and diminish negative long-term consequences.

Eight, there is also a strong "regional" specificity (interdependency) of agrarian, food and other rural assets. Subsequently, if a part of these assets/products is damaged or affected (e.g. destruction of critical transportation, communication, distribution, electricity and water supply etc. infrastructure; a nuclear, chemical, pathogen etc. contamination) the negative externalities impact all agents in the respective region (including undamaged lands, livestock, produce and services). In order to minimize damages it is important to properly identify (locate) risk and take prevention measures, recover rapidly critical infrastructure, strictly enforce quality (safety, authenticity, origin) of products and adequately communicate them to

all interested parties (producers, processors, distributors, consumers, international community).

Ninth, good management of information and communication is extremely important in emergency, recovery, and post disaster reconstruction operations. The March 2011 disasters have proven that any delay, a partial release or controversies of official information have hampered the effective (re)actions of agents, and adversely affected public trust and behavior (e.g. buying products from disaster regions). Before, during and after a disaster all available (risk, monitoring, measured, projected) information from all reliable sources is to be immediately publicized in an understandable by everyone form through all possible means (official and community channels, mobile phones, social media, etc.). It is essential always to publish alternative (independent, private, scientific, international) information as well, including in foreign languages, which would build public trust and increase confidence. In Japan it has not been easy to find all available information related to the Match 2011 disasters in a timely and systematized way (updates, diverse aspects, unified measurement, time series, alternative sources), which make many foreigners and local alike skeptical about accuracy.

Tenth, a big disaster like the Match 2011 in Japan often provides an extraordinary opportunity to discuss, introduce and implement fundamental changes in (agricultural, economic, regional, energy, disaster management) policies, improve disaster management and food security, modernize regulation and standards, relocate farms and houses, consolidate lands and operations, upgrade infrastructure, restructure production and farming organizations, introduce technological and business innovation, improve natural environment, etc. All such opportunities are to be effectively used by central and local authorities through policies, programs, measures, and adequate public support given for all innovative private and collective initiatives in the area.

Eleventh, it is important to learn from the past experiences and make sure that "lessons learned" are not forgotten. The impacts and factors of a disaster, disaster management, and post disaster reconstruction are to be continuously studied, knowledge communicated to public, and "transferred" to next generation. It is critical to share "good" and "bad" experiences with disaster prevention, management and recovery with other regions and countries, in order to prevent that happening again. It is particularly important to share the advance Japanese experience at international scale through media, visits, studies, conferences, etc. and turn Tohoku in a disaster risk management hub for other regions and countries. It is essential not to copy but adapt the positive Japanese experiences to the specific (institutional, cultural, natural) environment and risks structure of each community, subsector, region, and country.

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