AGRICULTURAL IMPACTS

OF THE GREAT EAST JAPAN EARTHQUAKE – SIX YEARS LATER

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AND

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Preface

On March 11, 2011 the strongest ever recorded in Japan earthquake occurred, also known as the Great East Japan Earthquake, which triggered a powerful tsunami and caused a nuclear accident in one of the world biggest nuclear power stations - Fukushima Daichi. More than six years after the triple disaster the overall impacts on Japanese agri-food chains is far from being completelydue 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. This paper presents updates on the impacts of the March 2011 earthquake, tsunami and Fukushima nuclear accident in Japan on country's agriculture and food sector. First, disaster events and their effects is outlined. Second, impact on farms and agricultural resources is estimated. Third, impact on food industries is assessed. Next, extend of radioactive contamination of agri-food products is presented and effects on markets, consumers and international trade evaluated. Chapter summarises responses of different agents, assesses progress and challenges in post-disaster recovery and reconstruction, and withdrawlessons from the Japanese experiences.

Contents

1. 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, natural and institutional environment, etc. in North-eastern Japan and beyond (Abe, 2014; Al-Badri and Berends, 2013; Belyakov, 2015; Biodiversity Center of Japan, 2013; Britannica, 2014; Buesseler, 2014;Fujita et al., 2012; IAEA, 2011; IBRD, 2012; Kontar et al., 2014; NIRA, 2013; Novia and Tatsuo, 2015; Ranghieri and Ishiwatari, 2014; Reconstruction Agency, 2017; Suppasri and Mas, 2013; TEPCO, 2012; UNEP, 2012; Vervaeck and Daniell, 2012; Umeda, 2013; WHO, 2013; WWF, 2013).

There have been numerous publications on diverse impacts of the 2011 disasters including on badly affected Japanese agriculture and food sector (Bachev and Ito, 2013, 2015, 2016; Hamada and Ogino, 2012; JA-ZENCHU, 2011; Johnson, 2011; Koyama, 2013;MAFF, 2017; Sekizawa, 2013; Liou et al., 2012; Miyashita 2014; Murayama, 2012; MHLW, 2017; Monma et al., 2015; Nakanishi and Tanoi, 2013; Oka, 2012; Pushpalal et al., 2013; Todo et al., 2015; Ujiie, 2012; Yasunaria et al., 2011; Watanabe A., 2011; Watanabe N., 2013). Most of the assessment focuses on

the individual disaster (earthquake, tsunami, nuclear accident) and/or aspects of the impact (farming structures, material and economic damages, markets, health, displacement, environment, etc.) while there are few studies on the overall impacts of the three disasters. What is more, 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 on Japanese agri-food chains is far from being completely evaluated 6 years after tragical events.

The goal of this paperis to present updated on socio-economic and environmental impacts of the Great East Japan Earthquake and the Fukushima nuclear disaster on the Japanese agriculture and food sector.

The individuals and households, farms and businesses, communities, material, biological and intellectual properties, institutional and natural environment, etc. all they have been affected by one, two or three disasters (earthquake, tsunami, nuclear accident). First, we identify and assess diverse impacts from the March 2011 disasters on the Japanese agriculture and food chains. Next, we summarize responses of individuals, households, farms, businesses, communities, consumers, stakeholders, and authorities as well as assess the progress and challenges in the post-disaster recovery and reconstruction.Finally, we withdraw lessons from the Japanese experiences and suggest recommendations for improving public policies, and individual, business and collective actions for effective risk management.

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. In addition, we have carried out two expert assessments and numerous in-deep interviews with leading experts in the areas, and representatives of the prefectural governments, farmers, food industries and non-governmental organizations, and affected farmers, business and consumers.

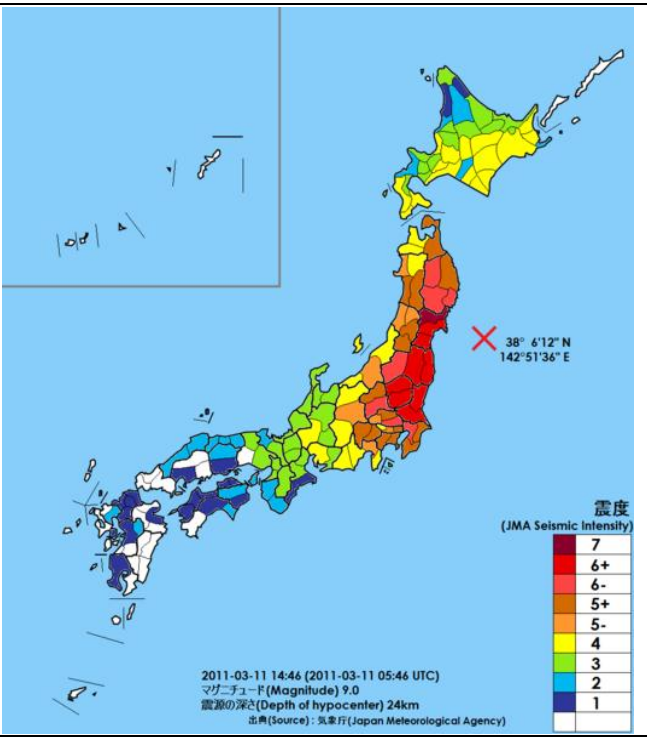
2. The Great East Japan Earthquake Updates

Description of the disaster

On March 11, 2011 at 14:46 Japan Standard Time 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 was with a magnitude of 9.0 Megawatt (Mw) and affected large parts of the country (Map 1).It was the most powerful earthquake ever recorded in or around Japan, and the fourth most powerful earthquake in the world since 1900 (Japan Meteorological Agency, 2013). According to some estimates the 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).

The Great East Japan Earthquake triggered powerful tsunamis that spread over the wide area from Hokkaido Island (North Japan) to Okinawa Island (South Japan). 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). The tsunami inundated a total area of approximately 561 km^2 or 4.53% of the total territories of the six Northeastern prefectures of the main Honshu Island (Geospatial Information Authority, 2011). The most affected was Miyagi prefecture where 16.3% of the territory was flooded by seawaters as in the worst affected by

flooding Wakayabashi words of Sendai 60.4% of the total area was inundated (Map 2).



Map 1. *Epicenter and seismic intensity of March 11, 2011 earthquake*
Source: Japan Meteorological Agency

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 (Photo 1). The tsunami arrived at the plant station around 50 minutes after the initial earthquake. The 14 meter high tsunami overwhelmed the plant's seawalls and damaged cooling systems and control rooms. 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 [1] leading to releases of huge radioactivity into the

[1] International Nuclear Event Scale (INES) runs from 0 (indicating abnormal situation with no safety consequences) to 7 (indicating accident causing

environment (Nuclear and Industrial Safety Agency, April 12, 2011).

Map 2. *Tsunami flooded areas of Sendai*
Source: U.S. Geological Survey

Photo 1. *Fukushima Daiichi Nuclear Plant*
Source: Tokyo Electric Power Company

widespread contamination with serious health and environmental effects). Prior to Fukushima, the Chernobyl disaster was the only level 7 event.

There have been diverse estimates about the total amount of radioactive elements released into environment as a result of the nuclear accident. According to the May 2012 nuclear power plant's estimates the cumulative radiation releases amounts 538.1 petabecquerel (PBq) 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 241, and neptunium-239 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.

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 cesium: 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 (Buesseler, 2014).

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. 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 (NHK World, 2011-2017). 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 (Nuclear Regulation Authority, 2017).

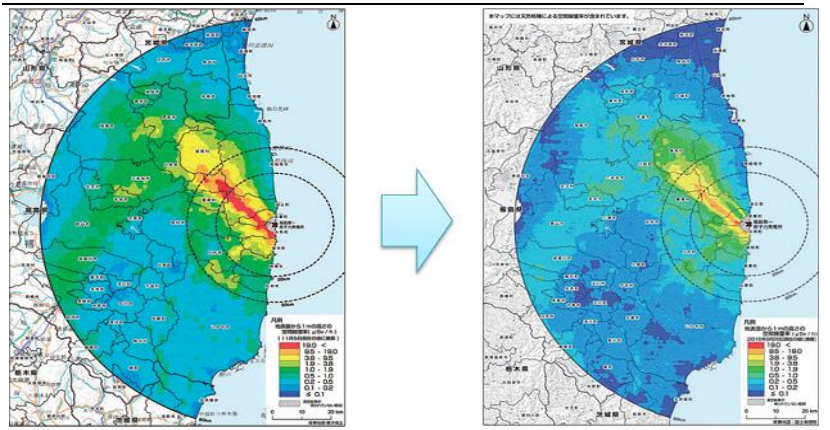
Radioactive contamination from the nuclear plant has spread in the region and beyond though air, rains, dust, water circulations, wildlife, garbage disposals, transportation, and affected soils, waters, plants, animals, infrastructure, and population. High levels of radiation were detected in large areas surrounding the nuclear plant and beyond (Map 3). 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).

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. 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).

Detailed surveys have found out that cesium 137[2] had strongly contaminated the soils in large areas of eastern and northeastern Japan (Yasunaria et al.; Nuclear Regulation 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

[2] 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 Radiological Protection and Nuclear Safety, 2012).

radiation levels that exceeded Japan's allowable exposure rate of 1 mSv per year[3] (Ministry of Education, Culture, Sports, Science and Technology, 2011).



Map 3. *Evolution of air radiation rates in 80 km zone from Fukushima nuclear plant*
Source: Nuclear Regulation Authority

The extent of radioactive contamination of air, waters and soils in Japan has been monitored and updating constantly. In Fukushima prefecture the environmental radioactivity varies according to location, it has been decreasing but it still higher than the levels before the disaster. The average air dose rate decreased significantly and according to the latest data air dose rate within critical places in Fukushima Prefecture is comparable with major cities overseas[4].In other prefectures the environmental radioactivity levels have been stable or decreased but mostly they are still higher than the period before the accident (Nuclear Regulatory Authority, 2017).

[3]On April 19, 2011 the official "safe" radiation exposure levels was drastically increased from 1 mSv to 20 mSv per year.

[4] e.g. Fukushima (0.18), Koriyama (0.11), Shirakawa (0.08), Iwaki (0.07), Aizuwakamatsu (0.06), Minamiaizu (0.04) and Minamisoma (0.07) compared to Seoul (0.11), Beijing (0.07), Singapore (0.10), Berlin (0.08), Paris (0.04), and New York (0.04) (Nuclear Regulatory Authority, 2017).

Human damages and health effects

The March 2011 earthquake and resulting tsunami killed almost 15,900 people, injured more than 6,100 and destroyed the lives of thousands more (Table 1). The majority of deaths were from tsunami and among elderly (Vervaeck and Daniell, 2012). The biggest number of victims has been from Miyagi, Iwate and Fukushima prefectures where whole communities were wiped out by the powerful tsunami. Six years after the disaster 2,553 people are still listed as missing and search for them is continuing.

Table 1. *Number of confirmed deaths, missing and injured person associated with March 2011 earthquake (March 10, 2017)*

Prefectures	Deaths	Missing	Injured	Prefectures	Deaths	Missing	Injured
Hokkaido	1	-	3	Gunma	1	-	42
Aomori	3	1	112	Saitama	-	-	45
Iwate	4,673	1,123	213	Chiba	21	2	258
Miyagi	9,540	1,230	4,145	Kanagawa	4	-	138
Akita	-	-	11	Nigata	-	-	3
Yamagata	2	-	29	Yamanashi	-	-	2
Fukushima	1,613	197	183	Nagano	-	-	1
Tokyo	7	-	117	Shizuoka	-	-	3
Ibaraki	24	1	712	Mie	-	-	1
Tochigi	4	-	133	Kochi	-	-	1
Total					15,893	2,553	6,152

Source: National Police Agency

What is more, official data for the "disaster related deaths" have been growing overpassing 3,000 in 10 prefectures (NHK World, 2017) with a majority of victims from Fukushima prefecture (1,691), followed by Miyagi prefecture (889) and Iwate prefecture (441). 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. Officials linked a great number of suicide deaths to disaster as suicides in Fukushima, Miyagi and Iwate prefectures were mostly associated with deteriorating health, money problems, and family issues.

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 and 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, 2017). What is more, as a result of long stay in

temporary accommodations many experienced diverse health problems.

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 direction from the Fukushima plant and the time spent in contaminated zones. 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).

According to the data 167 workers in the nuclear plant received radiation dose more than 100 mSv, 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 and for roughly 150,000 citizens from the fallout zone exposures were lower. There are still occasional reports for radiation overexposure of workers at the plant (NHK World, 2017).

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, 2013). For children and other vulnerable groups (old people, sick persons) these doses have been much higher.

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. 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). 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" (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.

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; Hasegawa, 2013; Rosen, 2013). Fukushima prefecture has been conducting thyroid checkups regularly on more than 380,000 residents who were younger than 18 at the time of the disaster. The first round of screening in 2011 found 108 confirmed or suspected cases of cancer. The results of the latest screening indicate that few local young peoplemay have thyroid cancer, even though they cleared a screening shortly after the nuclear accident in 2011 (NHK World, 2016). Officials say they have no enough data to prove whether nuclear fallout caused those cases since radiation levels in areas where people lived are not high enough to cause thyroid cancer.

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. For instance, according to the September–October 2012 survey the estimated annual radiation doses from radioactive cesium in foods were in safety limit ranging from 0.0009 to 0.0057 mSv/year (highest in Miyagi prefecture and certain regions of Fukushima prefectures). At the same time, annual radiation doses from radioactive potassium were between 0.14 and 0.22 mSv/year as no significant changes found comparing to before the accident.

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 (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, “health effects” from extra cumulative exposure above the official limit are difficult to be verified based on the current available knowledge (Koizumi, 2011).

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 for 4% of participating households (Fukushima Minpo News, March 7, 2014). Nevertheless, internal exposure to radioactive materials of all screened household members was below the 300Bq threshold for human exposure.

Despite that in many places the radiation level and overall artificial exposure are less than the level in some onsens (hot springs)or certain medical check-ups, many show a great concern on current figures. That worries have been further enforced by the controversial opinions of experts in the field, 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 believed that the health effects of the radiation release are "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. Furthermore, long periods of evacuee life, lost property and employment have caused many people to grow isolated or develop physical or mental problems. 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). Official survey has also found out 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.

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

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, 2017). 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 – accordingly 8,35%, 6,3% and 4,39% (World Health Organization, 2011). 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.

Immediately after the nuclear accident the government recommended 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.

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

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 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.

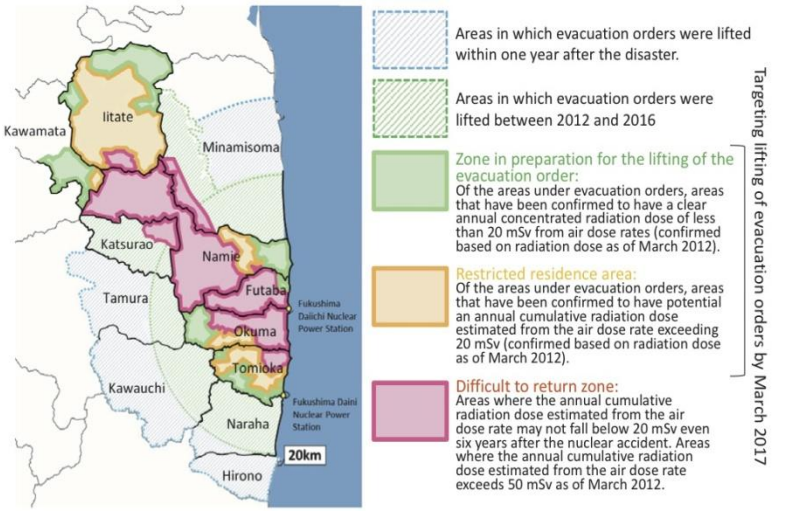
3) No entry areas - the annual integral dose of radiation is expected to be 20 mSv or more within five years and the current integral dose of radiation per year is 50 mSv or more. People are legally required to evacuate from the areas, for which physical barriers to entry such as barricades are placed 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, and 3).

5) Specific spots recommended for evacuation.

Since 2014 evacuation order for a number of places have been lifted and people are allowed to return back home. Present status of Areas under Evacuation Order is presented on Map 4.

The reconstruction process has been progressing rapidly, as most evacuees were moved to temporary built houses by September 2011. 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, 2017).



Map 4. *Present status of Areas under Evacuation Order*
Source: Reconstruction Agency, 2017

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 places such as higher ground in 276 districts in 26 municipalitie, and the readjustment and leveling of land for residential areas in 58 districts in 19 municipalities (Reconstruction Agency, 2017). Construction of public houses in most affected 3 prefectures was complete in 2015 and private houses are expected to end in 2017.

Most recent data shows that the total number of evacuees declined to 120,000 while evacuees living in temporary housing are approximately 40,000 (Figure 1). Until March 2017 83% out of planed 30,000 units of pubic houses were completed and 69% (out of 20,000 units) new housing to be relocated to uplands were done as well as 90% of school and medical facilities were rebuilt and 130,000 private houses (on their own) reconstructed (Reconstruction Agency, 2017). The cleaning up and disposal of enormous amount of earthquake and tsunami debris has been largely completed. Nevertheless, 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.

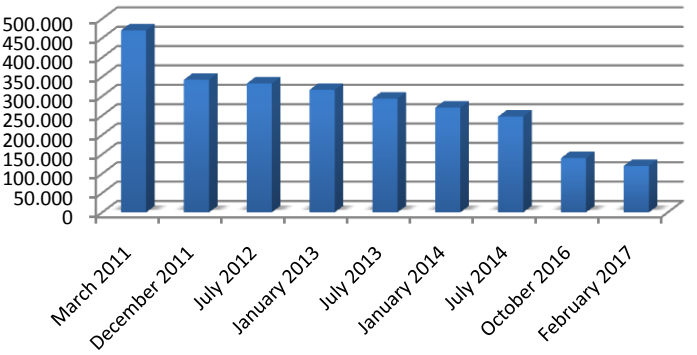


Figure 1. *Evolution of number of evacuees in post disaster years*
Source: Reconstruction Agency, National Police Unit

Official 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, 2017). However, radiation levels in no-go zones are expected to remain far above the internationally recommended safe level even a decade after the nuclear disaster.

Furthermore, the progress in decontamination work does not necessarily mean residents' return is smooth. 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. For some places in most contaminated areas 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. Evacuees are also having concerns about the safety of an intermediate storage facility for nuclear waste, which will be built in the area.

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 cities, 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 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, 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.

The 2011 disasters occurred at areas that had been facing problems of depopulation and aging. Populations of prefectures hardest hit by the disasters have continued to decline during the last 3 years. In Iwate, Miyagi and Fukushima prefectures total population dropped by more than 132,000 between March 1, 2011 and February 1, 2014. Fukushima prefecture has seen the largest population decline in post disaster years (86,077 people since March 1, 2011)where overall population has been decreasing due to out-migration (Statistics Bureau, Ministry of Internal Affairs and Communications). What is more there has been significant decline in youngerpopulationand an increase of older than 65.

Economic damages and impacts

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

The latest figure shows that more than 1,2 million 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 2). 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. 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 3). 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).

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).

Table 2. *Number of property damages associated with March 2011 earthquake (March 10, 2017)*

Prefectures	Totally coll-apsed	Half coll-apsed	Total burn down	Part-ial burn down	Flooded ab-ove floor	Flooded be-low floor	Partia-lly dam-aged	Non dwe-lling house
Hokkaido	-	4	-	-	329	545	7	469
Aomori	308	701	-	-	-	-	1006	1402
Iwate	19507	6568	33		-	6	18965	4707
Miyagi	83001	155129	135		-	7796	224202	26796
Akita	-	-	-	-	-	-	5	3
Yamagata	-	-	-	-	-	-	21	96
Fukushima	15218	80628	77	3	1061	351	141145	1010
Tokyo	15	198	1	-	-	-	4847	1101
Ibaraki	2629	24374	31		1799	779	187677	22606
Tochigi	261	2118	-	-	-	-	73552	295
Gunma	-	7	-	-	-	-	17679	-
Saitama	24	199	1	1	-	1	1800	33
Chiba	801	10152	15		157	731	55044	660
Kanagawa	-	41	-	-	-	-	459	13
Nigata	-	-	-	-	-	-	17	9
Yamanashi	-	-	-	-	-	-	4	-
Shizuoka	-	-	-	-	-	5	13	-
Mie	-	-	-	-	2	-	-	9
Tokushima	-	-	-	-	2	9	-	-
Kochi	-	-	-	-	2	8	-	-
Total	121764	280121	297		3352	10231	726443	59209

Source: National Police Agency

Table 3. *Places with infrastructure damages associated with March 2011 earthquake (March 10, 2017)*

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

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, 2017). 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 (Ministry of Environment, 2016). 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.

What is more, the nuclear accident has contaminated huge areas of lands, property infrastructure, and debris in Fukushima and neighboring prefectures. 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.

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 (Figure 2). 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.

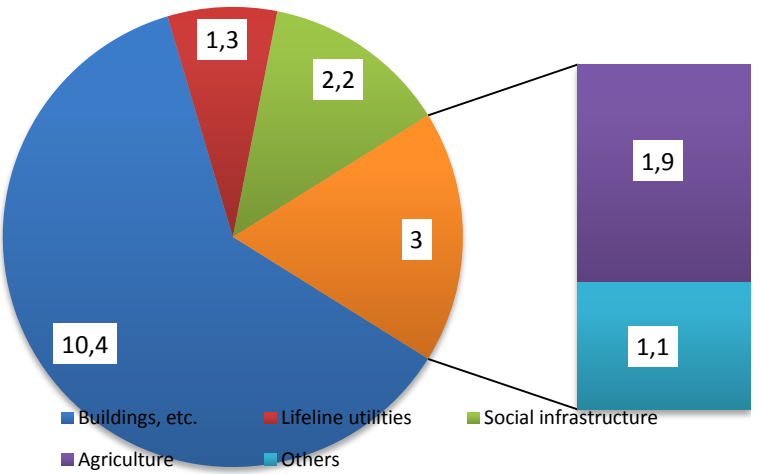


Figure 2. *Estimated economic damages of March 2011 earthquake (trillion yens)*
Source: Cabinet Office, June 24, 2011

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. In March 2011 the Index of Industrial Production in the country and the most affected areas dropped considerably – with 15% and 35% accordingly (Reconstruction Agency, 2014).

The insured losses from the Great East Japan Earthquake were estimated at ¥2,750 billion, or 16% of total direct economic losses (Raghieri and Ishiwatari, 2014). The insurance payouts stemming from the quake had reached ¥1,234.6 billion as of May 2012 (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.

Six year after disastersmerely 45% of companies have recovered to the pre-earthquake level with sales recovery rate varying considerably – e.g. Construction industry 80%, Marine and food processing industry 30%, etc. (Reconstruction Agency, 2017). Similarly, only 83% of the Tsunami-affected farmlands have been recovered and 91% of seafood processing industry restarted business.

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 (Ministry of Agriculture, Forestry and Fisheries, 2017). The high level of radiation has caused some Fukushima forests to be abandoned and there is concern about the long-term management of forestry.

By the end of November 2013 TEPCO received 2,035,000 applications 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%) , 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, 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. Most compensation payments to Legal Persons and Sole Proprietors were for "Lost earning" (94.5%), and for applicants from Evacuation Areas (other than agriculture), Tourisms and Service industries.

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). Meanwhile, four other

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

The macroeconomic impact of the March 2011 disaster has been also significant. 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 (Statistics Bureau, 2016).

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). The latest budget for the reconstruction period FY2011-2020 amounts to 32 trillion yens (or 263 billion USD), including 2.5 trillion yens for "Providing Health and Living Support", 13.4 trillion yens for "Rebuilding of Houses and Reconstructing Communities", 4.5 trillion yens for "Reviving Industry and Livelihoods", 2.1 trillion yens for "Revitalizing and reconstructing Fukushima", and 9.5 trillion yens for "Others" (Reconstruction Agency, 2017).

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 below 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.

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, 2017). 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. (Bachev and Ito, 2015).

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, 2016). In the three prefectures there has been also unlike speed in the infrastructure recovery by individual 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.

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). More recent experts estimates indicate that the overall macroeconomic impact of the disaster (on stock prices, housing prices, and so on) has not been so huge 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 (OECD, 2016).

According to the initial prediction, the March 2011 earthquake is likely to be the costliest natural disaster 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.

Nevertheless, there is still uncertainty about the full costs related to the nuclear accident. Recently it has been revealed that the cost of decontaminating areas affected by the 2011 Fukushima nuclear accident is nearly 1.5 times the initial estimate (NHK World, November 6, 2016). About 19.5 billion dollars had already been spent on decontamination projects by March 2016 but the

Environment Ministry and the Reconstruction Agency say an additional 17 billion dollars will be needed due to an increase in personnel costs. In addition more than 10 billion dollars of taxpayers' money will be needed to build facilities to store the waste from the decontamination process.

The process of compensation of victims, decommissioning of the nuclear plant, and decontamination, rebuilding businesses and social life in affected areas will last many years and incur enormous costs. 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. According to TEPCO available funds are not sufficient for compensation of the amount of payouts required (Tokyo Electric Power Company, 2017). 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, 2014-2017). In addition, there are lawsuits against the central and local governments related to earthquake and tsunami damages. Finally, there are unknown amount of private costs related to dispute and compensation associated with the triple disaster

Up to date huge challenges in decommissioning the nuclear reactors have been associated with changes in timetables and costs tags. The experts estimate to clean up areas designated as uninhabitable 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 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 Cost Verification Committee's estimate "over-optimistic" and predict that nuclear disaster costs are bound to increase further (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 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 peace 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).

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 21 reactors at 14 nuclear plants. The shortage of energy, the high energy and fuel import costs, and security risk from relying on imported energy have been pressing current government to speed up safety inspections and resuming operations of nuclear plants. Nevertheless, there is strong opposition to restart nuclear power plants by various groups, suggesting that nuclear power is not safe, it is the most expensive, disposal sites for nuclear waste are not secured, the evacuation routes not secured, and anti-terrorism measures insufficient. 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 (Government Office, 2014).

Environmental impact

The March 2011 disasters have had enormous environmental impacts (Kontar *at al.*, 2014; Ministry of Environment, 2017; NASA, 2011; Urabe *et al.*, 2013; UNSCEAR, 2014; WWF, 2013).

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).

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 (Biodiversity Center of Japan, 2013). 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.

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" (Biodiversity Center of Japan, 2013). "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.

Monitoring of the marine environment has found out a great disturbance of Zostera forest caused by the tsunami (Biodiversity Center of Japan, 2013). 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.

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.

It is estimated that the Great Japan Earthquake generated more than 20 million tons of debris 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 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, 2017). 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. According to some experts the undertaken large-scale decontamination by the authorities and at grass-room level would create new environmental problems such as: huge amounts of radioactive waste, removal of top soil, damage to wildlife habitat 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).

Process of decommissioning the nuclear reactors is at the beginning stare and is expected to last 30-40 years and associated with many challenges such as lack of experiences, available technologies, uncertainties and risks, public concerns, lack of disposal site, etc. (Reconstruction Agency, 2016).

Until now contaminated soil, leaves, and mud removed during decontamination work, and other radioactive waste have been stored at around 1,000 initial "temporary" storage sites and more than 75,000 private properties across Fukushima prefecture (NHK World, January 15, 2015).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 more than 146,000 tons of contaminated soils, debris, incinerated ash, mud from sewage, straw, etc. located in Tokyo and 11 other prefectures.

A little progress has been also made in deciding on final disposal facilities locations for handling radioactive waste from the

Fukushima nuclear crisis. The government has been considering locations to newly build final disposal in five prefectures (Miyagi, Tochigi, Ibaraki, Gunma and Chiba). 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. 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; Ministry of Environment, 2012; UNSCEAR, 2014; WWF, 2013). 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).

3. Agricultural Impacts Updates

Affected farms and agricultural resources

There have been a huge number of destructed agricultural communities, farms, and agricultural lands and properties from the March 2011 disasters (Bachev and Ito 2015).

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 3).The greatest part of damaged farms (45.6%) was in Fukushima prefectures where more than a third of farms were hurt by the earthquake, tsunami, or nuclear accident. The affected Agricultural Management Entities in Nagano, Nigata, Iwate and Miyagi prefectures also comprised a good portion of all entities in these prefectures.

The tsunami affected adversely almost 5% of all farms of the six coastal prefectures. Tsunami damaged Agricultural Management Entities account for about 27% of all damaged by the disasters entities. The majority of the tsunami-damaged farms are located in Miyagi (59.4%) and Fukushima (26.9%) prefectures.

Reported area of agricultural land damaged by the 2011 disasters in the six coastal and six inland prefectures is around 24,500 ha (Table 4). More than 98% of the damaged agricultural lands were in the coastal regions. The mostly hit farmlands were in Miyagi and Fukushima prefectures, which represent accordingly

60.6% and 24.7% of the damaged agricultural lands in the coastal areas. Affected by the disasters farmlands in Miyagi and Fukushima prefectures amount almost to 11% and 4% of the total agricultural land in these prefectures.

Table 3. *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

The tsunami damaged agricultural land accounts for more than 89% of the damaged farmland in coastal regions and the greatest portion of the damaged land in all but Ibaraki prefectures. Badly hit were 48 municipalities of the six Northeastern prefectures of the country. Particularly huge areas of farmland were washed or flooded by tsunami in Minami-Soma city (2,722 ha), Watari town (2,711 ha), Yamamoto town (1,595 ha), and Soma city (1,311 ha) of Fukushima prefecture, Sendai city (2,681 ha), Ishinomaki city (2,107 ha), Natori city (1,561 ha), Higashi-Matsushima city (1,495 ha), and Imanuma city (1,206 ha) of Miyagi prefecture, and Kasennuma city (1,032 ha) of Iwate prefecture (Ministry of Agriculture, Forestry and Fisheries, 2014). More than 85% of the washed away or flooded by the tsunami farmlands were paddy fields. In most affected Miyagi and Fukushima prefectures the destroyed by the tsunami paddy fields accounted for 11.5% and 5.3% of all paddy fields in these prefectures.

The average farms size in the affected by the 2011 disasters regions is 2.51 ha. The average damaged-land per affected Agricultural Management Entities comprises a considerable portion of the average agricultural land under farm management in Miyagi, Chiba and Ibaraki prefectures (Figure 4). What is more, the average tsunami-damaged land per affected Agricultural Management Entities represents a significant part of the average farm size in all costal prefectures ranging from 12% (Aomori) up to 92% (Fukushima). Therefore, the 2011 disaster has enormously

damaged the farmland, production capability and the entire economy of the (most) affected farms. The latter is also confirmed by the detailed classification of the agricultural holdings in different parts of the most tsunami-damaged Miyagi prefecture where a significant portion are up to 1 ha and the majority below 3 ha.

Table 4. *Area of damaged agricultural land by 2011 earthquake (March 11, 2012)*

Prefectures	Damaged agricultural land		Tsunami damaged agricultural land		Share of completely restored 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 Japan	24,477	1.6	21,476	87.7	33.8	27.3

Source: Ministry of Agriculture, Forestry and Fisheries

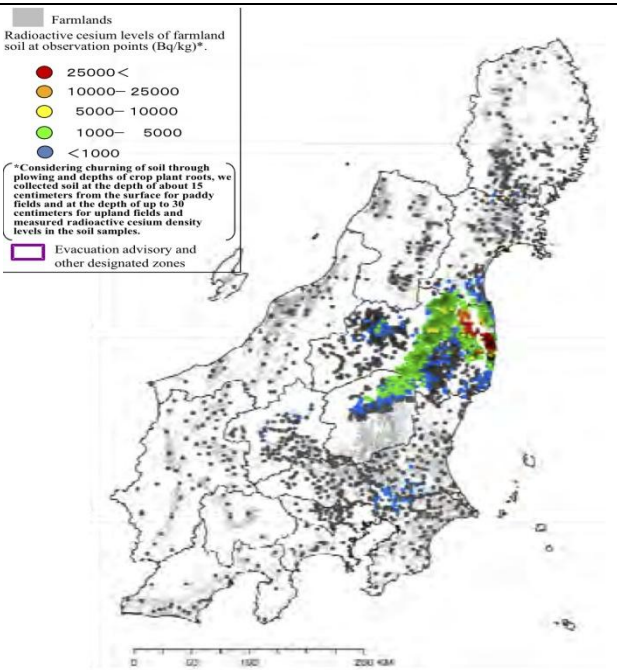
In the three most strongly hit prefectures two-third of municipalities (85) has been damaged by the 2011 disaster, including 41.9% of them tsunami damaged (Ministry of Agriculture, Forestry and Fisheries, 2014). The biggest number of damaged municipalities has been in Fukushima prefecture (34, including 10 tsunami-damaged), followed by Miyagi prefecture (31, including 15 tsunami-damaged), and Iwate prefecture (20, including 11 tsunami-damaged).Almost 56% of the traditional agricultural hamlets in Miyagi prefecture have been damaged by the disasters, including 20.1% tsunami-damaged (Ministry of Agriculture, Forestry and Fisheries, 2014). In other two most affected prefectures Iwate and Fukushima the share of damaged traditional agricultural hamlets is 35.8% and 27,7%, including 7.4% and 4.1% tsunami-damaged.

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 (Ministry of Agriculture, Forestry and Fisheries, 2014).

The biggest number of places with damaged lands was registered in Iwate (73.9%), Fukushima 10%) and Miyagi (8.3%) prefectures (Ministry of Agriculture, Forestry and Fisheries, 2014). The number of points with damaged agricultural facilities etc. was biggest in Miyagi (27.7% of total), Fukushima (22%), Iwate (21.4%), Chiba (13%) and Ibaraki (10.6%) prefectures; with damaged coastal farmland protection facilities in Miyagi (74.1%), Fukushima (14.4%) and Iwate (10.8%) prefectures; and with damaged rural community facilities in Fukushima (31.8%), Miyagi (24.1%), Ibaraki (21.7%) and Iwate (9.3%) prefectures.

Furthermore, there has been radioactive contamination of farmlands from the nuclear accident's fallout (Map 5). A 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 5). Most heavily contaminated farmlands are in Fukushima prefecture where 3.6% of all samples (including 4% of the paddy fields and 2.9% of other lands) are above 5000 Bq/kg.



Map 5. *Farmland soil radiation (March 23, 2012)*
Source: Ministry of Agriculture, Forestry and Fisheries

Table 5. *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
Fuku-shima	50-41,400	39	16.1	40.8	4	56,600	34.3	21.2	41.6	2.9
Ibaraki		0	0	0	0	230-560	50	50	0	0
Tochi-gi	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

There has been 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 (Ministry of Agriculture, Forestry and Fisheries, 2012). 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.

The official estimate for the inflicted damage on agriculture by the 2011 earthquake is 904.9 billion yen (Figure 3). 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%).

The biggest portion of the damage value (worth) on agricultural land was in Miyagi (69%), Fukushima (23.6%) and Iwate (5.8%) prefectures; on agricultural facilities, etc. in Miyagi (44.4%), Fukushima (34%), Ibaraki (9.9%) and Chiba (6.3%) prefectures; on coastal farmland protection facilities in Miyagi (42.5%), Iwate (32.4%) and Fukushima (24.8%) prefectures; on rural community facilities in Miyagi (43.1%), Fukushima (38.7%) and Ibaraki (12%) prefectures. The bulk of damage on crop and livestock, etc. was in Miyagi (57.8%), Iwate (13.9%), Tochigi (7.2%), Ibaraki (6.9%), Fukushima (5.7%) and Saitama (4.4%) prefectures, while on livestock facilities, etc. in Miyagi (71.2%), Ibaraki (8.8%), Tochigi (7.1%), and Iwate (5.8%) prefectures.

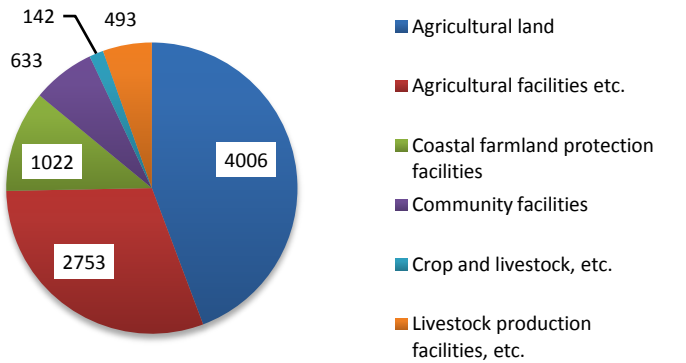


Figure 3. *Damages to agriculture from 2011 earthquake as of July 5, 2012 (100 million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

The greatest amount of damage has incurred in Miyagi prefecture representing 56.5% of the total worth. The second most affected prefecture was Fukushima with 26.4% of the total

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

One year after the disasters around a third of the damaged agricultural land was completely restored, including 27% of the tsunami damaged farmlands. During the same period about 90% of the tsunami-afflicted farmland was cleaned of rubble, a large part of the agricultural infrastructure reconstructed (including 100% of the major draining pumping stations and 7.3 km priority restoration zones of coastal farmlands, and 92% of the rural community sewages) (Ministry of Agriculture, Forestry and Fisheries, 2012). Consequently, 70% of all damaged farms in 9 prefectures and 40.2% of the tsunami damaged farms in 6 prefectures resumed farming (Figure 4).Until March 2013 the restoration and salt removal on 38% of the tsunami-damaged farmland was completed and it was available for farming (with restoration on another 63% ongoing) (Ministry of Agriculture, Forestry and Fisheries, 2013). That was close to the target in the 3 years plan for complete restoration of tsunami-damaged farming. Consequently, a half of the affected by the tsunami farms resumed agricultural production or preparations for it (Ministry of Agriculture, Forestry and Fisheries, 2013).The latest figures indicate that 83% of farmlands have been recovered (end of September 2016) and considerable portion of the affected farms resumed operation (Reconstruction Agency, 2017)

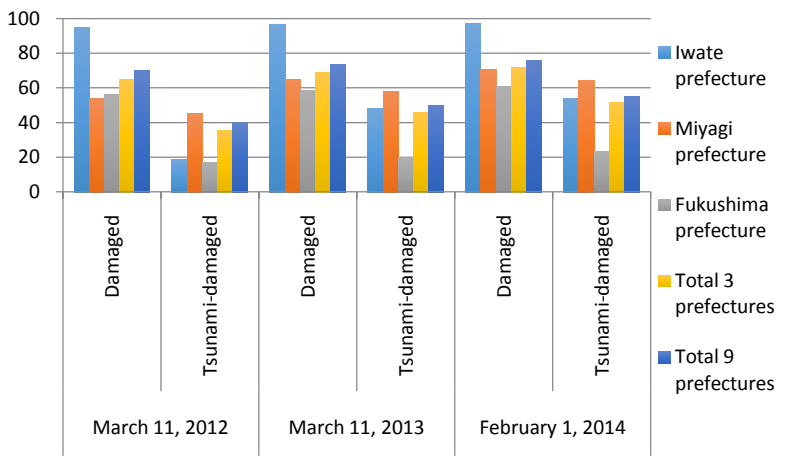


Figure 4. *Share of Agricultural Management Entities, which resumed farming (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

In Fukushima prefectures the 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 the Agricultural Management Entities resume operations (Ministry of Agriculture, Forestry and Fisheries, 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 resumes.

The 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 5). The importance of most 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 of the nuclear crisis as a reason deterring an effective resumption of operations by the majority of farms has been increasing. The post disaster lack of family labor and other factors such as sickness and injuries prevented resumption of activity in a few farms, and their number further decreased in the last 3 years.

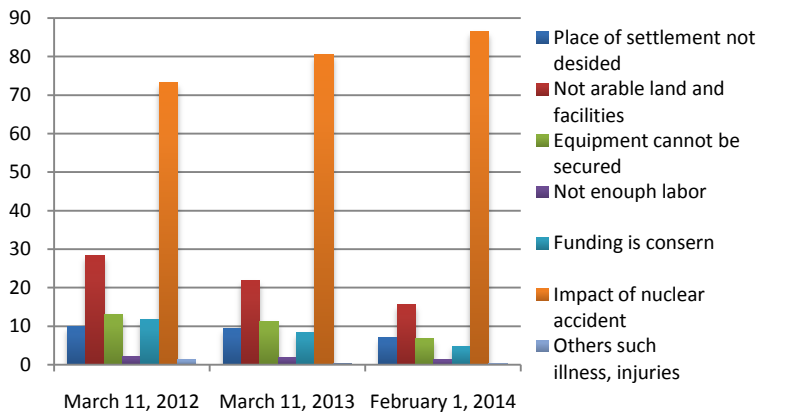


Figure 5. *Reasons for not resuming farming in Iwate, Miyagi and Fukushima prefectures, multiple answers (% of farms)*
Source: Ministry of Agriculture, Forestry and Fisheries

The most critical factors for "not resuming farming" for the majority of farms in Iwate and Miyagi prefectures have been unavailable arable land and facilities (Figure 6). 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 the damaged farms in Iwate prefecture), funding of farming activities is an issue, and equipment cannot 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". The aging of farmers and the lack of successors in business has been a serious problem in the disaster areas and nationwide. Therefore, any further delay in the reconstruction would be a great challenge for farming resumption by the previous farm managers (older in age, lack of investment capability, short time span, lack of ability to put rebuilding efforts, lack of skills other than for rice paddy cultivation, unavailable successor, etc.).

A survey on the 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% (Ministry of Agriculture, Forestry and Fisheries, 2013). Farmers in Miyagi prefecture experienced the biggest decrease in sales and income, followed by the producers in Iwate and Fukushima prefectures (Figure 7). Severe blows on sales and income were registered by producers in the three dominant type of farming in affected 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 (Figure 8).

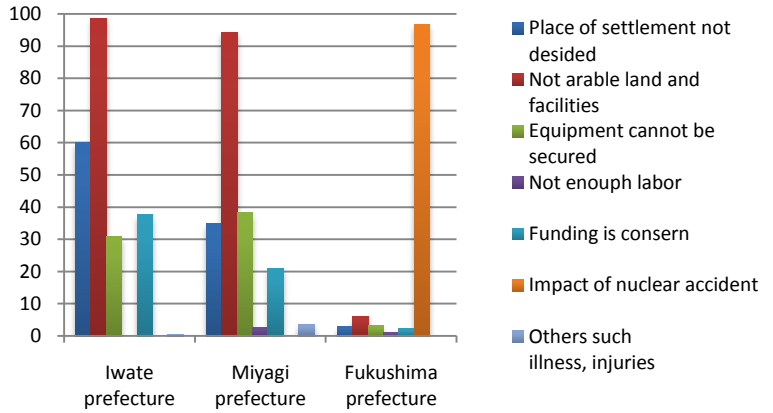


Figure 6. *Share of farms with diverse reasons for not resuming farming, multiple answers (%)*
Source: Ministry of Agriculture, Forestry and Fisheries

Figure 7. *Evolution of agricultural sale and income of agricultural management entities in tsunami-damagedareas (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

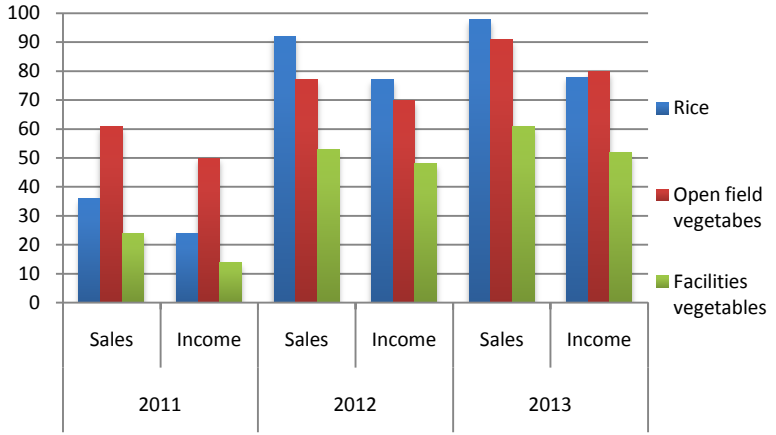


Figure 8. *Evolution of agricultural sale and income of agricultural management entities with different specialization in tsunami-damaged areas (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

There was some improvements in sales and incomes in all areas but in 2013 they were still far below 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).

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 (Ministry of Agriculture, Forestry and Fisheries, 2013). In 2013 there was a further augmentation of the agricultural output value in 67.4% of the tsunami-damaged municipalities, a reduction in 25.6% of them, and no change in the rest 7%. There was a regression or no progress in agricultural output of 46.7% of the affected Miyagi municipalities, third of damaged Fukushima and Ibaraki municipalities, a quarter of hit Iwate municipalities, and a fifth of destroyed Chiba municipalities (Ministry of Agriculture, Forestry and Fisheries, 2014).Individual municipalities differed substantially in terms of amount of damages, the 2011 production level, and the 2011-2013 sell-price levels. Therefore, the evolution of agricultural output value gives only a partial insight on the state of farming recovery in different municipalities.

There are official estimates on some of the damages from the Fukushima nuclear disaster as well. For instance, the total product damages from the accident accounts for 2,568 billion yen in Fukushima prefecture, out of which 41.9% are in the evacuated and restricted areas (Table 6). These figures cover damage of products that cannot be sold, because of the restrictions on planning and distribution, and loss of the value caused by rumors. However, that assessment does 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). The later losses are quite difficult to measure and "compensate" (Koyama, 2013).

Table 6. *Agricultural product damages in areas affected by nuclear disaster in 2012*

	Vege-tables	Live-stock	Fruit	Rice	Evacuated/restricted area total	Fukushima prefecture
Evacuated/restricted area share (%)	42.4	68.0	48.9	35.9	-	100
Evacuated/restricted area (100 million yen)	225	346	135	371	1,077	2,568
Evacuated/restricted area ratio (%)	8.8	13.5	5.2	14.4	41.9	100

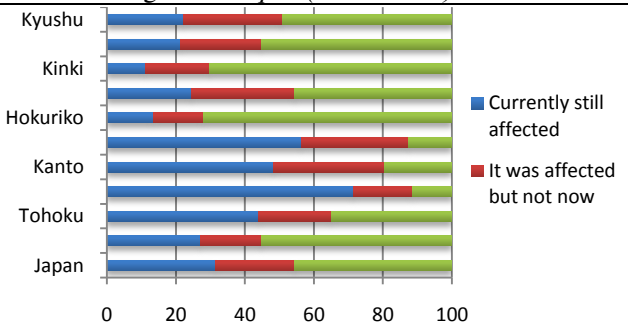
Source: Tohoku Department of Agricultural Administration, MAFF Statistics

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 (Bachev and Ito, 2013). Many farms livelihood and businesses have been severely destructed as a result of loss of lives, 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 prefecture 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 products (JA ZENCHU, 2012; Koyama 2013; Ujiie, 2012; Watanabe, 2011; Watanabe, 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 2012 survey the disaster affected negatively almost 55% of the Japanese farms (Figure 9). 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.One year of the disaster 31.4% of the surveyed farms in the country reported adverse effect on their management by the disasters. More than 71% of farmers in Iwate, Miyagi, and Fukushima prefectures, and more than 56% of those in Ibaraki, Tochigi, Gunma, and Chiba prefectures continued to feel the adverse effects of 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 productions (Figure 10). Furthermore, one year after the disasters almost 78% of surveyed beef farmers, around a half of mushroom and dairy producers, more than 42% of tea and almost 37% of facility flower producers reported they are still feeling the adverse effects of the disasters.

Figure 9. *Adverse effect of Great East Japan Earthquake on farm management in different regions of Japan (March 2012)*



Source: Japan Finance Corporation

There are also huge differences in the most affected sectors in each region of the country. One year after disasters in Iwate, Miyagi, and Fukushima prefectures a great majority of farms in beef, dairy, mushroom, facility vegetables, fruit trees and rice cultivation are still adversely affected by the earthquake, tsunami and nuclear accident. On the other hand, in Ibaraki, Tochigi, Gunma, and Chiba prefectures the negative impact lasted longer for the significant number of beef, mushroom, dairy, and open field vegetables producers.

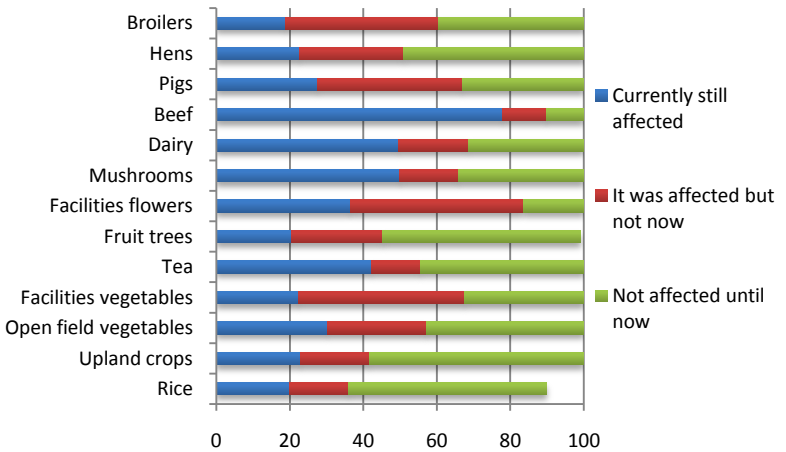


Figure 10. *Adverse effect of Great East Japan Earthquake on farm management in different subsectors of Japanese agriculture (March 2012)*
Source: Japan Finance Corporation

The major reasons for the negative impacts of the triple disasters have been the "decline in sell prices" and "harmful rumors", while the damaged inputs supply and production affected less farms. 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. There has been a great variation in the importance of different factors affecting producers in individual sectors of agriculture. 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 of "reduced sell prices" further increased for most subsectors, while of the "harmful rumors" for all producers. Having in mind multiplicities, complexity, spin-offs, and loner time spans of the agricultural impact of the 2011 disasters, its full evaluation is far from been complete.

Impact on food industries

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. Regular surveys on food industries dynamics reviled that 71% of the country's food companies were "affected" by the disasters, including more than 35% "still affected" at the beginning of 2014 (Figure 11). 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. What is more, a significant share of the food industry was not still recovered from the disaster by the end of 2013 in Iwate, Miyagi and Fukushima prefectures and Northern Kanto region. Relatively less affected by the disasters were food industry in Chugoku (57.9%), Kyushu (59%), and Shikoku (62%). Despite the fast recovery a significant amount of food companies in these regions reported they were still affected in the end of 2011.

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 12). The most severely affected have been the companies in the Northern Kanto (83.4%) and in Tohoku's Iwate, Miyagi and Fukushima prefectures (81.9%). In the most impacted Fukushima prefecture 93.8% of all

food companies have been adversely affected by the nuclear accident, including 92.6% of them "still affected" in the beginning of 2014 (Japan Financial Corporation, 2014). On the other hand, food industries in Kyushu have been relatively less affected by the nuclear disaster as only 38.8% of the companies report negative impact on activity (including 20.5% still impacted).

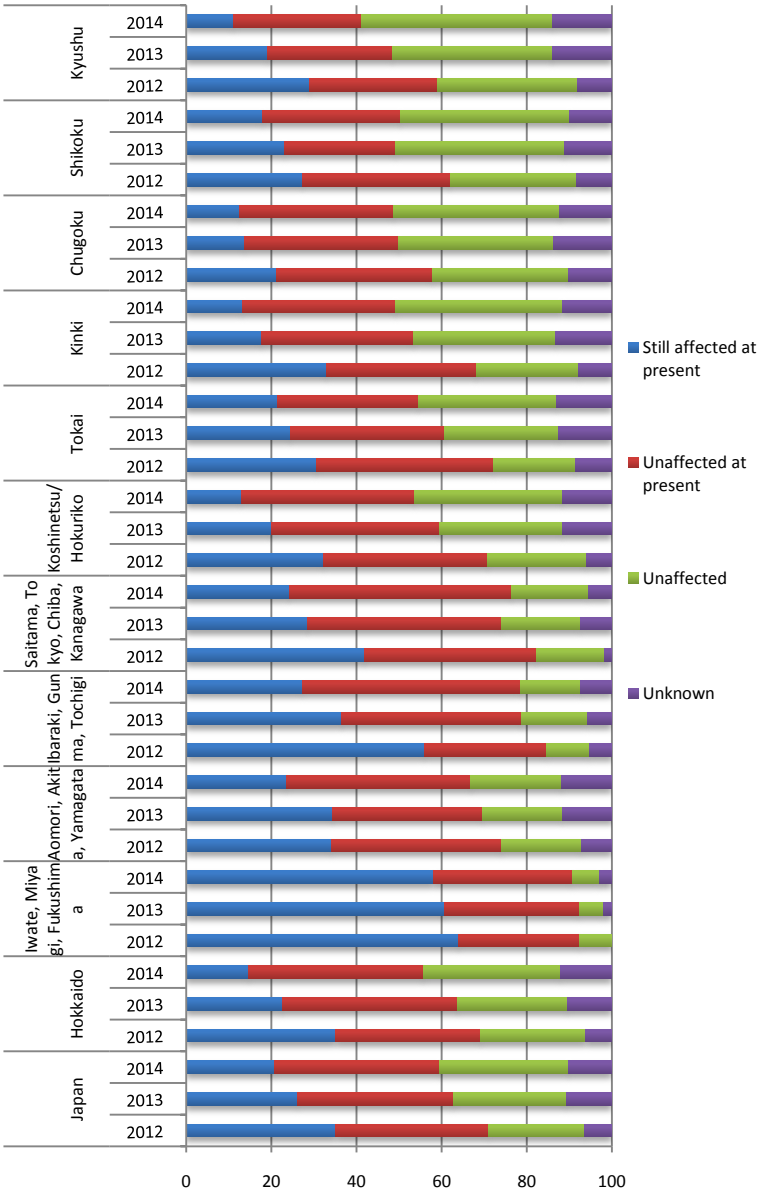


Figure 11. *Earthquake-tsunami disaster effects on food industry in Japan (January, 2012, 2013, 2014)*
Source: Japan Finance Corporation

In 2011 the most common reasons for the negative impact of the triple disasters was the reduction in sales volume, increase in the price of ingredients and materials, and the decrease in demand and number of costumers (Japan Finance Corporation, 2012). There has been also reported a great variation of the individual factors for the adverse impact of the nuclear accident in different regions of the country. There are also differences in the adverse impact in individual 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 (Figure 13). The 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, the Number of consumers, and the Price of ingredients and raw materials in Restaurants business. The Fukushima nuclear disaster has also affected mostly Demand from trade partners, Sales volume, and Procurement of ingredients and raw materials of many food companies (Figure 14). 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. The food industry in Fukushima has been particularly severely affected by the nuclear accident. For instance, a 2013 survey of 55 food industry companies in Fukushima prefecture show that three quarters of them have seen sales declined after the nuclear accident (Table 22) Moreover, in 40% of the companies the 2012 sale decreased comparing to 2011. Consequence of the declined sales, prices, restriction in shipment, and/or increased costs, more than 83% of the companies report a decrease in income after the nuclear accident. On the other hand, a great part of the companies with no income changes say that it is a result of received compensations. There has been different speed of recovery in the affected food industries in different parts of the country. Until January 2013 less than 50% of the pre-disasters operations were reported in 46.1% of the earthquake and tsunami affected food companies, and in 47.6% of the Fukushima nuclear accident affected food companies (Figure 15). The biggest progress in recovery of disasters destructed food companies has been achieved in Ibaraki, Gunma and Tochigi prefectures, while the slowest one in Aomori, Akita and Yamagata prefectures.

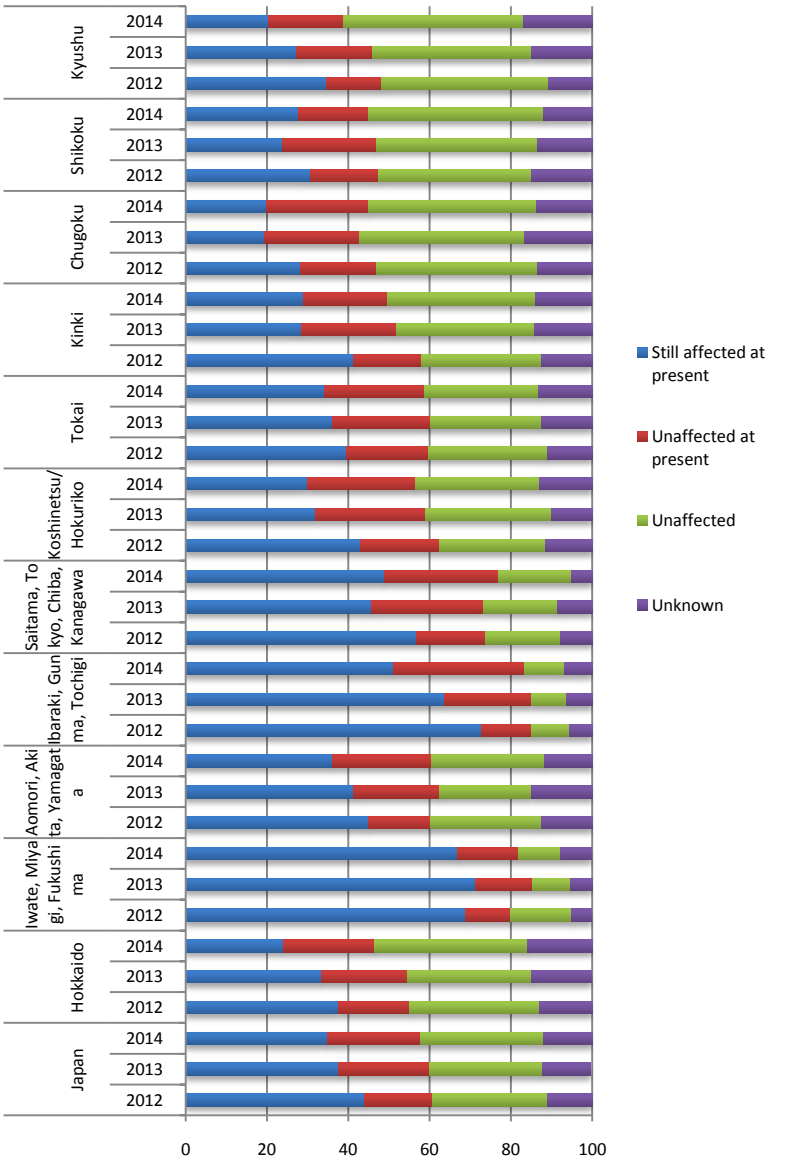


Figure 12. *Impact of Fukushima nuclear power plant accident on food industry in Japan (January, 2012, 2013, 2014)*
Source: Japan Finance Corporation

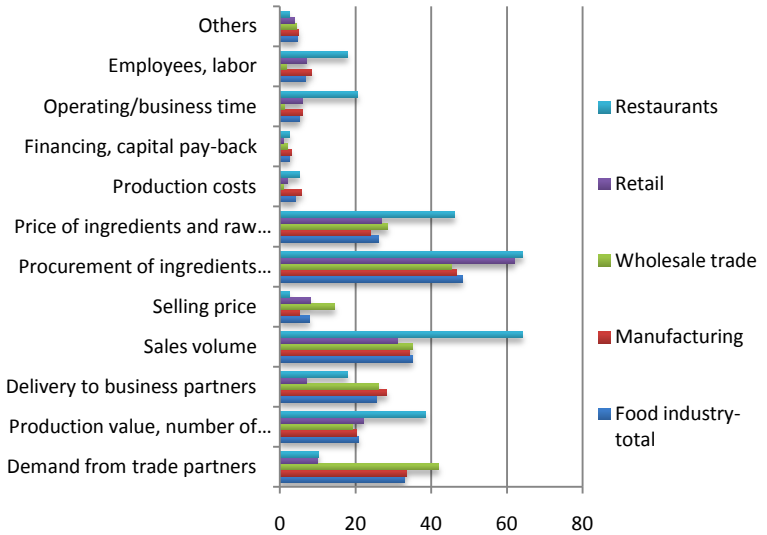


Figure 13. *Impact of earthquake and tsunami on overall management of food industry in Japan (January, 2014)*
Source: Japan Finance Corporation

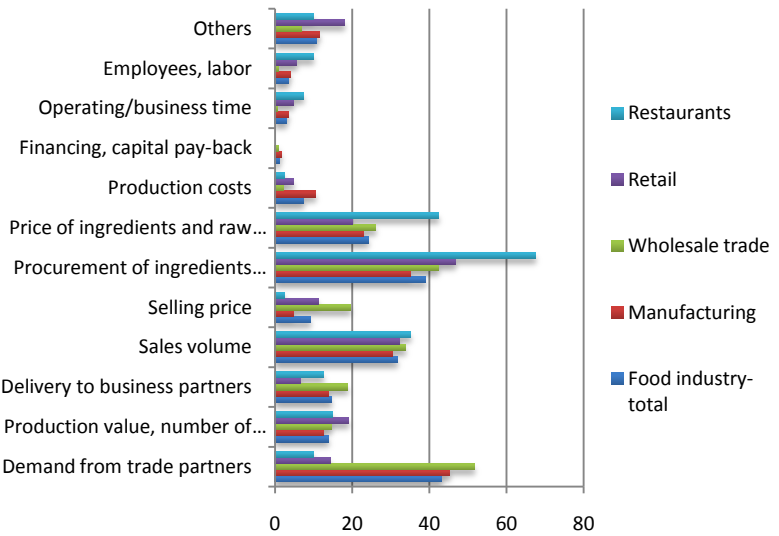


Figure 14. *Impact of Fukushima nuclear plant accident on overall management of food industry in Japan (January, 2014)*
Source: Japan Finance Corporation

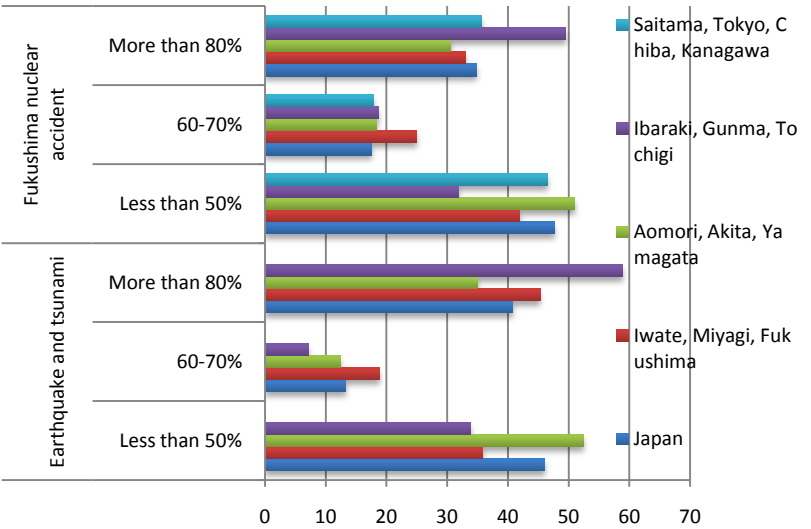


Figure 15. *Extent of food industry recovery from Great East Japan Earthquake effects (January, 2013)*
Source: Japan Finance Corporation

Radioactive contamination of agri-food products and impacts on demands

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.

On March 21, 2011 restrictions on food distribution were launched by the Director General the Nuclear Emergency Response Headquarters. Distribution restriction was put on milk from Fukushima prefecture and spinach and kakina in Ibaraki, Tochigi, Gunma, and Fukushima prefectures. On March 23, similar restrictions were placed on more leafy vegetables (komatsuna, cabbages) and all flowerheads brassicas (like cauliflower) in Fukushima prefecture, while parsley and milk distribution was restricted in Ibaraki prefecture.

On April 8, 2011 the "Policy on rice planting" was announced and restrictions on rice planting on 11,200 ha imposed (April 22,

2011) restricted areas, planned-evacuation areas, and areas prepared for evacuation in case of emergency in 12 municipalities (Ministry of Agriculture, Forestry and Fisheries, 2011). Voluntary moratorium of additional 2,000 ha of rice paddies was also introduced. Many farm related services such as eco-tourism, eco-farm, etc. were suspended in the most affected areas.

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. 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 3,600 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 5,000 inspected fish samples 4.5% were above safety norm.

In order to meet growing public safety concerns since April 1, 2012 new more stringent official limits on radioactive elements in food items have been enforced in the country as longer transitional periods were set for some commodities like rice and beef (until September 30, 2012), and soybean (December 31, 2012).

In the last past years the number of (official, collective, private) food inspections has multiplied in the 17 most vulnerable prefectures and around the country. Officially tested food items doubled in 2012, and 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). 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.

In FY 2013 the number of inspections increased further but only 0.30% of samples were found with level higher than the safety standard. 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 prefectures wild animal meats; and in Yamanashi prefecture mushrooms.

Up to December 7, 2014 of the FY 2014 positively tested items were fond inly in 14 prefectures and their number of was further diminished – just 0.16% of the total. Above a half of the contaminated items were in Fukushima prefecture (50.26%), followed by Miyagi (14.09%), and Gunma (10.63%) prefectures. The greatest proportion with highly contaminated items was detected in samples from Yamanashi (2.14%), Fukushima (0.63%), and Shizuoka (0.34%) prefectures. Most of the detected items in Fukushima prefectures were wild animals meat, fishery products, and agricultural products (mostly wild ones, and soybean); in Miyagi prefecture wild animal meat, agricultural products (mostly wild, and log-grown Late fall oyster mushrooms), and fishery products; in Gunma prefectures wild animal meats, fishery products, and agricultural products (wild ones, and log-grown Shitake powdered.

Official inspections results in the last 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 7). What is more, the share of samples with detected radioactivity higher than the half of the new safety norm (>50 Bq/kg) has been minor, declining or zero. For instance, during April 1, 2013 - March 31, 2014 this portion was merely 0.002% in beef meat, 0.008% in rice, 0.01% in vegetables, 0.45% in tea infusion (>5 Bq/kg), 0.66% in fruits, 1.19% in other cultivated plants, 3.03% in honey, 4.58% in pulse, and 6.76% in mushrooms and wild edible plants (Ministry of Agriculture, Forestry and Fisheries, 2014). Similarly, for the period April 1, December 31, 2014 the proportion of such items in all samples was

merely 0.0001% for rice, 0.068% for fruits, 0.27% for pulses, and 3.03% for in mushrooms and wild edible plants.

Table 23. *Results of inspections on radioactivity levels in agricultural products in Japan**

Prod-ucts	March, 2011 - March 31, 2012			April 1, 2012 -March 31, 2013		April 1, 2013 - March 31, 2014		April 1, 2014 - March 31, 2015	
	Number samples	Above old limit	Above new limit	Number samples	Above limit	Number samples	Above limit	Number samples	Above limit
Rice	26,464	39	592	10.4 million	84	11 million	28	11 million	2
Wheat, burley	557	1	27	1,818	0	592	0	383	0
Vegetables	12,671	139	385	18,570	5	19,657	0	16,712	0
Fruits	2,732	28	210	4,478	13	4,243	0	3,302	0
Pulse	698	0	16	4,398	25	6,727	59	3,459	4
Other plants	498	1	16	3,094	14	1,613	0	1,049	0
Mushrooms, wild plants	3,856	228	779	6,588	605	7,583	194	8,557	103
Tea/infusion**	2,233	192	1,562	867**	13**	446**	0**	206**	0**
Raw milk	1,937	1	7	2,453	0	2,052	0	1,846	0
Beef	91,973	157	1096	187,176	6	208,477	0	na	
Pork	538	0	6	984	1	693	0	na	
Chicken	240	0	0	472	0	385	0	na	
Eggs	443	0	0	565	0	418	0	na	
Honey	11	0	1	124	0	66	0	na	
Other livestock	23	0	0	99	1	118	0	na	

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

The test data for marine fishery products radioactive contamination also indicate that the number of cases above safety limit has dropped considerably (Fishery Agency, 2016).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 3 quarters. This percentage has continued to decline, and has fallen to 0% since April 2015. In other prefectures the share of contaminated fish decreased from 4.7% to less than 1% in 3nd quarter of 2012.

From January 1 until October 5, 2014 the total number of tested agri-food items was 168,667, out of which 272 (0.16%) were with levels exceeding the official safety standards in 13 prefectures (Ministry of Health, Labor and Welfare, 2014). The greatest part of the above safety limits items (260) was not under cultivation and feeding management. The biggest proportion of detected items was in Fukushima (146), Miyagi (39) and Gunma (32) prefectures, followed by Tochigi (19) and Nagano (11) prefectures. In other regions the amount of detected foodstuff above safety standards

was minor – 5 in Chiba and Shizuoka prefectures, 3 in Iwate, Ibaraki and Nigata prefectures, 2 in Akita and Yamanashi prefectures, and 1 in Yamagata prefecture. All tests since then now indicate atiny portion of detected items throughout the country (Ministry of Health, Labor and Welfare, 2017).

There are still a number of products from certain areas of 17 prefectures, which are subject to mandatory or voluntary shipment restrains. In Fukushima prefecture the mandatory and voluntary restrictions cover a wide range of vegetables, fruits, livestock and fish products grown in heavily contaminated areas. There is also a ban on rice planting on 2,100 ha (almost 3 times less than in 2013) and overall production management restrictions on 4,200 ha paddies in the evacuation area. Consequently, Fukushima rice paddy acreage has yet to recover to the level before the accident standing at around 85% of 2010 level in last two years (Ministry of Agriculture, Forestry and Fisheries, 2016). In other prefectures the mandatory and voluntary shipment restrictions mostly concern mushrooms, wild plants, and fish.

Since the nuclear accident, 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). That dynamics of the 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 commonly 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. Consequently, the demand for many traditional farm produces from the affected by the nuclear disaster regions (such as rice, fruits, vegetables, mushrooms, milk, butter, beef, etc.) significantly declined while prices considerably decreased.

Since autumns of 2011 and 2012 radiation measurement tests in all beef and package of rice have been carried out in Fukushima prefecture. Until April 30, 2013 more than 10.3 million bags of rice

were checked by JA Fukushima, and detected radiation in 99.78% of them were less than 25 Bq/kg while in only 71 bags (0.0007% of the total) it was above 100 Bq/kg (JA Fukushima Prefecture, 2013). Despite that the prefectural authority introduced a higher than the national radiation level safety standard for rice (60 Bq/kg) the recovery of sale has been slow. Intensive safety checks have been also carried out on a great range of agri-food products by the authority, farmers, agricultural organizations, processors, retailers etc.

Despite all safety checks many consumers in the big consumer centers (Tokyo, Osaka, Nagoya, etc.) and in the region alike continue to avoid Fukushima products (Takeuchi and Fujioka, 2013; Koyama 2013). In the end of March 2013 the rice sales from Fukushima was almost half of what it had been before the disaster while rice prices considerably lower. Nowadays many consumers continue to avoid buying products from Fukushima prefecture despite the vigorous safety checks – e.g. merely 20% of the rice put on the market in 2013 was bought by consumers (NHK World, July 14, 2014).

The consumer attitude to purchase food products from the affected by the nuclear disaster regions has evolved in post disaster years (Figure 16). 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 nuclear disaster impact.

Latest data indicate that a good portion of Japanese consumers (36.5%) “often” or “sometimes” purchase foodstuffs from affected by the 2011 disasters areas (Figure 17). The figure is much higher in Tohoku region then in the other parts of the country. There are also gender and age differences in willingness to buy from the affected regions. For instance, older generation and women tend to buy more from the affected regions than the younger generation and men (Japan Finance Corporation, 2014). 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.

Diverse promotions about produce safety etc. increase consumer willingness to purchase products from the affected regions (Japan Finance Corporation, 2014). For most Japanese consumers who do not want to purchase food stuff from the effected regions even the promotion the main reasons is “worry about safety” (Figure 18).

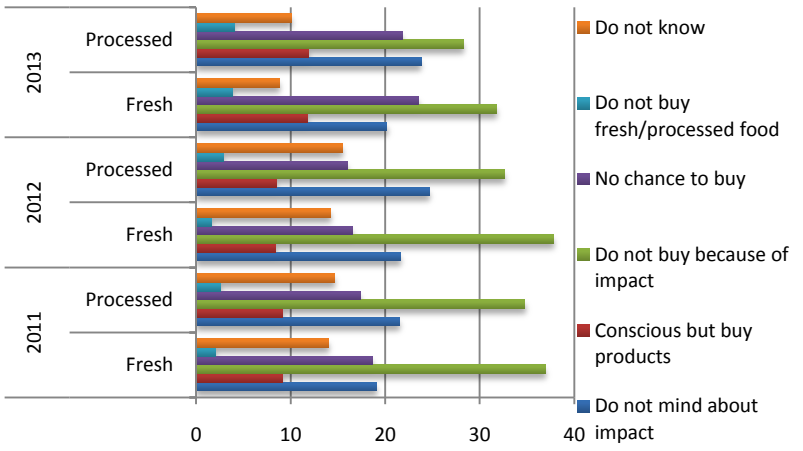


Figure 16. *Awareness when purchase fresh and processed food from region after nuclear accident (July 2011, January 2012, January 2013)*
Source: Japan Finance Corporation

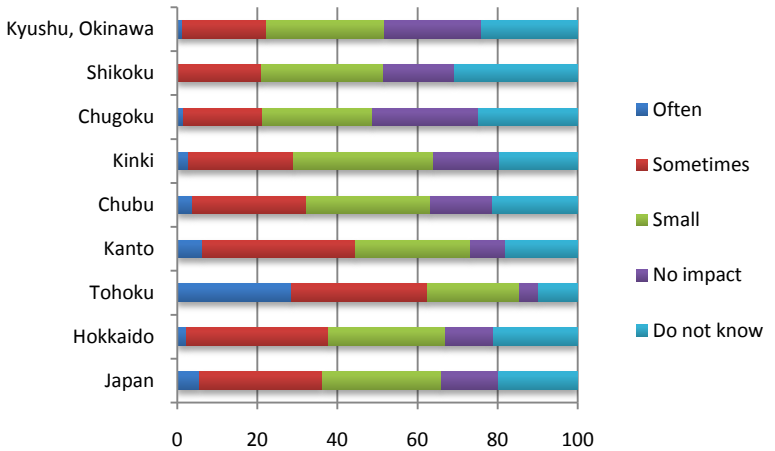


Figure 17. *Purchase of foodstuffs produced* in areas affected by Great East Japan Earthquake (including eating out) (January 2014)*
Source: Japan Finance Corporation; *processed goods and agricultural products

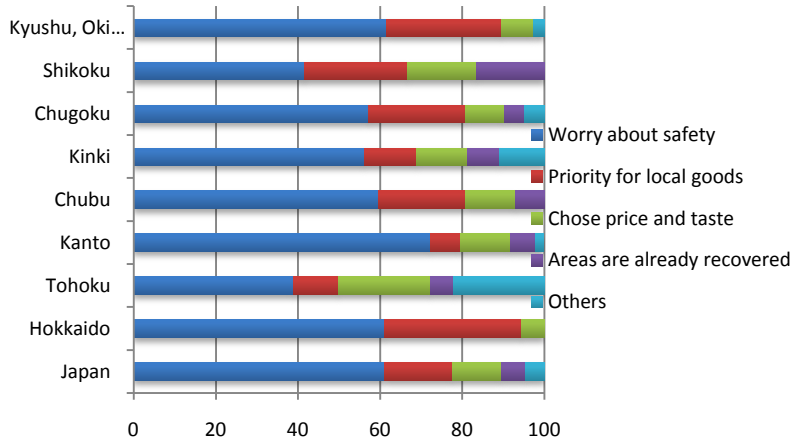


Figure 18. *Reason do not want to purchase even there is a promotion (January 2014)*
Source: Japan Finance Corporation

After the nuclear accident, there was a considerable decline in the absolute and relative prices of the affected farm products and the products from contaminated regions. Fukushima prefecture has lost its comparative advantage to other farming regions. Wholesale market shipment prices of vegetables in summer-fall 2012 were 20-30% lower in absolute terms than for 2011 (Watanabe, 2013). There was sharp decline in the demand and prices for the agricultural products mostly affected by the accidents such as vegetables, fruits, beef, etc. In Fukushima prefecture the extent of price reductions and the pace of price recoveries have been much slower than the nation ones.

Latest data suggest that demands for Fukushima (Ibaraki and Northern Honshu) agricultural products (e.g. rice, beef, vegetables) have been recovering fast while the farm-gate and wholesale prices in the most affected regions (Fukushima, Ibaraki) are still lower than in the other part of the country. That is consequences of a number of factors: reduction of radioactive contaminations, improving consumer confidence on inspection and safety, "forgetting" the contamination issue by some part of population, preferences to lower prices regardless the quality by some segment of consumers, changing marketing strategies of processors and smaller shops (not promoting/labeling anymore some farming and processed products as "Fukushima origin"), increasing

procurement by restaurants and processors of safe and cheap produces from the region, etc. Consequently, despite negative impact on local producers in affected region some actors in the food chain (restaurants, food stores, middleman, etc.) have been profiting enormously from a higher margin.

The 2011 disasters 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 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, etc.) 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 the EU also substantially eased import restrictions from 11 prefectures but kept restrictions for products from Fukushima prefecture as radioactive test certificates are usually required.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 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 (Ministry of Agriculture, Forestry and Fisheries, 2012). 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. 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.

In April-December 2012 it was registered a 5.98% growth in the export of agricultural products of the country. A slight augmentation of the annual exports of agricultural and field crops products were reported but the export value was still below 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.

Japan's exports of agricultural, forestry and fishery products (like marine products, beef, processed foods and sake) hit a record in 2014. Exports of such products totaled ¥489.3 billion in January-October 2014, up 10% from the same period of 2013. The latter is due to demonstrated safety as well growing popularity of Japanese cuisine worldwide coupled with a weaker yen. For instance, beef exports jumped 43% to ¥6.3 billion and demand for high-grade Japanese beef grew further as the European Union lifted a ban on beef imports from Japan. Agriculture, Forestry and Fisheries Ministry now hopes to achieve the government's goal of ¥1 trillion exports of agricultural, forestry and fishery products ahead of the target year of 2020.

4. Conclusion

The unprecedented triple disaster in Northeast Japan in March 2011 is among the worst in the Japanese and world history. 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. Nevertheless, more than six years after the disaster there are still a number of challenges associated with the recovery and reconstruction in Tohoku region and elsewhere.

A number of conclusions on the agricultural and food chain impacts from present updates could be also made. Agriculture, food industry and food consumption have been among the worst hit by the disasters areas. There is a great variation of the specific and combined impacts of the earthquake, tsunami, and nuclear disaster on different type of farming and business enterprises, individual sub-sectors, and specific locations. Moreover, there have been enormous damages and long-term consequences on farming and rural households, important properties, personal ties, established brands, informal organizations and traditional communities. Many of all these negative effects can hardly be adequately expressed in quantitative (e.g. monetary) terms.

The post disaster recovery and reconstruction have given opportunities and induced considerable policies and institutional modernization in agrarian and other sectors, and improve disaster prevention and management, food safety information and inspection, technological and product innovation, jobs creation and investment, farmlands consolidation and enhancement, infrastructural amelioration, organizational restructuring, etc.

That is a result of study in progressand 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" agricultural and food 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 farms and productions, and component of agri-food chain.

A big disaster like the Match 2011 provided 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. 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 also critical to share "good" and "bad" experiences of Japan with disaster prevention, management and recovery with other regions and countries, in order to prevent that happening again.

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