HRABRIN BACHEV

GREAT EAST JAPAN EARTHQUAKE

Implications for Agriculture, Food Industries and Consumption

KSP BOOKS

Great East Japan Earthquake - Implications for Agriculture, Food Industries and Consumption

Hrabrin Bachev
Institute of Agricultural Economics, Bulgaria

KSP Books
http://www.books.ksplibrary.org
http://www.ksplibrary.org

Great East Japan Earthquake - Implications for Agriculture, Food Industries and Consumption

Hrabrin Bachev

KSP Books
http://www.books.ksplibrary.org
http://www.ksplibrary.org

ISBN: 978-605-2132-48-7 (e-Book)
KSP Books 2018

http://www.books.ksplibrary.org
http://www.ksplibrary.org

Summary

On March 11, 2011 the strongest ever recorded in Japan earthquake occurred which triggered a powerful tsunami and caused a nuclear accident in one of the world's largest nuclear plant stations. The triple disaster has been having immense impacts on people's life, health and property, social infrastructure, economy, policies, natural and institutional environment, etc. in the affected regions, Japan, and beyond. This book tries to make a comprehensive assessment on the multiple impacts of the March 2011 Great East Japan Earthquake, tsunami and Fukushima nuclear accident on the Japanese agriculture and food sector. It identifies and evaluates radiation, displacement, health, physiological, production, economic, technological, organizational, environmental, institutional, political, etc. impacts of the disasters in all stages (inputs supply, farming, storage, wholesaling, transportation, processing, distribution, retailing, consumption) and components (natural resources, labor, biological and material assets, intangibles, technology, production structure, finance, waste disposal, information, management) of agri-food chain, and temporal (immediate, short-term, long-term) and spacial (local, regional, national, trans-national) scales. It summarizes responses of individuals, households, farms, businesses, communities, consumers, stakeholders, and authorities as well as assesses the progress and challenges in the post-disaster recovery and reconstruction. The book withdraws lessons from the Japanese experiences and suggests recommendations for effective risk

management in Japan and around the globe. The study is based on a wide range of information from governmental, academic, farmers, industry, international, etc. organizations, media, experts assessments and in-deep interviews with leading experts, stakeholders, and affected agents. Findings are presented in a popular way in order to reach a larger audience of researchers, educators, students, experts, farmers, businessmen, administrators, policy makers, professionals, non-governmental and international organizations, consumers, victims, and public at large.

Preface

On March 11, 2011 the strongest ever recorded in Japan earthquake occurred (known as the Great East Japan Earthquake) which triggered a powerful tsunami and caused a nuclear accident in one of the world's largest nuclear plant stations (Fukushima Daichi). That was the "costliest" disaster in human history and the first one that included an earthquake, a tsunami, and a nuclear power plant accident.

The triple disaster has been having immense impacts on people's life, health and property, social infrastructure, economy, policies, natural and institutional environment, etc. in the affected regions, Japan, and beyond. More than five years after the disasters the lives of many are still to be rebuilt, and socio-economic and environmental implications of the disasters fully understood.

There has been a huge public, media and experts' interest, and a growing number of publications on the (effects, responses to, challenges associated with) 2011 disasters, including badly affected agriculture and food sector. Most information and publications are in Japanese, which makes it difficult for foreigners to get a full insight on the scale and diverse implications of the disasters. Besides, there are few comprehensive studies on the overall impacts of the disasters on agri-food chains.

Our motivation to write this book was to fill that gap and assess multiple impacts of the March 2011 earthquake, tsunami, and nuclear disaster on Japanese agriculture and food sector. We have included all type of impacts (radiation, displacement, health, physiological, production, economic, technological, organizational, environmental, institutional, political, direct, indirect), all stages (inputs supply, farming, storage, wholesaling, transportation, processing, distribution, retailing, consumption) and components (natural resources, labor, biological assets, material assets, intangibles, technology, production structure, finance, waste disposal, information, management) of agri-food chain, and all temporal (immediate, short-term, long-term) and spacial (local, regional, national, trans-national) scales.

We have used a huge amount of data from various organizations (governmental, academic, farmers, industry, non-governmental, international, media) and original experts' assessments and in-deep interviews with leading experts, stakeholders, and affected agents. Our goal is to present a wide range of information, stakeholders' positions, and experts' assessments, and summarize responses of different agents, and assess the progress and challenges in post-disaster reconstruction, and withdraw lessons for effective risk management in Japan and around the globe. Our findings are presented in an easily understandable way in order to reach a large audience of researchers, educators, students, experts, farmers, businessmen, administrators, policy makers, professionals, non-governmental and international organizations, consumers, victims, and public at large.

This book is a result of our long-term research cooperation with one of the leading experts in the area Prof. Fusao Ito of Tohoku University in Sendai. It presents the current findings of a "study in progress" giving international readers a "better" picture about the agri-food chain implications of the March 2011 disasters. We are aware that the final assessments are difficult and require multidisciplinary, large team and long-term efforts due to the scales of the disasters, the numbers of affected agents, the effects' multiplicities, spillovers, and a long time horizon, the nuclear crisis constant evolution, the post disaster reconstruction challenges, the lack of "full" information and models of analysis, etc.

We would like to express our gratitude to all individuals and organizations providing valuable information and expertise as well as all participants in the expert assessments and interviews.

Contents

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) whichtriggered 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 hashad immense impacts on people life, health and property, social infrastructureandeconomy, natural and institutional environment, etc. in North-eastern Japan and beyond (Abe, 2014; Al-Badri & Berends, 2013; Belyakov, 2015; Biodiversity Center of Japan, 2013; Britannica, 2014; Buesseler, 2014; FNAIC, 2013; Fujita *et al.,* 2012; IAEA, 2011; IBRD, 2012; Kontar *et al.,* 2014; NIRA, 2013; Novia & Tatsuo, 2015; Ranghieri & Ishiwatari, 2014; Suppasri & Mas, 2013; TEPCO, 2012; UNEP, 2012; Vervaeck & Daniell, 2012; Umeda, 2013; WHO, 2013; WWF, 2013).

There have been numerous publications on diverse impacts of the 2011 disastersincluding on badly affectedJapanese agriculture and food sector (Bachev & Ito, 2013, 2016; JA-ZENCHU, 2011; Johnson, 2011; Hamada & Ogino, 2012; MAFF, 2012; Koyama, 2013; Sekizawa, 2013; Pushpalal *et al.,* 2013; Liou *et al.,* 2012; Monma *et al.,* 2015; Miyashita 2014; Murayama, 2012; MHLW, 2013; Nakanishi & Tanoi, 2013; Oka, 2012; 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.Furthermore, most of the domestic information and publications have been in Japanese, which make it difficult for international public to get a full insight on the scales and diverse implications of disasters.

The goal of this book is to present results of our studyon socio-economic 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) (Figure 1).

First, we identify and assess diverse impacts from the March 2011 disasters on the Japanese agriculture and food chains. The analysis embraces:

- Individual stages of the agri-food chain - inputs supply, farming, storage, wholesaling, transportation, processing, distribution, retailing, and consumption;
- Individual components of the agri-food chain - natural resources, labor, biological assets, material assets, technology, production structure, finance, waste disposal, information, and management;
- Different spacial scales – local, regional, national, trans-national, and global.

Multiple effects from the disasters are identified, described and "assessed" including:

- Direct and indirect effects;
- Immediate, short-term, and long-term effects;

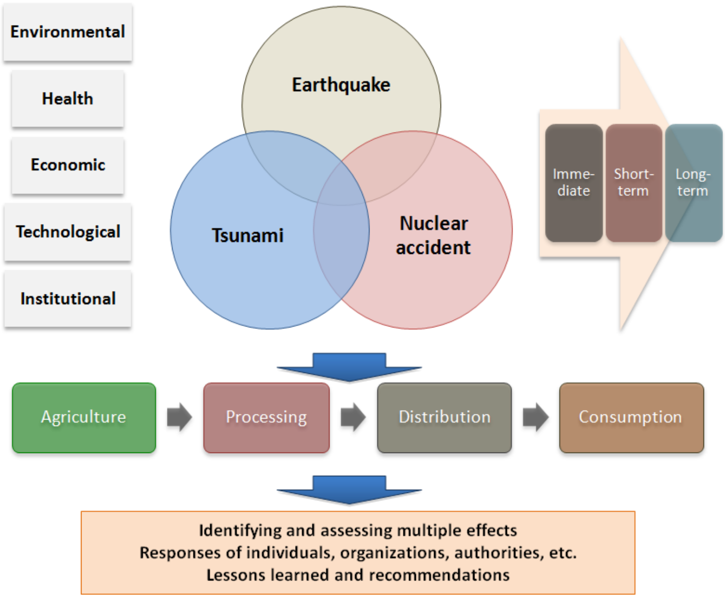


Figure 1. *Framework foranalyzing impacts of March 2011 triple disasters on Japanese agriculture and food chains*

- Radiation, displacement, health, physiological, production, economic, technological, organizational, environmental, academic, institutional, and political effects;
- Expected, real, likely, perceived, and modeled effects.

Next, we summarizeresponses of individuals, households, farms, businesses, communities, consumers, stakeholders, and authorities as well asassess the progress and challenges in the post-disasterrecovery and reconstruction.

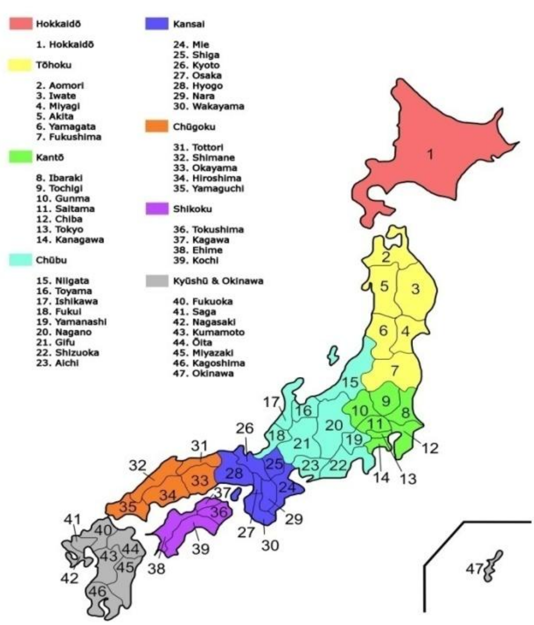
Finally, we withdraw lessons from the Japanese experiences and suggest recommendations for improving public policies, and individual, business and collective actions for effective risk management in Japan and around the globe.

The specification and assessment of individual effects has been associated with great difficulties because of their multiplicity, interdependency, synergy and multidirectional character, surround big uncertainty, shortage and controversy of data, large temporal and special scales, multiple agents with different perception, time horizon and interests involved, week methods of assessment and integration, etc. Therefore, we extended the uni-disciplinary and uni-sectoral analysis with multi and interdisciplinary approach and multisectoral study in order to better understand the overall impacts of the disaster on agri-food chain and its components.

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.

This book contains three parts and a conclusion. Initially, a short description of the three events is presented and the overall impacts on population, economy and environmental assessed; next theimpacts on agri-food organizations, products, markets and regulations are evaluated; after that the impacts on agri-food production, distribution and consumption are estimated; finally, a conclusion is made with major findings, lessons learned, and recommendations.

Unless otherwise stated, the officialnames oforganizations, agencies, local and regional administrative divisions (Map 1), etc. are used throughout the book.



Map 1. *Regions and prefectures of Japan*

Part 1.
Overall Impacts of March 2011 Triple Disaster

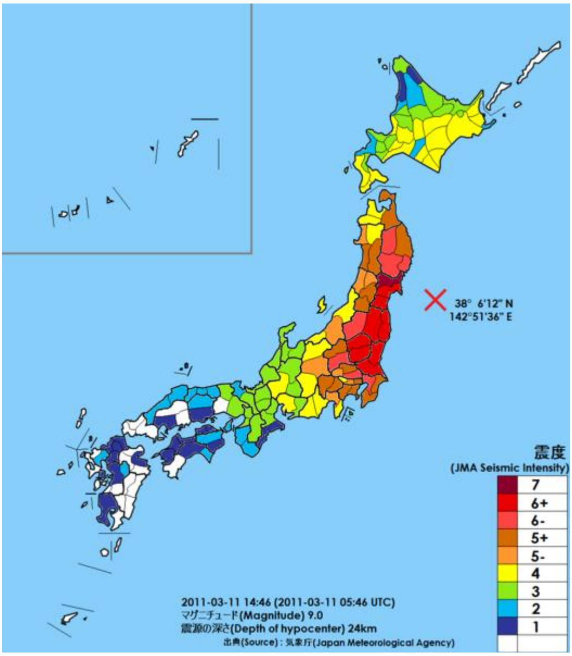
Chapter 1. Description of Events

The Great East Japan Earthquake

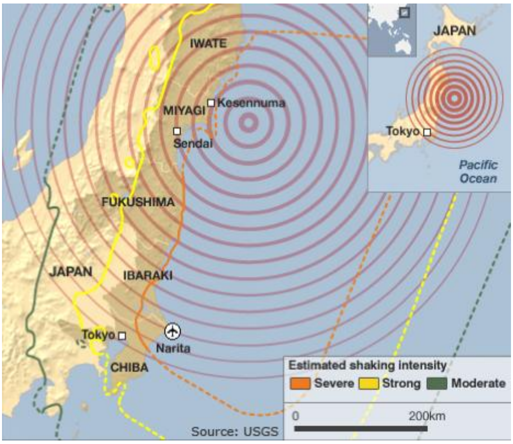
On March 11, 2011 at 14:46 Japan Standard Time[1] a mega thrustundersea earthquake occurredoff the Pacific coast of Japan widely known as the Great East Japan Earthquake (Japan Meteorological Agency, 2014). The earthquake hypocenter was at a depth of 24 kmand epicenter 130 km (38° 6.2′ N, 142° 51.6′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

The earthquake was with a magnitude of 9.0 Megawatt (Mw) (Japan Meteorological Agency, 2011). Its seismic intensity was 7 in the Northern part of Miyagi prefecture (Kurihara city), 6+ in the Southern and Central part of Miyagi prefecture, Nakadoti and Hamadori of Fukushima prefecture, the Northern and Southern part of Ibaraki prefecture, the Northern and Southern part of Tochigi prefecture, 6- in the Sothern part of coastal area, the Northern part of inland area and the Southern part of inland area of Iwate prefecture, Aizu region of Fukushima prefecture, the Southern part of Gunma prefecture, the Southern part of Saitama prefecture, and the North-west part of Chiba prefecture, and a lower intensity in other areas of the country (Map 2 and Map 3).

[1] 05:46 Universal Time Coordinated



Map 2. *Epicenter and seismic intensity of March 11, 2011 earthquake*
Source: Japan Meteorological Agency



Map 3. *Areas affected by March 11, 2011 quake*
Source: U.S. Geological Survey

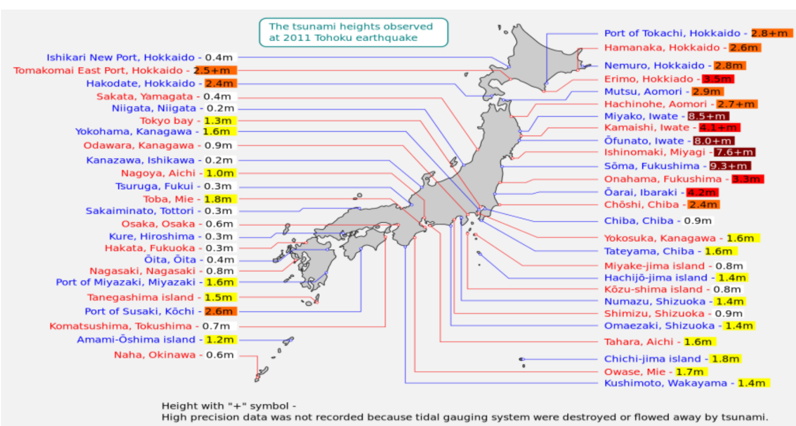
The Great East Japan Earthquake was the most powerful earthquake ever recorded in or around Japan,and the fourth most powerful earthquake in the world since 1900 (Japan Meteorological Agency, 2013).

The main earthquake,lasting approximately six minutes,was preceded by a number of large foreshocks first major of them being on 9 March (with 7.2 Mw).Almost 1000 aftershocksof magnitude 5.0 Mw or greater occurred since the initial quake by the end of 2013 (Japan Meteorological Agency, 2014).

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

Subsequent tsunami

The Great East Japan Earthquake triggered powerful tsunamisthat spread over the wide area from Hokkaido to Okinawa[2](Map 4).According to estimates an extensive coastal area surpassing 400 km was hit by tsunami higher than 10 m that submerged plane areas more than 5 km inland (Mori *et al.,* 2011).



Map 4. *Great East Japan Earthquake observed tsunami heights in Japan*
Source: Japan Meteorological Agency

[2] Simulations available on [Retrieved from].

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

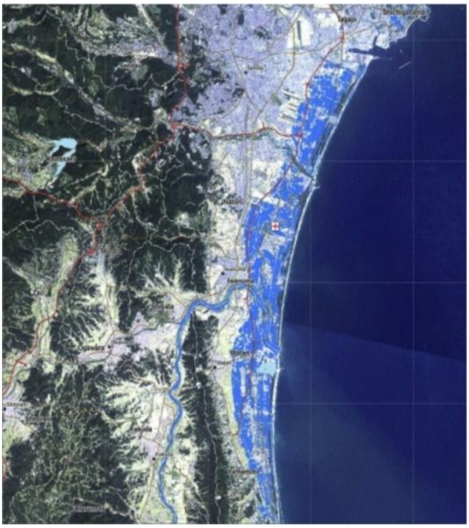
The tsunami raced outward from the earthquake epicenter at speeds that approached about 800 km per hour (Britannica, 2014). Experts suggestthat it would have taken 10 to 30 minutes to reach the areas first affected, and then areas further North and South based on the geography of the coastline (Deutsche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

The most severe effects of the tsunami were felt along a 670-km long stretch of coastline from Erimo, Hokkaido, in the north to Ōarai, Ibaraki, in the South, with most of the destruction occurring in the hour following the earthquake (Biggs & Sheldrick, 2011). The most severely affected areas were areasKuji, Ōfunato, Rikuzentakata Kamaishi, Miyako, Ōtsuchi, and Yamada in Iwate prefecture, Namie, Sōma and Minamisōma in Fukushima prefecture, and Shichigahama, Higashimatsushima, Onagawa, Natori, Ishinomaki, and Kesennuma in Miyagi Prefecture[3].

The tsunami inundated a total area of approximately 561 km^{2}or 4.53% of the total territories ofthe six Northeastern prefectures of Honshu island (Geospatial Information Authority, 2011). The most affected was Miyagi prefecture where 16.3% of the territory was flooded by seawaters. The worst affected by flooding wereWakayabashi and Migagino words of Sendai (60.4% and 4.5% of the total areas inundated), Watari-cho (47.9%), Iwanuma

[3] Detail maps of areas hit by the tsunami are available at: [Retrieved from].

(43.9%), Shishigahama town (38.5%), Yamomoto-cho (37.5%), Higashimatsushima (36.3%) and other areas (Map 5).



Map 5. *Tsunami flooded areas of Sendai*
Source: U.S. Geological Survey

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

Fukushima Daiichi nuclear power plant accident

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[4] overwhelmed the plant's seawalls and damaged cooling systems and control rooms (Figure 2). 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 meltdownsoccurred[5]leading to releases of huge radioactivity into the environment (Nuclear and Industrial Safety Agency, April 12, 2011).

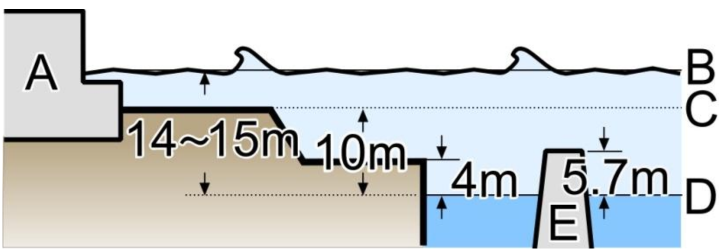


Figure 2. *Tsunami height at Fukushima nuclear plant*
Notes: A - plant building; B - peak tsunami height; C –siteground level; D - average sea level; E - sea wall
Source: Wikipedia

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

[4] Nuclear Regulation Authority has concluded that the tsunami triggered the meltdown (NHK World, July 18, 2014). It rejected the conclusion of the Diet commission (July, 2012) that the earthquake caused the reactor to lose power-damaging pipes leading to the meltdown before tsunami hit the plant.
[5] International Nuclear Event Scale (INES) runs from 0 (indicating abnormal situation with no safety consequences) to 7 (indicating accident causing widespread contamination with serious health and environmental effects). Prior to Fukushima, the Chernobyl disaster was the only level 7 event.

Table 1. *Radionuclides released from Fukushima nuclear power plant (Bq)*[6]

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

Source: Nuclear and Industrial Safety Agency, 2011

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

There have been diverse estimates about the total amount of radioactive elements released into environment as a result of the nuclear accident. Table 2 and Table 3 summarize the assessments of Tokyo Electric Power Company[7], related government agenciesof Japan (Nuclear Safety Commission, Japan Atomic Energy Agency, Nuclear and Industrial Safety Agency, and the French Institute for Radiological Protection and Nuclear Safetyfor the major radioactive materials released into theair and the sea duringthe period March-September, 2011 (Table 2 and Table 3).

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

[7] The operator of the Fukushima nuclear power plant.

Table 2. *Amounts of radioactive materials released into atmosphere for March 12-31, 2011 as result of Fukushima nuclearplant accident (PBq)*

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

Note: * value obtained by converting amount of radioactivity into iodine equivalent
Source: Tokyo Electric Power Company, Institute for Radiological Protection and Nuclear Safety,Nuclear Safety Commission, Nuclear and Industrial Safety Agency

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[8], and neptunium-239[9] 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[10].

Table 3. *Amounts of radioactive materials released into oceanbetween March 26- September 30, 2011 as result of Fukushima accident (PBq)*

Organization	Period of assessment	I-131	Cs-134	Cs-137
Tokyo Electric Power Company	March 26-September 30, 2011	1	3.5	3.6
Japan Atomic Energy Agency	March 21-April 30, 2011	1.4	-	3.6
Institute for Radiological Protection and Nuclear Safety	March 21-mid-July, 2011	-	-	7

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

[8] 120 gigabecquerel (GBq)
[9] 7.6 terabecquerel (TBq)
[10] Due to human activities at the plant the emissions rose again up to 19 thousand Bq in January 2012.

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

- radioactive noble gases: 6,550 PBq (the same order of magnitude as the Chernobyl accident), composed mainly of xenon-133;
- radioactive iodine: 408 PBq (about ten times less than the Chernobyl accident), including 197 PBq of iodine-131 and 168 PBq of iodine-132;
- radioactive tellurium: 145 PBq including 108 PBq of tellurium-132with 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[11] (Buesseler, 2014).

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

Different assessments of radioactivity from the Fukushima plant ranged from 10-40% of that of Chernobyl accident while significantly contaminated area is estimated to be 10-12% that of Chernobyl's. For example, the largest source of Cs137 is global fallout from weapons testing amounting 950 PBq (including 600 PBq in the ocean), Chernobylaccident contributed 100 PBq, while releases from Fukushima plant are estimated to be between 4-90

[11] Recently it has been announced that for the first time trace amounts of radioactive cesium-134 emitted from Fukushima nuclear plant were detected off the northern California coast in water collected about 150 km off Eureka in August 2014 (The Japan News, November 17, 2014).

PBq (including 10-50 PBq atmospheric and 3.6-41 PBq direct ocean) (Buesseler, 2014). Cesium 137 leaks from Fukushima are compared with the amount released by 168 atomic blasts similar to that in Hiroshima in the end in of World War II (The Telegraph, August 25, 2011).

Since the accident there have been continued spills of contaminated water at the plant grounds and into the sea. On August 20, 2013 it was announced that 300 metric tons of heavily contaminated water had leaked from a storage tank (Tokyo Electric Power Company, 2013). On February 27, 2014 it was revealed that another leak of 110 tons of contaminated water occurred (The Japan News, February 27, 2014). A new up to a ton water leakswas reported on April 14, 2014 (NHK World, April 14, 2014). On June 6, 2014 TEPCO announced that up to 3.4 tons of radioactive water may have leaked from barriers surrounding storage tanks (NHK World, June 6, 2014). Moreover, about 11,000 tons of water used to cool melted-down fuel leaked out of reactor buildings into underground utility tunnels, from where it is believed to be flowing out to sea (NHK World, June 25, 2014).

Furthermore, the underground tunnels of the facilities have been filled with highly radioactive water, which is believed to be leaking into the nearby sea after mixing with groundwater (NHK World, November 25, 2014). In June 2014 TEPCO found that radioactive water can easily spread in a deep layer of groundwater[12] and could be spilling into the ocean. On June 4 as much as 4,700 becquerels of tritium per liter were detected in a well near the No. 1 reactor building (NHK World, June 25, 2014). Water pressure in the layer was lower than that of a shallower layer making it easier for contaminated water to spread in the deep layer.

After a strongtyphoon in October 2014 it was found high levels of radioactive cesium in groundwater (up to 460,000 becquerels per liter)[13] in the compound of the nuclear plant in wells around the reactorsbuildings(NHK World, October 25, 2014). TEPCO began pumping up groundwater from the wells on a trial basis in August 2014 and full-scale operations in October[14].

Since May 2014 TEPCO has beenreleasing water in the ocean from "groundwater bypass operation"[15] as more than 8,600 tons of

[12] Deep layer of water is about 25 meters below the surface.

[13] 800 to 900 times the previous peak level of 500 becquerels per liter.

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

[15] Intended to reduce the amount of radiation-tainted water at the plant. Groundwater is pumped up from 12 wells near the 1 to 4 reactors before it flows

groundwater has been discharged so far (The Japan News, June 28, 2014). The first (about 560 tons) groundwater releasedin May contained 0.016 becquerel of cesium-134 per liter, 0.047 becquerel of cesium-137 and 220 becquerels of tritium (The Japan News, May 21, 2014).

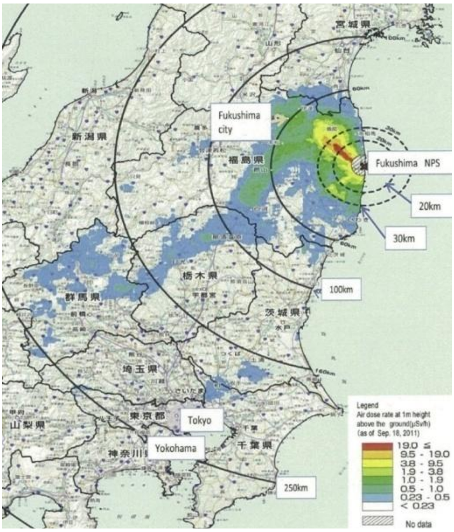
Consequently, the significant pollution of sea water along the coast near the nuclear plant persist as a result of the continuing arrival of radioactive material transported towards the sea by surface and ground water running over contaminated soil as well as the leakages and releases from the power station[16].

Furthermore, in summer 2014 TEPCO announced that more than one trillion becquerels of radioactive substances were released as a result of debris removal work(280 billion becquerels per hour) at one of the plant's reactors (NHK World, July 23, 2014). The plant is believed to be still releasing an average of 10 million becquerels per hour of radioactive material.

Radioactive contamination from the nuclear plant has spread in the region and beyond though air, rains, dust, water circulations, wildlife, garbage disposals, transportation, and affected soils, waters, plants, animals, infrastructure, and population. Highlevels of radiation were detected in large areas surrounding the nuclear plant and beyond (Map 6). Besides, numerous anomalous “hot spots” have been discovered in areas far beyond the adjacent region – e.g. in the year after the accident there were about150 reports in Tokyo alone (Ministry of Education, Culture, Sports, Science and Technology, 2012).

into the basement of the reactor buildings, temporarily stored in a tank and is released into the sea once radiation levels are confirmed to be lower than TEPCO standards.

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



Map 6. *Radioactive pollution caused by Fukushima accident (September 18, 2011)*
Source: Ministry of Environment

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

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

More detailed surveys have found out that cesium 137[17] had strongly contaminated the soils in large areas of eastern and

[17] 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

northeastern Japan (Yasunaria *et al.*, 2000; 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 radiation levels that exceeded Japan's allowable exposure rate of 1 mSv per year[18] (Ministry of Education, Culture, Sports, Science and Technology, 2011).Outside Fukushima prefecture reported soil radiation of cesium-134 and cesium-137 was between 30,000 and 100,000 Bq/m^2 in Ichinoseki and Oshu (Iwate prefecture), in Saku, Karuizawa & Sakuho (Nagano prefecture), in Tabayama (Yamanashi prefecture) and elsewhere.

Plutonium-238 and 239+240, Strontium-89 and 90, Tellurium-129m and Silver-110m fallouts have been also detectedin the affected regions (Ministry of Education, Culture, Sports, Science and Technology, 2011, 2012). The highest levels of Pu-239 and Pu-240 combined were15 becquerels per square meters [19] in Fukushima prefecture and 9.4 Bq in Ibaraki prefecture. Nevertheless, measured plutonium, and radioactive strontium, tellurium and silver were very small compared with the accumulated effective doses for 50 yearsof Cesium 134 and 137.

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

The extent of radioactive contamination of air, waters and soils in Japan has been monitored and updating constantly [20]. In Fukushima prefecturethe environmental radioactivity varies according to location (and even within the same locality because ofthe numerous"hot spots"), ithas been decreasing but it still higher than the levels before the disaster[21] (Table 4 and Map 7).

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

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

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

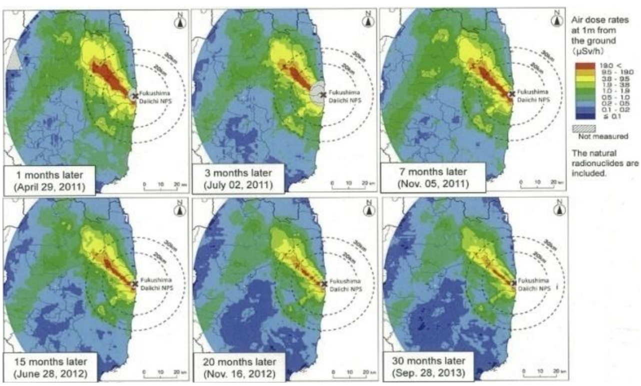
[20] Up to date environmental radioactivity levels can be found on [Retrieved from].

[21] In April 2014 radioactivity levels inside 20 km zone of nuclear plant was still extremely high - from 0.2μSv/h in Nahara and Tomioka towns up to 12.5 μSv/h,

Table 4. *Evolution of radiationlevels in Fukushima prefecture (μSv/h)*

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

Note: *radioactivity levels surveyed in 2010
Source: Fukushima prefectural government



Map 7. *Evolution of air radiation rates in 80 km zone from nuclear plant*
Source: Nuclear Regulation Authority

The average air dose rate at a distance within 80 km from Fukushima nuclear plant decreased by 65% compared to November 2011 (Reconstruction Agency, November 2016). According to latest data air dose rate within critical places in Fukushima Prefecture is comparable with major cities overseas[22] – Fukushima (0.18), Koriyama (0.11), Shirakawa (0.08), Iwaki (0.07), Aizuwakamatsu (0.06), Minamiaizu (0.04) and Minamisoma (Odaka) where evacuation order was lifted on July 12, 2016 (0.07) (Nuclear Regulatory Authority, 2016). In other prefectures the environmental radioactivity levels have been stable or decreased but mostly they are still higher than the period before the accident (Table 5).

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

16.8 μSv/h and 28.6 μSv/h in Futaba, Namie and Okuma towns (Nuclear Radiation Authority, 2014).

[22] E.g. Seoul (0.11), Beijing (0.07), Singapore (0.10), Berlin (0.08), Paris (0.04), New York (0.04) etc.

Prefecture (monitoring post)	Before March 11, 2011	March 20, 2011*	March 20, 2012*	March 20, 2013	March 20, 2014	March 20, 2015	November 22, 2016
Hokkaido (Sapporo)	0.02-0.105	0.027-0.028	0.028-0.033	0.034	0.037	0.038	-
Aomori (Aomori)	0.017-0.102	0.021-0.023	0.018-0.024	0.021	0.026	0.032	0.032
Iwate (Morioka)	0.014-0.084	0.025-0.040	0.021-0.029	0.038	0.039	0.037	0.036
Miyagi (Sendai)	0.0176-0.0513	0.15**	0.051-0.053	0.055	0.054	-	-
Akita (Akita)	0.022-0.086	0.034-0.041	0.034-0.036	0.054	0.052	0.052	0.054
Yamagata (Yamagata)	0.025-0.082	0.040-0.129	0.037-0.039	0.092****	0.092	0.089	0.091
Fukushima (Fukushima)	0.037-0.046	2.1***	0.89	0.82	0.27	0.21	0.16
Ibaraki (Mito)	0.036-0.056	0.159-0.263	0.074-0.075	0.077	0.079	0.067	0.064
Tochigi (Utshunomiya)	0.030-0.067	0.136-0.164	0.050	0.079	0.084	0.073	0.071
Gunma (Maebashi)	0.016-0.049	0.069-0.103	0.025-0.026	0.071	0.076	0.065	0.067
Saitama (Saitama)	0.031-0.060	0.052-0.062	0.046-0.047	0.047	0.055	-	-
Chiba (Ichihara)	0.022-0.044	0.031-0.033	0.037-0.038	0.058	0.069	0.048	0.047
Tokyo (Shinjuku)	0.028-0.079	0.044-0.049	0.049-0.050	0.057	0.071	0.059	0.057
Kanagawa (Chigasaki)	0.035-0.069	0.046-0.048	0.044-0.045	0.042	0.052	0.038	0.038
Nigata (Nigata)	0.031-0.153	0.047-0.052	0.046-0.052	0.063	0.071	0.063	0.063
Toyama (Imizu)	0.029-0.147	0.049-0.054	0.046-0.048	0.064	0.084	0.065	0.066
Ishikawa (Kanazawa)	0.0291-0.1275	0.047-0.063	0.046-0.051	0.052	0.063	0.051	0.052
Fukui (Fukui)	0.032-0.097	0.046-0.053	0.044-0.049	0.061	0.073	0.059	0.059
Yamanashi (Kohu)	0.040-0.066	0.044	0.043-0.044	0.051	0.056	0.05	0.052
Nagano (Nagano)	0.0299-0.0974	0.06-0.067	0.038-0.040	0.067	0.070	0.061	0.065
Gifu (Karamigahara)	0.057-0.110	0.061-0.066	0.060-0.061	0.067	0.076	0.064	0.067
Shizuika (Shizuoka)	0.0281-0.0765	0.035-0.040	0.029	0.041	0.055	0.039	0.037
Aichi (Nagoya)	0.035-0.074	0.039-0.042	0.039	0.068	0.071	0.079	0.07
Mie (Yokkaichi)	0.0416-0.0789	0.046-0.051	0.045-0.046	0.070	0.081	0.064	0.067
Shiga (Otsu)	0.031-0.061	0.034-0.037	0.031-0.032	0.065	0.081	0.063	0.065
Kyoto (Kyoto)	0.033-0.087	0.039-0.045	0.037-0.038	0.048	0.063	0.045	0.047
Osaka (Osaka)	0.042-0.061	0.042-0.046	0.042-0.043	0.080	0.083	0.075	0.079
Hyogo (Kobe)	0.035-0.076	0.036-0.037	0.036-0.037	0.072	0.091	0.067	0.071
Nara (Nara)	0.046-0.080	0.048-0.053	0.047-0.048	0.077	0.062	-	-
Wakayama (Wakayama)	0.031-0.056	0.031-0.033	0.031-0.032	0.081	0.083	0.078	0.076
Tottori (Touhaku)	0.036-0.110	0.063-0.075	0.062-0.063	0.071	0.073	0.07	0.073
Shimane (Matsue)	0.033-0.079	0.038-0.041	0.037-0.039	0.056	0.054	-	-
Okayama (Okayama)	0.043-0.104	0.049-0.053	0.048-0.049	0.067	0.082	0.064	0.068
Hiroshima (Hiroshima)	0.035-0.069	0.048-0.053	0.046-0.049	0.086	0.081	0.08	0.082
Yamaguchi (Yamaguchi)	0.084-0.128	0.094-0.096	0.091-0.095	0.080	0.075	0.074	0.079
Tokushima (Tokushima)	0.037-0.067	0.037-0.039	0.037-0.038	0.069	0.070	0.064	0.066
Kagawa (Takamatsu)	0.051-0.077	0.053-0.054	0.054-0.057	0.063	0.067	0.059	0.06
Ehime (Matsuyama)	0.045-0.074	0.047-0.051	0.046-0.048	0.084	0.098	-	-
Kochi (Kochi)	0.019-0.054	0.026-0.030	0.025-0.026	0.035	0.041	0.034	0.053
Fukuoka (Dazaifu)	0.034-0.079	0.036-0.040	0.036-0.037	0.066	0.060	0.057	0.043
Saga (Saga)	0.037-0.086	0.040-0.049	0.040-0.041	0.064	0.048	-	-
Nagasaki (Omura)	0.027-0.069	0.028-0.033	0.030-0.031	0.074	0.053	0.051	0.053
Kumamoto (Uto)	0.021-0.067	0.027-0.032	0.027-0.028	0.049	0.043	0.04	0.043
Oita (Oita)	0.048-0.085	0.049-0.053	0.040-0.050	0.057	0.055	0.051	0.053
Miyazaki (Miyazaki)	0.0243-0.0664	0.026-0.028	0.026	0.060	0.034	0.031	0.039
Kagoshima (Kagoshima)	0.0306-0.0943	0.034-0.039	0.034	0.056	0.047	-	-
Okinawa (Uruma)	0.0133-0.0575	0.020-0.021	0.023-0.031	0.021	0.022	0.021	0.025

Notes: * Minimum and maximum readings;** Tohoku University data;***MEXT data; ****March 24 data
Source: Nuclear Radiation Authority

The National Diet of Fukushima Nuclear Accident Independent Investigation Commission[23] concluded that the Fukushima nuclear accident "cannot be regarded as a natural disaster. It was a profoundly manmade disaster - that could and should have been foreseen and prevented. And its effects could have been mitigated by a more effective human response" (The National Diet of Japan, 2012). It was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by these parties. They effectively "betrayed the nation's right to be safe from nuclear accidents".

Recent disclosure of the records of interviews of the government panel investigating the nuclear crisis (so-called "Yoshida file")[24] also illustrates how badly the officials handled crisis management at Fukushima nuclear power plant and how serious the situation was (NHK World, September 11, November 12, December 26, 2014; The Japan News, September 13, 2014).

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

[24] Former manager of the power plant Masao Yoshida, former Prime Minister Naoto Kan and 17 others was relised in September 2014, more 56 in November 2014, and additional 127 in December 2014. The government plans to disclose interviews with all 772 government and TEPCO officials if interviewees give approval.

Chapter 2. 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 6). The majority of deaths were from tsunami and among elderly.[25] The biggest number of victims has been from Miyagi, Iwate and Fukushima prefectures where whole communities were wiped out by the powerful tsunami. Five after the disaster 2,557 people are still listed as missing and search for them has been continuing.

Table 6. *Number of confirmed deaths, missing and injured person associated with March 2011 earthquake (September 9, 2016)*

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	229
Miyagi	9,541	1,233	4,145	Kanagawa	4	-	121
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					15,894	2,557	6,152

Source: National Police Agency.

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

What is more, official data for the "disaster related deaths"[26] have been growing reaching 3,076 in 10 prefectures by the end of March 2014 (NHK World, May 6, 2014). The majority of victims are from Fukushima prefecture (1,691), followed by Miyagi prefecture (889) and Iwate prefecture (441).

The June 25, 2014 data for Fukushima prefecture show that 1,729 people have died as a result of lingering effects of the accident exceeding the 1,603 deaths caused directly by the disaster (Fukushima Minpo News, June 26, 2014). Nevertheless, it is becoming increasingly difficult to identify a relationship between deaths and the accident due to the long period of time that has lapsed[27].

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

What is more, at least 97 people affected by the disaster have died unattended[28] in temporary housing units in Iwate, Miyagi and Fukushima prefectures, and experts say that the number of solitary death cases would likely increase in future (The Japan News, March 2014).

Officials linked the number of suicide deaths to disaster of 2,916 as of September 2013 (LDP, 2014). In 2013 disaster related suicides in Fukushima[29], Miyagi and Iwate prefectures were associated with deteriorating health of 22 of them, money problems of nine more, and family issues of five.

Many farmers from the affected areas and beyond who saw their businesses and livelihood destructed also suffered stress and anxiety (Murayama, 2012; Watanabe, 2011). For instance, a 64-

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

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

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

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

year-old farmer in Sukagawa was pushed over the edge since he lost "everything he had ever worked for during his life"[30]. One day after the government imposed a ban on the sale of cabbages he took his life (The New York Times, March 29, 2011). Another dairy farmer in 50s killed himself on the land he struggled to maintain since tsunami and nuclear crisis began few months after the disaster (CNN, June 14, 2011).

There have been also many reports for affected survivors from disaster exposed to a high risk or suffering from various diseases after the accident – injuries, respirationproblems 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, July 28, 2014). For instance, in the three months after the disaster in Kesenuma, Motoyashi and Otomo hospitals 225 were admitted suffering from pneumonia, 52 of whom consequently died. Similarly in Ishinomaki 122 were hospitalized in days after the disaster at rate 7 times higher than the normal one.

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

Another factor for increased health risk has been caused by radiation exposure after the nuclear accident. The levels of radiation exposure of population varied according to the direction from the Fukushima plant and the time spent in contaminated zones[31]. Major pathways humans were exposed to radioactive materials after the accident were: external exposure from radionuclides deposited on the ground; external exposure from radionuclides in the radioactive cloud; internal exposure from inhalation of radionuclides in the radioactive cloud; and internal exposure from ingestion of radionuclides in food and water (World Health Organization, 2012). However, the gap between our understanding of the biological effects of radiation in humans and

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

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

the determination of regulatory values in too wide (Fukumoto, 2013).

Workers in the nuclear plant have suffered the highest exposures[32]. According to the data 167 workers received radiation dose more than 100 mSv[33], 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[34] and for roughly 150,000 citizens from the fallout zone exposures were lower. For instance, in Namie town and Iitate village, nearby communities where the evacuation was delayed, residents received 10 to 50 mSv. There are still occasional reports for radiation overexposure of workers at the plant (NHK World, May 8, 2014). Furthermore, working in some areas[35] and using some new methods (e.g. pouring cement into underground tunnels) are likely expose workers to more radiation than originally expected (NHK World, November 25, November 28,2014).

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

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[36].

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

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

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

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

[36] Since April 2011the maximum annual allowable radiation exposure to let evacuees return to the areas near nuclear plant is 20 mSv. For Fukushima

Nevertheless, there have been debates and great concerns about the risks for people exposed to lower doses since risks are lower and hardly to detect (Akiyama *et al.,* 2012; Fisher *et al.,* 2013; Foodwatch, 2011; Hasegawa, 2013; Pacchioli, 2014; Rosen, 2013).

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

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

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

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

The latest UN report of more than 80 international experts also pointed out that no deaths or serious illnesses have so far been reported from the radiation exposure from the nuclear accident. It concluded that no discernible increased incidence of radiation-related health effects (e.g. rate of cancer) are expected among exposed members of the public or their descendants" (The Japan News, April 3, 2014; NHK World, May 28, 2014). However, it warned that "an increased risk of thyroid cancer can be inferred for infants and children" stressing the need for continued research[37]. The maximum radiation dose for a year after the Fukushima crisis

schools a target of exposure dose 1 mSv/y was set up which should be used in decision making on limiting outdoor activity at schools.

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

began was estimated at 9.3 mSv for adults in areas near the Fukushima plant and at 13 mSv for 1-year-old infants.

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 (started in April 2014) indicate that 4 local young people[38] may have thyroid cancer, even though they cleared a screening shortly after the nuclear accident in 2011 (NHK World, December 25, 2014). Officials saythey have no enough data to prove whethernuclear fallout caused those cases since radiation levels in areas where people lived are not high enough to cause thyroid cancer. It is still much unknown about how children develop thyroid cancer andclose monitoring of the situation have to continue.

People living and working in different locations of the affected regions have been exposed to diverse levels of radiation[39]. What is more, even in the same locations the radiation level often differs due to the different precision of instruments or local hot spots. In addition, people are constantly exposed to small amount of no harmful natural background radiation – it is approximately 2.1 mSv per person in Japan, including 0.3 mSv from space, 0.33 mSv from land, 0.48 mSv from Radon etc. and 0.99 mSv from food (National Institute of Radiological Science, 2014).

In addition, confusion has been also spreading among municipalities tasked with radiation cleanup under changinggovernment decontamination policy[40] (Fukushima Minpo News, July 22, 2014). Under the new policy, the government will determine decontamination needs by using radiation exposure data collected from individual dosimeters (which tend to be lower than the current safe dose) leading to reduction areas of government-mandated decontamination.

Some municipalities welcome those new policies since it will allow scaling down decontamination efforts in areas where radiation levels are unlikely to go down significantly. However, others are worried that residents will be confused. For instance, according to Date officials, the city measured the radiation

[38] They were 6 to 17 years old at the time of the Fukushima accident.

[39] Government maintains that radiation exposure on residents in Fukushima prefecture are no different from those of in other prefectures (The Japan News, May 18, 2014).

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

exposure of its 52,000 citizens wearing dosimeters (July 2012-June 2013) and results showed that per-year exposure levels for nearly 70% of them (even in areas where aerial radiation levels exceeded 0.23 microsievert per hour) was less than 1 millisievert in total (Fukushima Minpo News, July 22, 2014). Moreover, Tamura officials declare that city will not change its decontamination plan, since if the cleanup projects are scaled back, it would cause anxiety among residents. Some experts[41] also suggest that new approach is inappropriate since many residents have deliberately stayed indoors and if they start to go out like they used to, the individual radiation doses might go up.

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

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

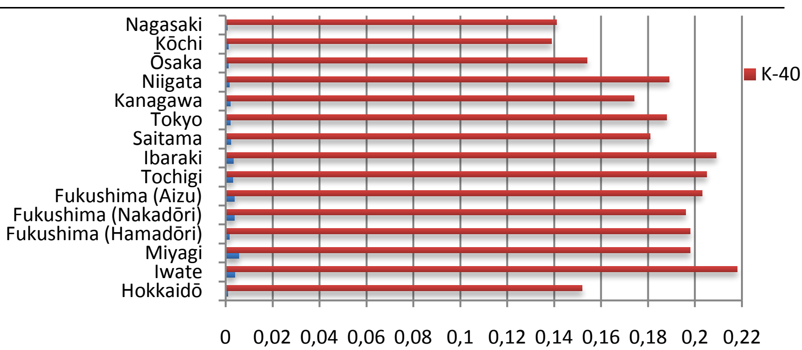


Figure 3. *Estimation on annual dietary intake of radionuclides for September-October 2012 in Japan (mSv/year)*
Source: Ministry of Health, Labor and Welfare

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

Furthermore, radiation doses from radioactive cesium have been found to be decreasing over time - for 15 studied areas it was lower comparing to previous estimates for September-November 2011 (0.0024–0.019 mSv/year) and February-March 2012 (0.0009–0.0094 mSv/year). Likewise, in Fukushima prefecture (Nakadōri Area) the effective dose from radioactive cesium in foods has been decreasing constantly and it is less than 1% of the maximum allowed level[42] (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[43]. Therefore, even if people are exposed to more than "around 100 mSv" of the extra cumulative exposure, it will not necessarily mean they will have adverse health effect (Koizumi, 2011).

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

November 2013-February 201 survey of the Fukushima Consumer Cooperative found out that the levels of radioactive cesium in home-cooked meals in the prefecture were slightly above the limit for radioactive cesium [44] for 4% of participating households (Fukushima Minpo News, March 7, 2014). Nevertheless, internal exposure to radioactive materials of all screened household members was belowthe 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[45] or certain medical check-ups, many show a great concern on current figures[46].

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

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

[44] Highest level detected in a household of 2.6 Bq/kg for Cs 137 and 1.1 Bq/kg for Cs 134.

[45] Hot springs regularly visited by many Japanese.

[46] Also true in other countries – e.g.US National Academy of Sciences report on lessons from Fukushima crisis notes that poor communication between central government and local governments, as well as a lack of clear standards about

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

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. As one Fukushima farmer was cited to say "his family is taking extreme care to protect their health by choosing only "safe" food, resulting in "a nerve-wracking lifestyle." (Kakuchi, 2013).

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

A 2014 survey indicates that 68% of evacuated households in Fukushima prefecture have one or more members with health problems such as lack of sleep or depression (NHK World, April 30, 2014). Data from the Fukushima Center for Disaster Mental

radiation levels that require decontamination led to public distrust in the government (NHK World, July 25, 2014).

Health shows that consultations for emotional instability, such as irritation, depression and mood swings, increased 50% since 2012, forming 19% of total health consultations (The Japan Time, March 1, March 1, 2014). Official survey has also found that almost 34% of children in Iwate, Miyagi and Fukushima prefectures who were aged 3 to 5 at the time of March 2011 earthquake now suffer from post-traumatic stress disorder such as sleeping disorders, flashbacks etc. (The Japan News, March 2, 2014). It wasalso reported that many elderly men cannot cook, so they became unable to maintain a balanced diet or develop a habit of turning to alcohol, and as a result they can easily fall ill (The Japan News, March 20, 2014). All these problems have been further aggravated by the lack of enough specialized doctors, health care centers and social workers in all affected areas.

Data show that the suicide-prevention hotline in Fukushima prefecture received record 18,194 calls in 2013[47] and consultations related to the 2011 disasters still stand out from the other issues (Fukushima Minpo News, June 5, 2014). The content of consultations has also changed over time - unlike the first days of the disasters, when new supply lines were in dire need, nowadays callers often discuss issues regarding mental distress. In 2011 almost 12% of all calls were related to the quake and nuclear crisis. In 2012 the later fell to just below 5% but counselors spent more hours talking to each person on average. Most recent topics range from arguments between spouses over whether to leave Fukushima, to the way fathers feel estranged from families after being forced to move out of the house to find work. Sense of loss and isolation, as well as pessimism about life in general, have recently stood out, while many used to mention “a sense of unity” and “preciousness of life” in the early stage of the disasters[48].

Free legal consultations service for the disaster victims[49] has also been on a rise – e.g. in fiscal 2013 totaled 48,418 nationwide (up 12.6% from the previous year) as more than 80% (39,288 cases) were in Iwate, Miyagi and Fukushima prefectures (The

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

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

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

Japan News, September 11, 2014). Family legal troubles, including divorce and inheritance, topped the list at 39.2%, followed by financial troubles such as loans between friends at 25.4%, multiple debts, including double loan problems, accounted for 13.7%, and real estate issues such as land purchases by municipalities aimed at post- disaster reconstruction were 10.5%.

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

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

Some people are concerned about deteriorating work quality as number of staff unfamiliar with working at nuclear plant environment increases (The Japan News, October 21, 2014)[50]. According to TEPCO 25 workers experienced some work-related difficulties, such as injury or heat stroke in 2012, but that figure increased to 32 in 2013. What is more, in March 2014 a 55--year-old man died after he was buried in soil while excavating it[51].

Consequently, the Nuclear Regulation Authority announced it will consider revisions to the law for protecting nuclear plant workers' health in emergencies responding to calls in negotiations that started 3 years ago with the Tokyo Occupational Safety and

[50] Manpower shortages have occurred because veteran workers left Fukushima unsatisfied with short-term contracts and working environment. At the same time there are many employed from other regions with no experience in working at nuclear plant.

[50] The first fatality since decommissioning work started.

[51] The first fatality since decommissioning work started.

Health Center[52] (NHK World, July 10. 2014). The later stresses that such revision is vital for ensuring that workers are better prepared for emergencies and must be informed of how radiation exposure could affect health and decide in advance whether to give consent.

The number of workers taking part in the decommissioning and other work at the Fukushima nuclear plant has doubled to more than 5,700 in the past year (HNK World, September 29, 2014). According to TEPCO contractors hire most of them[53] and theyare responsible for labor safety[54] (NHK World, July 17, September 29, 2014).

NRA recently approved a proposal to study raising the emergency radiation exposure limit beyond current accumulative limit of 100 mSv (NHK World, July 30, 2014). It will decide on the level by referring to overseas standards as well as on how to get prior consent from workers and train them.

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

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

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

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

Chapter 3. Evacuation and migration

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

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

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

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

Notes: * including evacuees from Fukushima and/or Miyagi
Source: World Health Organization, 2011

Immediately after the nuclear accident the government recommendedevacuation 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[55]. In April 2011, the evacuation of about 10,000 more people form areas further to the Northwest of the plant was recommended (so called "Deliberate Evacuation Area") because of the high levels of radioactive material on the ground[56].

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

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

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

3) Evacuation prepared areas in case of emergency[57] - 20-30 km radius from Fukushima nuclear plant where certain groups (pregnant women, with special needs) are not permitted.

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

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 farmingdepends 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

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

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

[57] Lifted on September 30, 2011.

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.

Map 8. *Restricted, Deliberate evacuation,Specific spots areas (September 30, 2011)*
Source: Ministry Economy, Trade, Industry.

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.

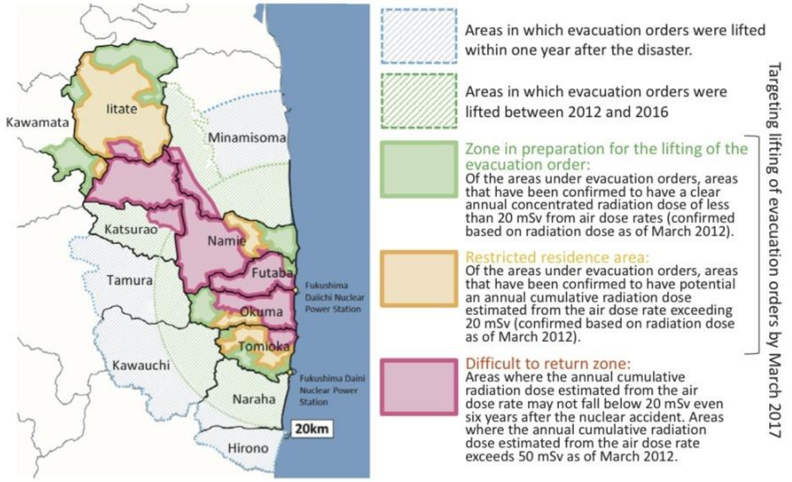
3) No entry areas - the annual integral dose of radiation is expected to be 20 mSv or more within five years and the current integral dose of radiation per year is 50 mSv or more. People are legally required to evacuate from the areas, for which physical barriers to entry such as barricades are placed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

On April 1, 2014 evacuation order for a portion of Miyakoji District, Tamura City was lifted, which was the first complete lifting in the initial "no go zone". On October 2014 evacuation advisory was lifted for bulk of Kawauchi village within 20 km of nuclear plant (status of western part of village also changed to a zone preparing for lifting of evacuation advisory). According to many these are a test whether people would be ready to return back to areas surrounding nuclear plant. Present status of Areas under Evacuation Order is presented on Map 9.



Map 9. *Present status of Areas under Evacuation Order*
Source: Reconstruction Agency, 2016.

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

The overall number of evacuees has decreased significantly and in February 2012 there were 342,509 evacuees living in 1,200 municipalities in 47 prefectures around the country (National Policy Unit, 2012). Most of them (94.1%) were in temporary and public housings[58], hospitals etc., some 4.9 % lived with relative, friends etc., 97 stayed in hotels and similar facilities, and only 584[59] remained in evacuation centers (community hall, school etc.) in 2 prefectures.

The reconstruction process has been progressing rapidly, as most evacuees were moved to temporary built houses by September 2011[60]. Some evacuees have moved to permanent homes and return to a normal life. Vital infrastructure such as major road, railway, harbors, and telecommunications network have been quickly restored, and essential public services such as hospitals, schools, water and energy supply etc. quickly re-established. In recent months there has been considerable progress (decontamination, lifting evacuation orders, rebuilding, re-opening administration, hospitals, schools, train services, etc.) in some parts of the evacuation zone around the crippled nuclear plant as well (NHK World, April 1, April 24, June 2, 2014; The Asahi Shinbun, April 7, 2014; The Japan News, June 1, 2014).

At the same time diverse national and local initiatives for building disaster resilient towns have been in progress, including the collective relocation of residential areas to safe places such as higher ground in 276 districts in 26 municipalities[61], and the readjustment and leveling of land for residential areas in 58 districts in 19 municipalities (Reconstruction Agency, 2014). Latest data indicates that while 81% of planed housing reconstruction started merely 11% have been completed[62] (Reconstruction Agency, 2014).

In July 2014 there were still more than 247,000 evacuated people living in temporary housing and other makeshift facilities nationwide (Figure 4). What is more, a significant number of them live outside home prefectures – e.g. in the end of August 2014 as many as 47,149 former Fukushima residents are living outside the prefecture, 6,974 people from Miyagi prefecture, and 1,513 from

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

[59] Compared with 41,143 in June 2011 (Reconstruction Agency, 2014).

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

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

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

Iwate prefectures. Furthermore, many evacuees have been moved multiple times before settling to a “permanent” place or returning home[63] (NHK, August 4, 2014).

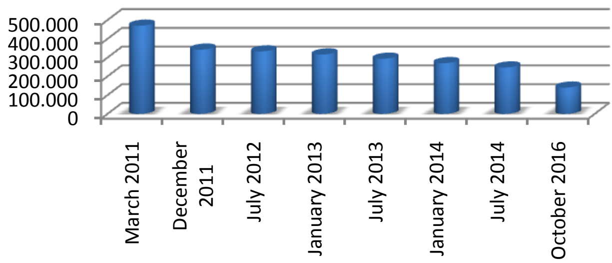


Figure 4. *Evolution of number of evacuees in post disaster years*
Source: Reconstruction Agency, National Police Unit

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

In Iwate, Miyagi and Fukushima prefectures more than 90,000 people live in makeshift housing (The Japan News, September 12, 2014).In the end of July 2014 the occupancy rate of temporary housing stood at 79% in Iwate prefecture, 80% in Miyagi prefecture, and 78% in Fukushima prefecture, while only a fraction of planned public housing were completed - 12.7% in Iwate, 9.8% in Miyagi and 7.3% in Fukushima prefecture.

Continued use of the makeshift facilities[64] has been an issue as their conditions rapidlydeteriorate (damages, bacteria, etc.). Recent deadly mudslidesalso caused fear about the safety of makeshift housing residents since some of these houses were built in

[63] E.g. in the year after the accident around 70% of residents of Futaba, Okuma, Tomioka, Naraha and Namie had to evacuate four times or more (The National Diet of Japan, 2012).

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

sediment related “caution zones”[65] (The Japan News, November 2, 2014).

The construction of public housing has remained slow, with only about 10% of planned 30,000 new low-rent units completed in most affected Miyagi, Iwate and Fukushima prefectures by the end of August, 2014 (NHK World, September 10, 2014).According to the officials selecting locations and acquiring land plots take time as well limited availability of workers and building materials have been delaying factors. Recent data indicate that about 330 of the completed units in 19 municipalities are unoccupied while in other locations applicants outnumber the available units[66].

The progress in projects to relocate tsunami stricken communities has also been slow and merely 10% of the areas planned for relocated communities had been developed by the end of January 2014 (NHK World, March 11, 2014). A new town is coming to existence in Tamaura-Nishi district of Iwanuma (Miyagi Prefecture), where residential land has been developed for a collective relocation project (The Japan News, September 11, 2014). About 60% of about 1,800 people who lived in the city’s six districts along the tsunami hit coast will move into the housing units.The new town will have 336 residences, including 178 publicly operated housing units scheduled to be completed by the end of the fiscal 2014[67]. Bus services started in October 2014, but a large supermarket is set to be opened in summer 2015.

The post disaster reconstruction has been much more delayed in Fukushima prefecture (The Japan News March 11, 2014). Amid-October public opinion poll indicated that for 86% of voters reconstruction work “has not progressed at all,” or “has not sufficiently progressed” (The Japan News, October 28, 2014).

More than three and halfyears after the accident about 127,000 Fukushima prefecture residents were displaced, of which 101,000

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

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

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

from the “Evacuation Order Area” [68] (Reconstruction Agency, 2014). The number of evacueeswithin Fukushima prefecture was 81,000[69], and most of them (92,59%) were living in temporary houses (including private), 4,94% are in employees houses, etc., and the rests staying in houses of relatives and friends.

Furthermore, around 45,000of Fukushima evacueeswere still evacuatedoutside[70] the prefecture (Reconstruction Agency, 2014). Most of them werein Tokyo (6,300), Yamagata (4,700), Nigata (4,100), Ibaraki (3,400) and Chiba (3,300) prefectures. Available data show that 81% of them live in the temporary housing complexes including apartments or civil servants housings, and the rest stay with relatives and friends (Fukushima Prefecture Government, 2014).

About 40% of the first batch of public housing for people displaced by the Fukushima nuclear disaster will not be ready by the end of fiscal 2015[71], forcing those who evacuated to wait longer for permanent homes (Fukushima Minpo News, August 5, 2014).According to the prefecture it takes longer than expected to conclude deals with landowners of construction sites for large housing complexeswhile work to transform forests and rice paddies into residential land is also going slowly.

Most recent data shows that the total number of evacuees declined to 140,000 (October 2016) while evacuees living in temporary housing are approximately 50,000 (September 2016) (Reconstruction Agency, 2016). Until August 2016 out of planed 20,000 units new housing to be relocated to uplands 49.7% have been completed[72], out of 30,000 units public housing for the disaster-affected 66.2% are completed[73], and as many as 130,000 rebuilt private houses on their own are done (Reconstruction Agency, 2016).

[68] Incl. 32,000 from Evacuation lifting preparation area, 23,000 from Residence restricted areas, and 25,000 from Returnnig back difficult areas (Reconstriction Agency, 2014).

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

[70] Only reported to governmentnumber. It is assumed thatactual number should be higher.

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

[72] It is scheduled to complete 69.4% by March 2017 and 91% by March 2018.

[73] It is scheduled to complete 85.9% by March 2017 and 96.6% by March 2018.

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

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

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

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

What is more, experimental decontamination results show that current decontamination technology has limits and considerable time would be needed to clean up tainted areas[74]. Radiation levels in some areas near the damaged nuclear plant have been more than halved due to decontamination but still remain high (NHK World, June 10, 2014). For instance, radiation levels in residential districts of Namie town averaged 3.26 to 8.47 microsieverts per hour (about 40 to 50% of the pre-decontamination levels) and in Futaba town averaged 3.01 to 4.46 microsieverts per hour (about 20 to 30% of the pre-decontamination levels). These figures are more than 10 times higher than the government set level (0.23 microsieverts per hour) that requires decontamination. Consequently, the government will consider whether to carry out full-scale decontamination of such areas after asking former residents whether they hope to

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

return to hometowns as well as receiving suggestions on reconstructing the no entry areas.

This estimate suggests that decontamination work may reduce radiation levels at no entry zones below the government set maximum annual threshold of 20 millisieverts in 10 years (NHK World, June 23, 2014). In places with an annual radiation reading of 100 millisieverts, decontamination would lower levels to a range of 9 to 19 millisieverts by 2021 while areas with 50 millisieverts would see a drop to between 6 and 11 millisieverts[75]. Nevertheless, radiation levels in no-go zones are expected to remain far above the internationally recommended safe level even a decade after the nuclear disaster[76].

Besides, the progress in decontamination work does not necessarily mean residents' return is smooth (The Japan News, October 28, 2014). For example, evacuation instructions were lifted in eastern parts of the Miyakojimachi district in Tamur in April 2014 but only about one third of the 354 registered residents have returned until October(mostly elderly). This is largely because living circumstances in the district have not returned to previous state[77].

August 2014 survey in Namie and Tomioka indicated that 50% of former residents have made decision "never return to hometowns" (NHK World, October, 2014). The latter figure was much higher than in 2013 indicating that some "undecided" have taken decision not to return for a good because of difficulties (e.g. lack of infrastructure, sufficient government support, etc.) and risks[78].

In December 2013 the government compiled new guidelines for helping people affected by the nuclear accident including financial assistance for residents who plan to return home because their evacuation orders have been lifted and those who need to move

[75] Based on a hypothetical model (person spends 8 hours/day outdoors and lives in wooden house). If decontamination does not take place, annual radiation reading of 100 mSv would naturally drop to 37 mSv by 2021, and a reading of 50 mSv would drop to 19.

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

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

[78] In 2013 one third of evacuees from Namie responded that they will never return because "there is no hope of radiation levels decreasing", "the nuclear accident will not be brought under control", and ""it will be difficult to rebuild social infrastructure" (Pushpalal *et al.,* 2013). 70% of who want to return, certain conditions have to be met such as decrease in radiation levels, rebuilding infrastructure, and having certain portion of residents returning.

elsewhere. For residents of areas where evacuation orders are still in place, the government will cover the cost of purchasing homes if people want to start new lives elsewhere, andprovide a lump sum compensation for mental distress they could suffer after 2017.

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

In some cases (e.g. Kawauchi village) there has been a drop in the radiation levels[79] and improvements in infrastructure but the government postpone removal of the evacuation advisory after consultations with and opposition by residents (The Japan News, July 14, 2014). Residents in the area where the evacuation advisory was lifted on October 1, 2014 numbered 275 of 139 families, out of total, 48 people of 22 families have applied for long-term stays at their homes[80] (Fukushima Minpo News, October 1, 2014).

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

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

[79] By average of 63% from prior to decontamination work and bellow safety standards.

[80] 53.5% of population (2,758) live inside the village on a temporary or permanent basis.

evacuees hoping to return home but also for those giving up the idea".

In many places diverse organizations have been set up to support residents who will return. For instance, a community-based organization has been set up to support residents who will return to Naraha town after the evacuation order is lifted[81] (NHK World, June 30, 2014). The support organization (including three officials and volunteers) will provide services such as keeping the houses in order, weeding residents' gardens, building ties among residents, and consultations on radiation exposure.

Data suggests that more and more evacuees have been settling down permanently away from hometowns (NHK World, June 25, 2014). Residents of evacuation zones are entitled to tax reductions if they acquire a new house or land while they have to live elsewhere and such was given to nearly 1,400 applicants during the fiscal year that ended in March, 2014[82].

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

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

All these issues have caused further pressure to accelerate reconstruction processand pledge by the government people to feel

[81] Early 2015 after decontamination work is over.
[82] More than twice the number of cases in the previous year.

not only "the hard side of reconstruction, but also reconstruction of their hearts" (Abe, 2014). It has also lead to a shift from the previous policy (December, 2013) of "eventually having all those who were forced to live as evacuees return home" and include support measures for evacuees who have decided to live elsewhere than their hometown".

In June 2014 the Reconstruction Agency announced that the government is granting about 80 million dollars to Fukushima prefecture and its 16 municipalities to assist local rebuilding projects (such as designing public rental housing for returning residents who had to evacuate), for resumption of farming and industrial activities, etc. (NHK World, June 17, 2014). That money is part of about 1.6 billion dollars earmarked by the government to help local governments jump start projects in areas where evacuation orders have been being lifted hoping that will speed up rebuilding efforts in areas that experienced delays because of evacuation orders. Fukushima prefectural government estimates that ¥3.9 trillion will be needed for reconstruction work over a 10-year period from fiscal 2016 (The Japan News, October 28, 2014). The process of evacuation and reconstructions has been associated with a number of challenges such as: failure for timely evacuation from certain highly contaminated areas, slow response of authorities, lack of sufficient public information in the first stages of the disasters, mistrust to public and private institutions, multiple displacements of many evacuees, divided communities and families, bad communication between different organizations, lack of financial resources, insufficient manpower and building materials, ineffective use of public funds, discrimination toward some evacuees, emotional conflicts between evacuees (about "self-evacuation", compensations, rebuilding modes), insufficient and unequal compensation, substandard labor conditions for decontamination workers, increased number of individual and organized criminal cases, numerous lawsuits against TEPCO and authorities, revisions in national energy, disaster prevention etc. policies, etc. (Akiyama *et al.,* 2012; Fukushima Minpo News, February 17, March 13, 2014; Hasegawa, 2013; The Japan News, March 4, March 6, March 11, March 12, March 27, April 4, 2014; The Japan Times, March 13, 2014; NHK World, March 13, June 12, 2014; Manoliu, 2014).

The 2011 disasters occurred at areas that had been facing problems of depopulation and aging (Nemoto, 2014). Populations of prefectures hardest hit by the disasters have continued to decline during the last 3 years (NHK-World, March 11, 2014). In Iwate, Miyagi and Fukushima prefectures total population dropped by more than 132,000 between March 1, 2011 and February 1, 2014. In the first year the population declined by about 85,000 as many people died or were evacuated, in the second year, the number fell by 29,000, and the third year by 17,000[83]. Fukushima prefecture has seen the largest population decline in post disaster years - 86,077 peoplesince March 1, 2011 (Figure 5).What is more there has been significant decline in age groups up to 65, and increase in older population[84].

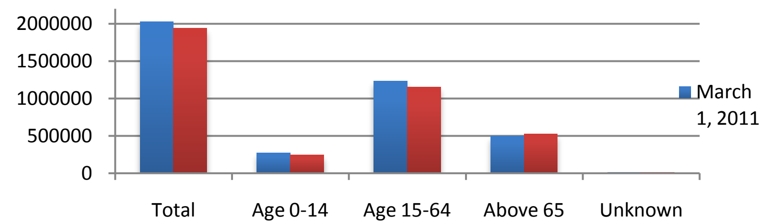


Figure 5. *Population dynamics in Fukushima prefecture*
Source: Statistics Bureau, Ministry of Internal Affairs and Communications

Most people especially younger one have been reluctant to return to home places due to the health risk, lack of basic infrastructure and services, reduced employment opportunities etc. What is more, the overall population has been decreasing due to out-migration since the nuclear accident (Figure 6).

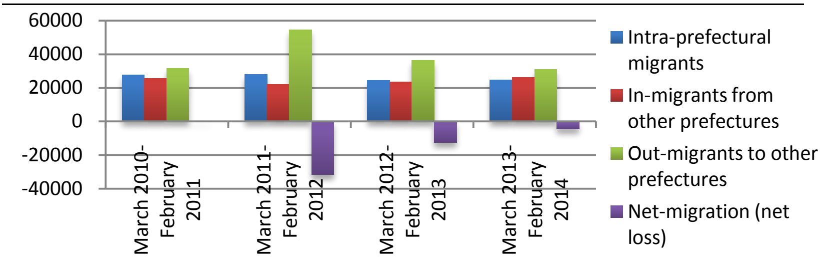


Figure 6. *Number of intra-prefectural migrants, in-migrants, out-migrants and net losses in population in Fukushima prefecture*
Source: Statistics Bureau, Ministry of Internal Affairs and Communications

[83] Populations began rising recently in some stricken areas (Iwanuma, Miyagi) due to progress in community relocation projects and in some urban areas (Sendai and Morioka).
[84] Currently, 27.3% of the total population is older than 65, of which 53.6% older than 75.

Recent available data show that Fukushima prefecture saw its population fall at a slower pace of 0.72% in 2013[85], which is seen by officials as an indicator that the impact of the nuclear accident has softened (The Japan News, June 25, 2014). On the other hand, Miyagi prefecture registered a 0.06% increase apparently due to a rise in the number of people moving to take part in reconstruction work.

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

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

[85] On the backgrownd of the drop of 0.19% for the country as a whole.

Chapter 4. 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[86] (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 9). The biggest property damages have been registered in Miyagi, Fukushima, Ibaraki, and Iwate prefectures.

Most of the totally and half destroyed buildings were from coastal municipalities - 94% and 75% accordingly[87]. According to experts 42% of damages to buildings come from the earthquake, 39% from the tsunami, and 19% from the nuclear disaster (Daniell et al., 2011).

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

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

[87] Coastal municipalities generally go much inland and therefore not impacted by the tsunami.

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).

Table 9. *Number of property damages associated with March 2011 earthquake (September 9, 2016)*

Prefec-tures	Totally coll-apsed	Half coll-apsed	Total burn down	Part-ial burn down	Floo-ded above floor	Floo-ded bellow floor	Partially dam-aged	Non dwe-lling house
Hokkaido	-	4	-	-	329	545	7	469
Aomori	308	701	-	-	-	-	1006	1402
Iwate	19507	6568	33		-	6	18921	4700
Miyagi	82999	155130	135		-	7796	224198	26796
Akita	-	-	-	-	-	-	3	3
Yamagata	-	-	-	-	-	-	2	96
Fukushima	15194	79575	77	3	1061	351	141332	1010
Tokyo	15	198	1	-	-	-	4847	1101
Ibaraki	2630	24374	31		1799	779	187507	22609
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	121739	279067	297		3352	10231	726412	59205

Source: National Police Agency

There have been considerable damages in agriculture, fishery and forestry sectors. Around 23,600 hectares of farmland were washed away or flooded by the tsunami as well as considerably salinized by the seawaters (Ministry of Agriculture Forestry and Fisheries, 2014). In Aomori, Iwate and Miyagi prefectures approximately 4,550,000 poultry, 5,850 hogs, and 750 beef cattle were drowned, crushed or starved (Tohoku Regional Agricultural Administration, 2011). In addition, large areas of farmland have been contaminated, and many livestock, crops and other products destroyed or devaluated due to the Fukushima nuclear disaster (Bachev & Ito, 2013; Koyama, 2013; Watanabe, 2013).

Table 10. *Places with infrastructure damages associated with March 2011 earthquake (Sept. 9, 2016)*

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

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

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

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

The amount of debris washed out by the tsunami in the three prefectures is estimated to be about 5 million tons, 70 % of which deposited on seabed along Japan coasts and the remaining 30% becoming floating debris[88] (Ministry of Environment, 2012). The debris and tsunami deposits in these prefectures have been stored in almost 1,700 temporary cites, debris account for more than 60% of the total amount, and around two-third of all debris and tsunami deposits are in Miyagi prefecture (Table 11).

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

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

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

Note: * exclude evacuation area; **Source:** Ministry of Environment, 2014.

In October 2011, the government announced that it will spend at least 1 trillion yen ($13 billion) to clean up the vast areas contaminated by radiation from the Fukushima nuclear disaster as country faces the prospect of removing and disposing 29 million cubic meters of soil from a sprawling area in Fukushima and four nearby prefectures (Reuters, October 20, 2011). Furthermore, evacuated zones have become home to an increasing number of wild animals like rats, boars and their offspring with domestic pigs, which have been causing huge (unaccounted) damages to empty houses and farms (NHK World, July 11, 2013, May 6, 2014). The initial official estimate for the direct economic losses from the March 2011 disaster was about 16.9 trillion yen ($210 billion

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

USD) or 4% of the Gross Domestic Product of Japan[89] (Figure 7). 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.

Map 10. *Special decontamination (red) Intensive contamination (yellow) areas*
Source: Ministry of Environment, 2014

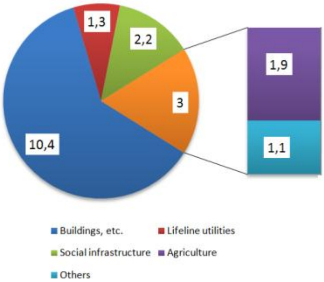


Figure 7. *Estimated economic damages of March 2011 earthquake (trillion yens)*
Source: Cabinet Office, June 24, 2011

[89] More than twice than the 1995 Great Hanshin Eartquake which caused damage of arroundten trillion yen ($102.5) billion or 2.5% of Japan's GDP at the time (Wikipedia).

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).In March 2011 the Index expressing Status of Activity declined 30% in Iwate prefecture, 40% in Fukushima prefecture and 80% in Miyagi prefecturecomparing to the previous month (National Institute for Research Advancement, 2013).

The insured losses from the Great East Japan Earthquake were estimated at ¥2,750 billion, or 16%of total direct economic losses[90] (Raghieri and Ishiwatari, 2014).The insurance payouts stemming from the quake had reached ¥1,234.6billion as of May 2012[91](Takabe & Inui, 2013). In addition, ¥360.3 billion (as of December 2012) monetary donations were distributed to the affected by the disaster via the Japanese Red Cross, the Central Community Chest of Japan and local authorities in affected areas.

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

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

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

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

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

The overall value of agricultural, forestry and fisheries products in Fukushima prefecture has declined considerably, and there has been no or only a slight recovery in these sectors of the economy (Figure 8).The high level of radiation has caused some Fukushima forests to be abandoned and there is concern about the long-term management of forestry resources (NHK World, May 6, 2014).

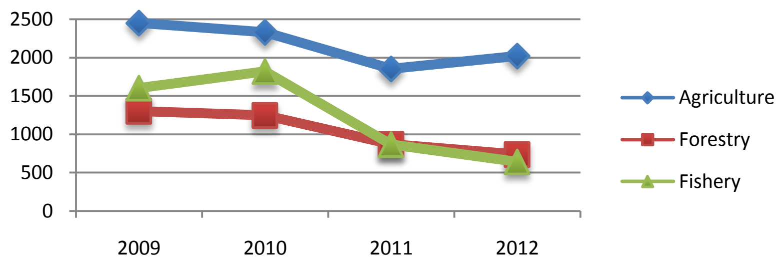


Figure 8. *Dynamics of values of agricultural, forestry* and fishery* products in Fukushima prefecture*
Note: * multiplied by 10
Source: Ministry of Agriculture, Forestry and Fisheries

Summer festivals are significant event in Japan in terms of keeping tradition and as attracting tourists and overall economic benefits. Data show that visitor figures for 14 major summer festivals in Tohoku six prefectures fell by 1.01 million or 6.5% from the previous year (The Japan News, July 24, 2014). Despite that numbers have been rising with 14.96 million visitors in 2013[92], this is still 4.2% fewer than in 2010. In 2013 visitors to the Sendai Tanabata, Morioka Sansa Odori and Soma Nomaoi festivals declined, respectively to 2.06 million (down 12.5%), to 1.3 million (down 3.6%) and 167,000 (down 22.4%) comparing to the pre-disaster period.

Tourism was an important part of the Fukushima economy and the number of overnight stays in hotels and other accommodationsdropped more than 65% in March 2011 comparing to the same period of 2010[93] (Tourist Agency, 2014). There has been some recovery in certain parts of the prefecture (Figure 9) but the overall level is far below the pre-disaster period

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

– in December 2013 it was still 26% bellow (comparing to 0.3% up nationwide).

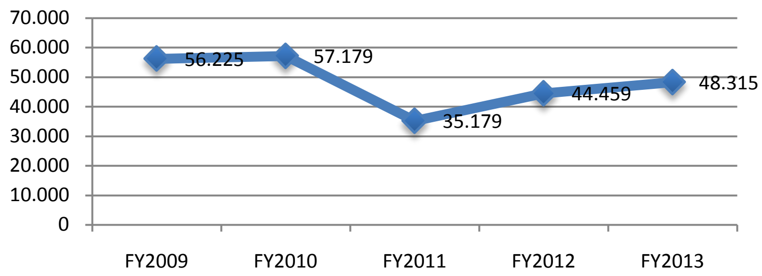


Figure 9. *Number of overnight stays in hotels and other accommodation in Naukomi, Fukushima prefecture*
Source: Tourist Agency, 2014

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

In order to support firms in Fukushima prefecture, which are under the weight of so-called "double loans", the Corporation for Revitalizing Earthquake Affected Business (a unit of the Deposit Insurance Corporation of Japan) set up a special team (May 2014) to extend support (The Japan News, June 6, 2014). Firms[94] need enhanced assistance since they have difficulty developing long-term plans for business restoration due to the ongoing nuclear crisis.

Furthermore, land prices[95] in disaster hit prefectures grew or slowed the pace of reduction in the last year[96] as an increasing number of residents moved to higher ground from coastal areas (The Japan News, July 2, 2014). In Miyagi prefecture the average

[94] Principal repayments began in summer 2014 for some afflicted companies that received loans from the government financial institutions.
[95] "Rosenka" (price of land facing major streets) used to calculate inheritance & gift taxes.
[96] Although average price for country fell for the 6 straight year (dropped by 0.7% in 2013) with exception of the 3 major metropolitan areas (Tokyo, Osaka & Nagoya).

land price grew 2.4%, marking the steepest growth in the country's 47 prefectures. In Fukushima land prices rose 0.8% rising for the first time in 22 years[97].

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

In mid-April 2011 a Panel to address compensation for nuclear related damage acting as intermediary[98] established "Guidelines for determining the scope of compensation for damage caused by the accident"[99]. The government and nuclear plant operators also established the Nuclear Damage Compensation Facilitation Corporation[100]. Some JPY 900 billion ($11.5 billion) were released to the company through bonds issued to the Nuclear Damage Facilitation Fund to cover compensation payments[101]. In February 2012 the government approved a further JPY 690 billion ($8.9 billion) in compensation support from the Nuclear Damage Liability Facilitation Fund giving the government voting rights[102]. In the end of July 2012 TEPCO sold the government 50.11% of the voting and 25.73% no voting rightsshares, and became government-controlled company.

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

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

[99] According to Law on Compensation for Nuclear Damage and Law on Contract for Liability Insurance for Nuclear DamageTEPCO liability is exclusive & absolute regardless of fault (World Nuclear Association, 2014). Government may relieve operator of liability if damage results from "grave natural disaster of exceptional character" (it did not do here).

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

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

[102] For JPY 1 trillion ($12.5 billion) paid through Nuclear Damage Liability Facilitation Fund.

In June 2013 TEPCO requested a further JPY 666 billion ($6.7 billion) in government support through the Nuclear Damage Liability Facilitation Fund, bringing the total amount to JPY 3.79 trillion ($38 billion). More than half of the request (some JPY 370 billion, $3.7 billion) resulted from the re-evaluation of the evacuation zone around the damaged plant and a re-examination of the estimated amount regarding compensation for mental damages, loss or depreciation of valuables such as housing lands and buildings. About JPY 43 billion ($431 million) was due to a higher estimate of compensation coming from damages by "harmful rumors"to the agriculture, forestry, fisheries, food processing and distribution industries[103].

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

By the end of November 2013 TEPCO received 2,035,000 applications for compensations related to the Fukushima nuclear accidents, and paid a total amount of 3,168.7 billion yen (Nomura and Hokugo, 2013). Untilthe end of January 2013 the biggest amount of compensation was paid to "Natural Persons" (48.5%)[104], 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[105], and Others (Nomura and Hokugo, 2013).

The greatest compensation payments were for demands from Fukushima prefecture (75%), followed by Kanto region (17.1%),

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

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

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

Hokkaido and Tohoku region (4.6%), and Other regions (3.2%). "Mental anguish" and "Damage from incapacity of work" took the largest portion of compensation payments to Natural persons (Figure 10). Most compensation payments to Legal Persons and Sole Proprietors [106] were for "Lost earning" (94.5%), and for applicants from Evacuation Areas (other than agriculture), Tourisms and Service industries (Figure 11).

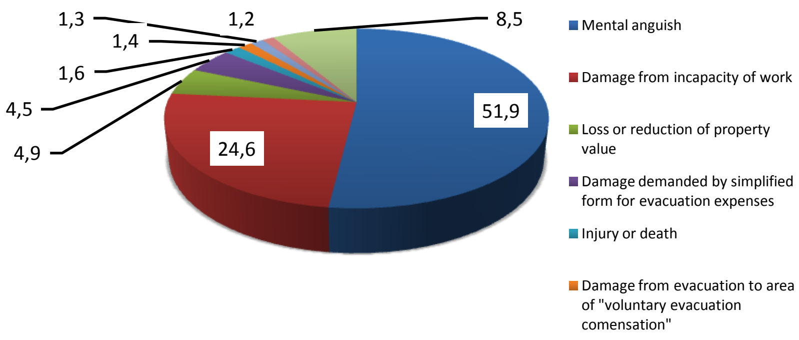


Figure 10. *Share of TEPCO payments to Natural Persons by damage categories (%)*
Source: Nomura & Hokugo, 2013

The nuclear disaster and the suspension of nuclear reactors has been also a severe blow for the nuclear industry in the country. For instance, TEPCO logged a net loss of ¥173.26 billion, against the year before profit of ¥437.93 billion, due to a special loss of ¥218.8 billion for compensation for the crisis at Fukushima nuclear power plant (The Japan News, August 1, 2014). It logged a group recurring profit of ¥52.51 billion in April-June 2014 against a loss of ¥29.49 billion a year before, marking the first profit for the period in 4 years [107]. Meanwhile, four other regional power suppliers[108] suffered group recurring losses of ¥74.7 billion, due

[106] Not including payments to farmers, fishermen and others who apply through "Group Representing Victims".
[107] It reflects electricity rate increase under system allowing power firms to pass higher fuel costs for thermal power generation on to customers. Group sales in first quarter of FY2014 rose 9.1%, labor costs grow 18.5%, while fuel costs fell 1.8% (thermal power efficiency).
[108] Hokkaido Electric Power Co., Kansai Electric Power Co., Kyushu Electric Power Co. and Okinawa Electric Power Co.

largely to hefty costs for fuel for thermal power generation with total recurring losses[109].

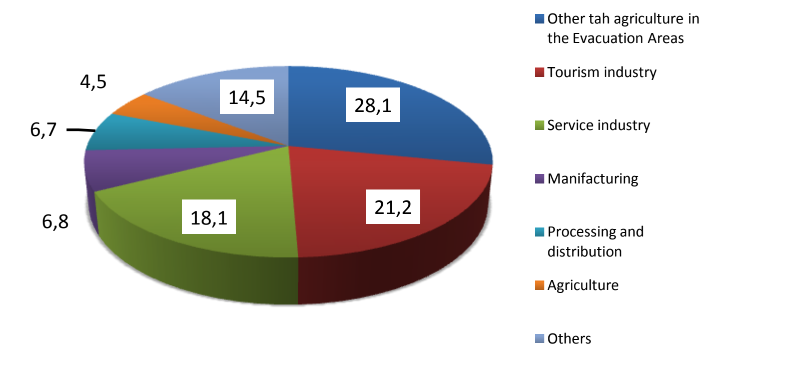


Figure 11. *Share of TEPCO payments to Legal Persons and Sole Proprietors by damage categories (%)*
Source: Nomura & Hokugo, 2013.

The macroeconomic impact of the March 2011 disaster has been also significant (Figure 12). 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.

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

What is more, there has been a huge government budget for recovery, reconstructions, compensations and development. Following the disaster, the Government approved two supplementary budgets of 6.14 trillion yens for relief and recovery (May and July 2011), and launched a ten-year reconstruction program (focusing on Fukushima, Miyagi and Iwate prefectures) with expended budget of 25 trillion yens for the period 2011-2015 (Government of Japan, 2012; Reconstruction Agency, 2014). The latest budget for the reconstruction period FY2011-2020 amounts

[109] Smaller than combined year before recurring losses of ¥233 billion at 9 of 10 utilities.

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, 2016).

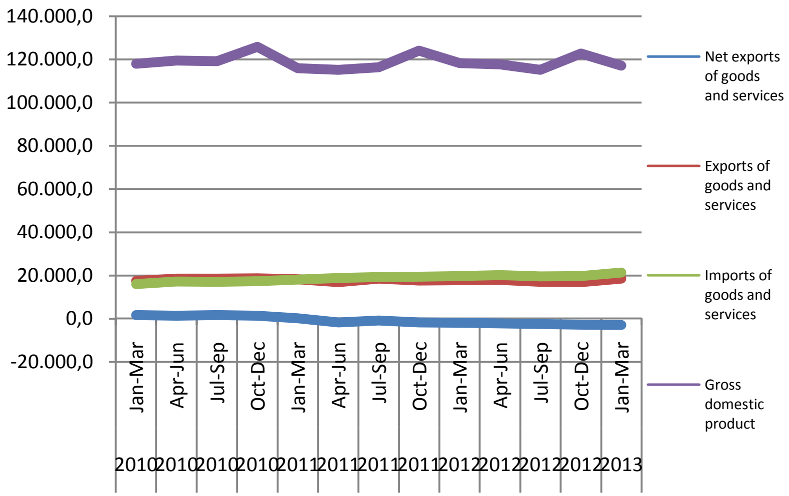


Figure 12. *Evolution of GDP, export and import of Japan*
Source: Statistics Bureau, MIAC, 2014

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

Subsequently, there has been a rapid recovery of infrastructure and economic activities in the country, including the most affected regions. By March 2013 the Index expressing status of recovery of basic infrastructure in Miyagi, Iwate and Fukushima prefecture reached 91%, 88% and 81.1% accordingly (National Institute for Research Advancement, 2013). At the same time the national Activity Status Index augmentedby 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 sizeableor complete recovery of damaged lifeline infrastructure in the months after the disaster – e.g. 96% of Electricity, 86% of Gas, 95% of LP Gas, 99% of Fixed line and Wireless phones, 100% of Mail delivery and Gas stations (as of October 2012),98% of Water and 90% of healthcare facilities (as of March 2012) and 92% of public school facilities (as of March 2013) (Reconstruction Agency, 2014).

Similarly, there has been substantial progress in recovery and reconstruction of long-term infrastructures such as land, transportation networks, utilities, fish processing facilities, etc. (Figure 13).

The progress of reconstruction of different type of public infrastructure has not been similar in different affected areas. For instance, in Fukushima prefecture reconstruction started in85% of planed cites, and in 65% have already completed (Figure 14).In Aizu and Nakadori regions progress has been substantial – in 100% and 99% of planed cites (26 and 536 accordingly) construction has been completed. On the other hand, in coastal Hamadori region in a fifth of planed (1,537) cites reconstruction has not started yet (Reconstruction Agency, 2014).

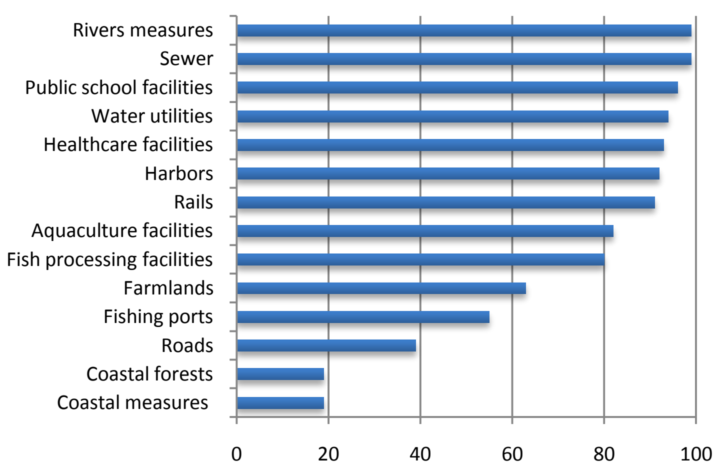


Figure 13. *State of full-scale recovery and reconstruction of public infrastructure after Great East Japan Earthquake (July, 2014)**
Note: *farmland, and healthcare, school, and fish processing facilities (March, 2014), Aquaculture facilities (December 2012)
Source: Reconstruction Agency, 2014

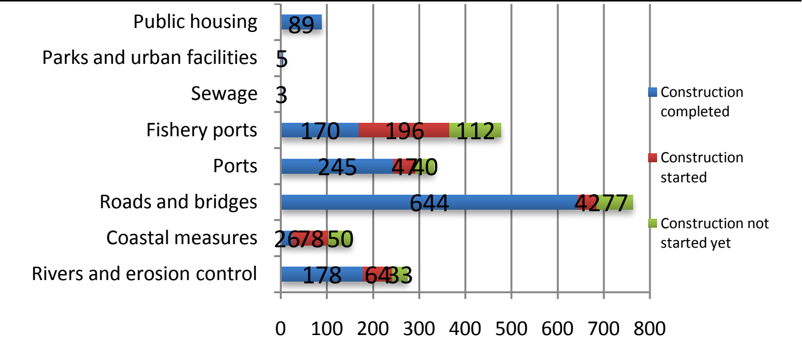


Figure 14. *Progress in reconstruction of public infrastructure in Fukushima prefecture, July 1, 2014*
Source: Reconstruction Agency, 2014

There has been also a constant recovery of sales of all industries in most affected prefectures (Figure 15). However, the rate of post-disaster recovery has not beensimilar in all sectors of affectedindustry. There is a fast and above pre-disasterrecovery of construction industry. On the other hand, the recovery in wholesale, service, and food processing industries has been slower. For instance, comparing with the same period of 2010 for January-March 2014 the number of guests in hotel rooms in affected 6 prefectures was 14.3% lower, and in most affected 3 prefectures 10.6% lower while there was a growth of 1.4% nationwide (Reconstruction Agency, 2014).

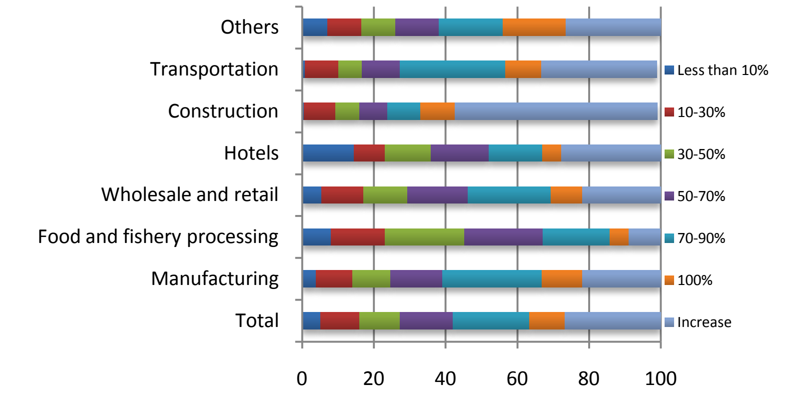


Figure 15. *Percent of sales recovery comparing to pre-disaster state in "Group subsidy recipients", July 2013*
Source: Reconstruction Agency, 2014

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

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

For instance, academic and corporate experts developed a technology to eliminate 90%-95% of radioactive cesium from fly ash resulting from the burning of combustible garbage [110] in Fukushima prefecture as a demonstration plant for cesium elimination opened in Hirono town (Fukushima Minpo News, November 7, 2014).

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

The government has decided to create a research center[111] in Fukushima prefecture operated jointly by members of industry, government and academia, to bring experts together from all over the world to develop improved technologies for decommissioning the crippled reactors at Fukushima nuclear plant (The Japan News, June 20, 2014). The plan pledges to bring together 200 domestic and overseas experts with knowledge of reactor decommissioning at the joint research center from five countries[112]

[110] In experiment, plant reduced radioactive Cs content of fly ash from 5,100 to 309 Bq/kg.

[111] International Joint Research Center for Safe Decommissioning will start in FY2016.

[112] Including United States and Russia who were involved in efforts following the 1986 Chernobyl disaster and the 1979 Three Mile Island crisis.

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

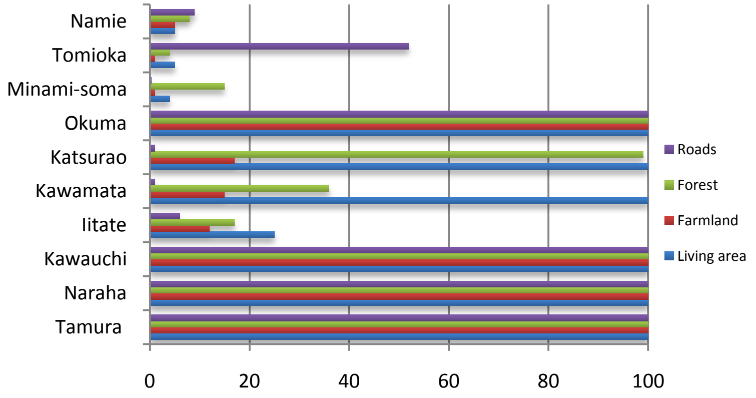


Figure 16. *Progress in implementation of decontamination work in Special Decontamination Area by September 30, 2014 (per cent)*
Source: Ministry of Environment

For instance, in Fukushima prefecture merely 68% of debris and 44% of tsunami deposits outside the evacuation areas has been treated (Reconstruction Agency, 2014). In the Special Decontamination Area[113] the progress of implementation of planned decontamination work also differ substantially (Figure 16).

Similarly, there is a considerable difference in the progress of decontamination in Municipality Decontamination Areas[114] in Fukushima and other prefectures (Figure 17). Furthermore, while the decontamination of public facilities (administration facilities, schools, parks and sport facilities, etc.) has been entirely or largely

[113] Responsibility of the central government.
[114] Responsibility of local governments in 94 municipalities, including 36 in Fukushima prefecture, 19 in Ibaraki, by 9 in Chiba and Gunma, by 8 in Miyagi and Tochigi, 3 in Iwate, and 2 in Saitama prefecture (Reconstruction Agency, 2014).

completed[115] reaching the end of full decontamination will likely take few more years (Reconstruction Agency, 2014).

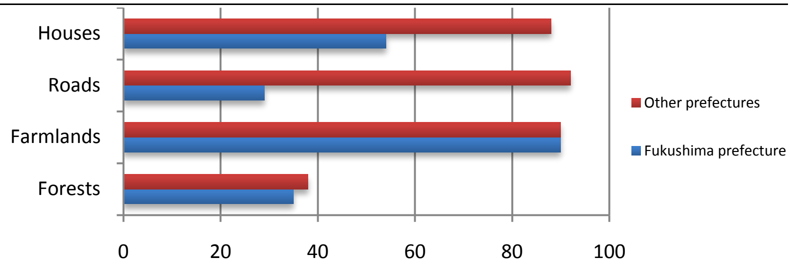


Figure 17. *Progress of decontamination of Municipality Decontaminated Areas, as of March 2014 (percent)*
Source: Reconstruction Agency, 2014

Besides, recentmedia reports indicate that some of the land along the coastal area flooded by the tsunami remains unused (NHK World, September 11, 2014). Municipal governments hit by the disaster have purchased land in the inundated areas hoping the financial assistance will help former residents move to higher ground away from the sea. However, according to 25 municipalities in Iwate, Miyagi, and Fukushima prefectures they have so far purchased a total of 2,600 ha[116] but 37% remains untouched because municipalities have no idea how to utilize the land, pieces of land are scattered making it difficult to put them to use, and businesses hesitate to move into the areas that were once flooded by tsunami.

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

[115] E.g. for public facilities, shools, etc. 90% in Fukushima prefectures and 100% outside Fukushima prefectures (Reconstruction Agency, 2014).
[116] For about 2.1 billion dollars.

What is more, there has been a huge proportion of the unused budget for the reconstruction –it was announced that 35.3% of the ¥7.51 trillion budget set aside in fiscal 2013 to rebuild disaster areas was left unused[117] (The Japan News, July 31, 2014). The proportion of the unspent funding was almost unchanged from fiscal 2012 (35.2%), indicating that the country has made little progress in overcoming delays in implementing reconstruction projects.

According to the Reconstruction Agency funds were unutilized because it took time to obtain local consent for reviews of reconstruction plans and to acquire land as well as because bidding for many reconstruction projects ended in failure due in part to price hikes for construction materials (Reconstruction Agency, 2014). The budget implementation rate stood at 62.8% for projects to assist disaster victims and at 77.5% for projects to revitalize industries. But the rate was low, at 47% for reconstruction projects related to the nuclear crisis at Fukushima nuclear power plant.

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

Table 12. *Macroeconomic impact of Great East Japan Earthquake*

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

Source: Bank of Japan, OECD

More recent experts estimates also indicate that the overall macroeconomic impact of the disaster (on stock prices, housing prices, and so on) has not been so huge[118] 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

[117] FY2013 consisted of special budget for reconstruction and funds carried over from FY2011-2012. Of the total, ¥4.86 trillion executed. Of unused funds, ¥1.96 trillion will be carried over to FY2014 and ¥691.7 billion used for projects other than originally planned.

[118] Calculated losses in Net Present Income accounts for 3.5 trillion yen for 2011-2012 or about 1% of GDP (Waldenberger & Eilker, 2014).

attributed to other factors (structural problems, inefficient policies, weak yen) rather than the 2011 disaster (The Japan News, April 23, 2014; OECD, 2013).

According to the initial prediction, the March 2011 earthquake is likely to be the costliest natural disaster[119] in the world history (Kim, 2011). One year after the disasterthe 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 & Daniell, 2012). Indirect losses were assessed between 185 to 345 billion USD across the earthquake, tsunami and nuclear plant.

According to the initial estimates of property damages and income losses are contrasted with the amounts shouldered by the insurance industry, TEPCO, donors and the government, those directly affected will on average have to come up for about 23% of the overall losses (Table 13). That catastrophe might turn out as the most expensive but the burden for the insurance industry will likely be lower[120] since the low proportion of individuals with earthquake insurance in Japan[121].

Table 13. *Distribution of costs related to Great East Japan Earthquake*

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

Source: Waldenberger & Eilker (2014).

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

119 Later found that nuclear disaster wasa "man made" which could have been prevented.
120 E.g.in the case of the hurricane Katrina (2005).
121 End of March 2010 only 23% of all private households were insured, including in Miyagi 33%, in Fukushima 14%, and Iwate 12% (Waldenberger & Eilker, 2014).

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 incurenormous 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[122]. According to the recent information TEPCO has paid about ¥3.53 trillion in compensation using government bonds while the total amount of compensation is estimated to be about ¥4.91 trillion (The Japan News, March 12, 2014). According to the company available funds are not sufficient for compensation of the amount of payouts required (Tokyo Electric Power Company, February 24, 2014). Nevertheless, the government will eventually pay all TEPCO's debt since it was placed under effective state control since June 2012 (The Japan News, March 27, 2014).

What is more, the estimated amount of compensation has been growing up each time the governmental panel has issued new guidelines. Besides, there have been reported thousands applicants and claimants seeking compensation or resolution of disputes on compensation from TEPCO or authorities through court or other ways (The Japan News, March 12, 2014; The Japan Times, March 13; 2014; NHK World, March, 17, May 8, May 26, May 27, December 19, 2014).

For example, in December 2014 as many as 340 residents of the Odaka district[123] filed suit against TEPCO (NHK World, December 19, 2014). The damages the evacuees are demanding include a doubling of the monthly evacuation compensation per capita of around 1,700 dollars and about 84,000 dollars per head for destruction of the basis for living conditions (e.g. deprivation of ancestral land and history, and severing residents' bonds).

[122] Despite our requests to TEPCO we have not been provide with such information.

[123] Entire district is designated as a no-entry zone and residents still must live elsewhere.

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

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

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

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

[124] By end August 2014 above 8,000 cases settled by it (NHK World, September 2, 2014).

[125] Tokyo police arrested 2 who under name of a dummy company defrauded TEPCO of 40,000 dollars making a false claim that staffing agency suffered a sales drop because it received fewer job orders from hotels in Fukushima prefecture. Other people were involved as well who submitted fake applications to steal more than 200,000 dollars in total (NHK World, June 2, 2014). Police also arrested 4 on suspicion of defrauding TEPCO of ¥12 million in compensation (The Japan News, August 3, 2014). They included official of NGO that does paperwork on behalf of clients for claiming damages from harmful rumors - not operating event company in Koriyama faced cancellations from customers.

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

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

Finally, there are unknown amount ofprivate costs related to dispute and compensation associated with the triple disaster. For instance, about 30 residents of Urayasu City (northeast of Tokyo) whose homes were damaged by massive liquefaction in the March 2011 earthquake[128] filed a lawsuit against the real estate company (Mitsui Fudosan) due to failure to reinforce ground when it developed the area more than 30 years ago[129] (NHK World, October 8, 2014).

Central government offered Fukushima prefecture, and the two candidate towns for interim storage facilities of highly radioactive waste (Okuma and Futaba) a total of ¥374 billion (2.2 billion dollars) over 30 years as financial assistance for regional development and restoration of local residents' lives (The Japan News, July 31, 2014; NHK World, July 30, 2014). First year's payment includes ¥90 billion for the local governments for rebuilding lives of local residents and for regional development (measures to repair damage to public image) while remaining ¥50 billion is for reconstruction of infrastructure in Okuma and Futaba (water supplies, sewerage systems and roads)[130]. In addition, the

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

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

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

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

government will continue to pay for 30 years allowances to areas hosting power plants planning to add ¥1.1 billion to the current ¥6.7 billion a year as subsidy [131] which is normally paid to municipalities hosting nuclear plants and typically used to develop local communities and improve residents' health[132].

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

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

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

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

[132] Local authorities are not satisfied with amount of money and asked increased sum. Government indicated that it would stop paying subsidies for offline Fukushima Daichi nuclear plant (10 km south of damaged one), which local calling to be decommissioned.

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

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

Experts find the latest Cost Verification Committee's estimate "over-optimistic" and predict that nucleardisaster costs are bound to increase further[135] (Okuyama, 2014). It is assessed that more and more public funding has been injected but the support for victims is being stopped or reduced. If compensation is conducted in good faith, damage costs could become as high as the annual tax revenue of 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 & Ito, 2013). Particularly, in the first five months of 2014 police have recorded 90 cases of burglary in 8 municipalities surrounding crippled nuclear plant, whichtotaled about 1,200 since 2011 (NHK World, June 12, 2014).

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

Finally, the 2011 disasters has led to increased public concerns about disaster preparedness and management efficiency, and fundamental revisions of country's disaster management, nuclear safety and energy policies. The later has been result of the 2011 experience and the post disaster reconstruction and development as well as some recent natural disasters like huge mudslides in

[135] E.g. unpecedented construction of ice walls as a temporary method of halting groundwater flow into reactor buildings is under way which will cost ¥31.9 billion (The Japan News, June 6, 2014). Consumption of 45.5 million kilowatt-hours (equivalent to electricity of 13,000 households) and ¥1 billion annually will be needed to keep underground walls frozen. Implementation has many dificulties while efficiency uncertain.

[136] Depending on approval by Nuclear Regulation Authority, operation of nuclear facility could get a one-time extension of 20 years. Out of 48 reactors, 7 are about 40 years old.

Hiroshima (August 2014), unexpected volcanic eruption at Mount Ontake (September, 2014), strong Typhoon Vongfong (October 2014), and a 6.7 earthquake in Nagano prefecture (November 2014).

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

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

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

For instance, the Government set concrete numerical targets to promote the nation's countermeasures to prepare for disasters and reduce damage on a long-term basis (The Japan News, May 16,

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

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

2014). The two plans are compiled based on the basic law (December 2013) to make Japan more resilient against disasters[139] and include measures such as: enhancing information and telecommunications networks, building road networks to enable drivers to take detours in the wake of major disasters and boosting the oil supply system, raise the completion rate of sea embankments from the current 31% (2012) to 66% by fiscal 2016, etc.

Similarly, government obliges local governments to compile evacuation rules that limit the time for operating floodgates and tide gates in coastal areas[140] in the event of tsunami (The Japan News, November 2, 2014).In addition, multiple nuclear disaster drill has been held in vulnerable regions of the country (including Kawauchi, Fukushima prefecture)under the new disaster preparedness guidelines[141], which highlighted existing problems (NHK World, November 3, 2014; The Japan News, November 22, 2014).

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

For instance, 2011 disaster seriously damaged or destroyed 60% of seawalls with length of about 300 km in Miyagi, Iwate and Fukushima prefectures. The central and prefectural governments are currently pushing a project to build 390 km of new seawalls with ¥800 billion from state coffers (The Japan News, June 23, 2014). However, many communities are opposed[142] to the project as local residents consider the proposed walls “too high” leaving less land available along the coasts, adversely affecting fisheries, and block ocean views, and affect negatively fishery and tourism industries on which local residents depend. What is more, cost-

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

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

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

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

effectiveness of the seawalls is to be more carefully estimated[143]. Some communities have already lowered the planned height of seawalls, while taking such measures as transferring houses to higher ground and building seawalls in locations further inland.

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

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

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

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

[143] Higher seawall more effective it is as safeguard. Higher seawalls are more expensive to construct, ruin scenic views, take toll on environment, entail higher maintenance costs. Life of concrete seawalls is 50 yearsmaking rebuilding inevitable at some point in the future.

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

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

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

Theinsurance industry is set to raise earthquake insurance premiums by an average 15.5% which is the first hike in 18 years (The Japan News, June 29, 2014).Meanwhile, proportion of newly concluded fire insurance contracts in FY2013 (including earthquake damage coverage[147]) rose 1.6 percentage points from the previous year to a record high of 58.1%[148] (The Japan News, August 26, 2014). Miyagi prefecture saw the highest proportion (85.2%), as the pace of growth was steepest in Hyogo (3.2 points), and third in Iwate, Tochigi, Kyoto, Tottori, Kagawa and Ehime prefectures (2.6 points).

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

After the 2011 accident all nuclear reactors were shut down for maintenance or refueling, and for the stress tests demanded by the government. Only two were restarted (in the Ohi facility) but shut down on September 14, 2013 leaving all 48 commercial nuclear reactors off-line. Since then the Nuclear Regulatory Authority has received safety-screeningapplications for 21 reactors at 14 nuclear plants (NHK World, January 5, 2014).

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

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

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

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

[150] Electricity rates TEPCO charges households have risen by 40% from before the crisis, while Kansai Electricity Power Co. have increased by nearly 30% (The Japan News, April 12, 2014). Bills for households jumped arround 20% and businessesarroud 30% (The Japan News, May 30, 2014). According to experts the additional rate hikes are inevitable.

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

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

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

The schedule for safety inspections is uncertain and no nuclear reactors restarted by the end of 2014 due to lack of readiness[155], uncompleted formal procedures[156] or strong opposition by local governments and communities, including a court ban[157]. A court order against resuming operations at the Ohi nuclear plant affected other similar lawsuits across the country[158] (NHK World, May 21, 2014). There have been numerous protests and a lawsuit against reopening Sendai nuclear station in Kagoshima prefecture

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

[153] In FY2013, a total of 169 thermal power plant shutdowns, mainly due to glitches, were reported by 9 of 10 regional power suppliers – that is up 70% from 2010 level.

[154] In April-Setember2014 TEPCO reported profit of ¥242.8 billion, second straight profit and topping ¥201.3-billion before the accident. Only Hokkaido Electric Power and Kyushu Electric Power suffered recurring losses since they relied heavily on nuclear energy.

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

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

[157] Most lawsuits since late 1960s by residents seeking to halt nuclear facilities have been dismissed (NHK World, May 21, 2014). On May 20, 2014 Fukui District Court ordered Kansai Electric Power not to restart 3 and 4 reactors at Oi nuclear plant in Fukui prefecture becouse safety of idled reactors is not ensured. It was first court order to ban nuclear plant operations since 2011 accident. Lawsuit was filed by 189 local residents, November 2012.

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

scheduled to be the first resuming operations (NHK World, May 30, June 1, June 13, 2014).

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

Furthermore, regarding a nuclear phase-out plan, 77% supported it while only 14% opposed it. Asked about how anxious they feel about the possibility of a serious accident at a nuclear power plant other than the Fukushima plant, 36% said they were "greatly" anxious, and 50% were anxious "to some degree".

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

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

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

Nevertheless, there is strong opposition to restart nuclear power plants by various groups, including some prominent politicians

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

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

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

(like Ex-PMs Junichiro Koizumi andMorihiro Hosokawa) [162] 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 (NHK World, July 7, September 24, November 2, 2014). The lack of a single power outage since the nuclear reactors have been offline is evidence that people can live without nuclear energy and calls for more renewables.

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

Experts suggest that further delays in restarting reactors at the nation's nuclear power plants will slow the recovery of the domestic economy, while the resumption of reactor operations could halve Japan's trade deficit (The Japan News, July 26, 2014).According to estimate, if all 19 reactors[163] resume operations in fiscal 2015 the total nuclear power generation would be less than a half of the output of fiscal 2010. That will reduce the nation's trade deficit[164] to ¥7.2 trillion, providing certain conditions (such as overseas economic growth) are met.

If 19 reactors resume operations, imports of fossil fuels are estimated to total ¥25.8 trillion in fiscal 2015. This is ¥900 billion lower than the ¥26.7 trillion in fossil fuel imports estimated under the scenario of having just 9 reactors in operation, and ¥1.5 trillion lower than when no reactors operate in the nation. In the latter case, imports were predicted to reach ¥27.3 trillion.Under such circumstances, the cost of power generation is likely to rise to ¥11.2 per kilowatt-hour from ¥8.2 in fiscal 2010, putting additional upward pressure on electricity prices[165]. Moreover, if the price of crude oil rises by $10 per barrel, imports of fossil fuels will

[162] Launched organization to ending reliance on nuclear power (NHK World, May 7, 2014).

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

[164] Which hit record high of ¥13.8 trillion in FY2013.In January-June 2014 Japan's trade deficit hit ¥7.6 trillion, worst since such records began in FY1979. Surge is mainly accounted for by growing imports of such fossil fuels as oil and liquefied natural gas.

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

increase ¥1.9 trillion, which is likely to lower the nation's gross domestic product by 0.2%.

Thanks to the recent decline in crude oil prices the procurement costs (liquefied natural gas and other fossil fuels)for national utilitiesare expected to decline. However, that would not improve financial balance of some of them (like Kansai Electric) under the government enforced fuel cost adjustment system [166] and an additional rate hikes would be inevitable (The Japan News, December 26, 2014). Therefore, the progress of safety inspections at the nuclear reactors will have a significant impact on the Japanese economy[167].

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

The government intends to diversify energy sources aiming to raise the share of renewable (solar, wind, hydro and geothermal) energy in the electricity supply to more than 13.5% of the nation's electricity in 2020, and more than 20% by end of 2030, from about 10% in 2012 (The Japan News, April 4, 2014). It also started reexamining the renewable energy purchase system making it mandatory for electric power companies to purchase electricity generated by renewable energy sources (solar and wind power) at fixed prices[168] for up to 20 years (The Japan News, July 8, 2014). Large numbers of applications have been filed for solar power generation, which entails relatively high purchase prices. Since the utilities pass the costs to the consumers the amount in a typical family's utility bill soared from ¥87 to ¥225 a month in 2014[169].

It is estimated that higher power costs have been also hampering pay rise of manufacture industry workers in average lost salary per year ¥52,000 (The Japan News, September 4, 2014). In order to make up for a maximum 40% increase in electricity costs in comparison to pre-disaster levels, workers could see their

[166] Making it mandatory to reflect fuel cost changes in utility rates.
[167] NRA has given priority to safety inspections on reactors at Kyushu Electric Power Co.'s Sendai nuclear plant, expected to resume operations spring 2015. Dates for restarting other reactors are unknown and restarting all 19 in fiscal 2015 is considered difficult.
[168] Purchase prices have been set at levels more than double those in Europe.
[169] Households and businesses will have to pay ¥38 trillion in the next two decades because of surcharges on utility bills (The Japan News, July 8, 2014).

annual pay cut by as much as ¥100,000 while if manufacturers deal with the situation by reducing employment as many as 180,000 jobs could be lost.

Another problem is that operations have started at only 10% of the approved mega solar power plants[170]. Seven of the nation's 10 major utilities (including Hokkaido Electric Power Co., Tohoku Electric Power Co. and Kyushu Electric Power Co.) are freezing new applications by producers keen to access their grids with electricity generated through solar, wind and other renewable sources since they exceeded the capacity their grids can accept[171] (The Japan News, October 9, 2014). A major weak point of solar and many other renewable energy sources is that output can fluctuate sharply depending on weather conditions and the time of day. Failure to maintain a steady balance with demand presents the risk of disrupting the frequency and voltage of electricity supplies, which could in turn cause power outages and damage equipment and facilities[172].

Calculations of independent experts also shows that the electricity from nuclear power is the second cheapest energy to produce at ¥8 per kilowatt-hour[173] even after such expenses as costs related to accident compensation were factored the production cost rose to ¥8.4 (The Japan News, October 26, 2014).Production cost of electricity from renewable energy sources is comparatively high – e.g. large mega solar power facilities generate electricity at ¥30.6 per kilowatt-hour, electricity from wind power cost ¥21.2 per kilowatt-hour, etc. Beside, some renewable energy producers have

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

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

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

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

been gleaning excessive profits while users have borne the financial burden.

The government has limited the role of the Atomic Energy Commission an advisory panel that has served to promote nuclear energy for over half a century[174] (NHK World, April 18, 2014). The commission no longer will draw up the policy and focus to solving problems related to nuclear power, such as how to deal with radioactive waste and what do to with damaged Fukushima power plant. The number of commissioners has been also reduced (from 5 to 3) and a new code of conduct introduced to ensure neutrality and transparency.

A bill has been enacted for the Nuclear Damage Liability Facilitation Fund's reorganization to allow the state-backed body to provide financial assistance for decommissioning the reactors at Fukushima nuclear plant (The Japan News, May 14, 2014). The government will take the lead in work to decommission the reactors and contain the radioactive water at the nuclear plant. The body will provide TEPCO with technical instructions on how to proceed with the decommissioning work, monitor whether the utility maintains adequate budget and manpower for decommission, and promote development of related technologies. The government is also planning to review the law on compensation for accidents at nuclear power plants according to which the power companies in principle bear unlimited responsibility for damage payments in the event of an accident (NHK World, June 3, 2014).

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

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

Chapter 5. Environmental Impact

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

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

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

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

Tsunami badly affected about 1,718 ha of coastal disaster-prevention forests in 253 sites situated over an extensive area from Aomori to Chiba (Ministry of Environment, 2012). In

Rikuzentakata, Iwate the destruction left nothing but a single tree out of a coastal protection pine forest with more than 60,000 trees planted two century ago (National Aeronautics and Space Administration, 2011). In addition, many traditional Igune were destructed by tsunami and consequently cut because they were composed by badly damaged by salt water Japanese cedar (Ogata & Pushpalala, 2013).

One year after the tsunami, the landscape near the mouth of the Kitakami River[175] remains irrevocably altered, farmland north and east of nearby Nagatsura become river bottom, the river mouth widened, and water from Oppa Bay crept inland, leaving only a narrow strip of land and new islands near the river mouth (National Aeronautics and Space Administration).

Similarly, tsunami tide swept away all fishing weirs and hatcheries in Kido River which boast large numbers of returning salmon on Honshu island[176] (Fukushima Minpo News, April 16, 2014).A trial study in 2013 has found out that both fish born before the and after disaster are returning[177] to rivers significantly altered by the tsunami (NHK World, November 20, 2014). Only a third of salmon born before the disaster made their way upstream while 38.88% never entered rivers since environs changes (riverbeds and embankments) may make it difficult to find a way back.

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

Monitoring of the changes in vegetation in areas submerged by the tsunami along the Pacific coastline shows that “Changed to barren land” areas (where weeds grow abundantly in damaged areas) occupies the greatest share - around 30% of the total area (Figure 18). This is followed by “Changed for artificial use” such as developed lands and debris storage areas etc. (10% of the overall

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

176 In April 2014 Naraha fisheries cooperative released young salmon for first time since disaster, considering rebuilding hatcheries, resuming egg collection/hauling, and restart release self-hatched salmon in spring 2016 (Fukushima Minpo News, April 16, 2014).

177 Salmon usually returns to its river 3 to 5 years after birth.

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.

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

Monitoring on changes in the sandy and muddy beaches due to the tsunami also indicates that “Sand dune vegetation” and “Coastal forest” were vastly reduced and mostly were transformed through man-made developments or changed into “Barren lands” included under “Others” (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.

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

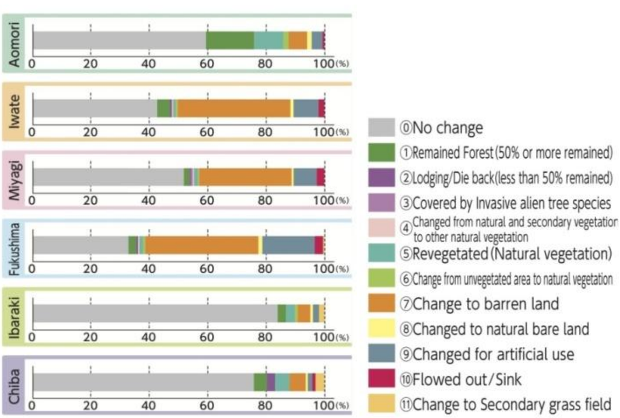


Figure 18. *Vegetation changes in areas submerged by March 2011 tsunami (percent)*

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

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

Monitoring of the marine environment has found out a great disturbance of Zostera forest caused by the tsunami (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.

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

Enhanced habitats in the seawater have been also reported due to reduced fishing after disasters (Biodiversity Center of Japan, 2013). For instance, estimated number of chub mackerel in waters near Kinkasan is now 2.6 times higher and there are 80% more adult fish than in the summer of 2010 (The Japan News, March 29, 2014).

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

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

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

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

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

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

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

Recently it has been found out that most of the radioactive cesium that leaked from the Fukushima nuclear plant settled in a common mineral that comes from granite (NHK World, November 11, 2014). According to scientists it is important to identify how the element exists in the soil predicting that most of the radioactive cesium in Fukushima soils is likely to be found in black mica. That finding is expected to encourage others to develop ways to remove it from contaminated lands[178].

The first assessments of “health effect” on farm and domestic animals and plants in the most affected areas havebeen also completed. Many of the farm livestock in the contaminated area has been slathered or died. However, a farmer M.Yoshizawa kept 360 cows [179] alive at his 80-acre spread inside the nuclear evacuation zone in defiance of a government kill order (Uncanny Terrain; Fackler 2014). The farmer could monitors effects of prolonged radiation and there are reports that white spots on the fur and skin are appearing on some of his Japanese black cattle (CAN, 2013; Fackler 2014).

The first study of cattle abandoned in the evacuation area[180] and euthanized indicates that in all examined specimens deposition of Cs 134 and Cs 137 was observed (Fukumoto, 2013). Organ-

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

[179] More than half are ones that others left behind.

[180] 79 cattle, including 3 fetuses from pregnant cattle and 3 mother-infant pairs, all obtained between August 29 -November 15, 2011.

specific deposition of radionuclides with relatively short half-life was also detected such as Silver-110m in the liver and Te 129m in the kidney. A linear correlation was found between radiosesium concentration in peripheral blood[181] and in each organ as the resulting slopes were organ dependent with the maximum value obtained for skeleton muscles. The levels of rediosesium in the organs of fetuses and infants were 1.19 fold and 1.51fold higher than in corresponding maternal organs. Radiosesium concentration in organs was found to be dependent on the feeding conditions and the geographical locations location where cattle were caught.

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

As far as Te129m is concerned it was detected in 62% of cattle examined. Its deposition in kidneys suggests that Te132[182] also accumulated in kidney shortly after the nuclear accident. These results suggest that monitoring of Te132 and I131 warrants more attention in terms of assessing health risk to the thyroid.

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

Analyses of this type[183] are extremely valuable for the assessment of environmental pollution, bio distribution, metabolism of radionuclides, dose evaluation and the influence of internal exposure as well as likely consequences for humans from long-term exposure[184].

It is estimated that the Great Japan Earthquake generated more than 20 million tons of debris[185] in the three most affected prefectures, of which about 5 million tons is estimated to have been

[181] Thus the activity concentration d Cs in organ can ne estimated from that of blood.
[182] With half-life 3.2 days and decay product I132.
[183] The team collected tissue samples from different animals (cattle, swine, Japanese macaque, wild pigs, horses) which are currently being examined.
[184] The amount of radioactivity concentration does not reflect biological effects but it is the first clue for understanding the biological effect of radiation.
[185] Tsunami washed out collapsed houses, cars, woods, ships, aquaculture facilities, fixed fishing nets, cargo containers, etc. More than 90% of floating debris is parts of collapsed houses and driftwoods, which are difficult to sink.

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 2014). The official data indicate that almost all disaster debris were removed (99%) as treatment and disposal of 97% of them completed (over80% recycled) (Figure 19). Similarly, around 96% of the tsunami deposit were removed and processing of 92% finished (almost all recycled). Approximately 85% of debris and nearly all of the tsunami deposits can be recycled, and materials used in public works projects in disaster-affected area (Ministry of Environment, 2014).

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

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

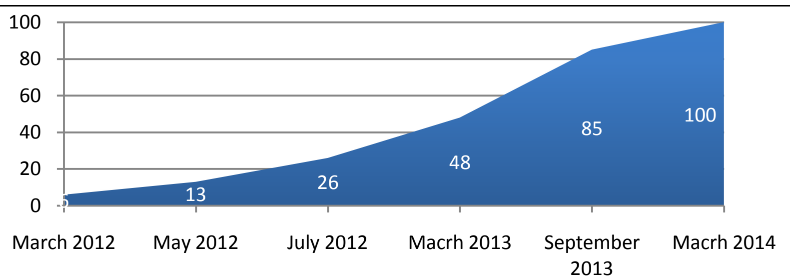


Figure 19. *Processing rate of disaster waste in coastal municipalities (percent)*
Source: Reconstruction Agency

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

Recently the International Atomic Energy Agency (IAEA) sent marine experts[186] to Japan to report their analysis of the seawater off the coast of Fukushima nuclear plant, and compare results from Japanese and IAEA laboratories to assess accuracy of Japanese data (NHK World, November 1, 2014).The IAEA has been advising Japan to disclose comparative analysis of the results of more than one institution to enhance transparency and ease concerns of neighboring countries.

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

A pilot work for forest decontamination in 4 Fukushima localities[187] started in September 2014 (for completion March 2015), covering a forest area tens of hectares wide in each selected municipality (Fukushima Minpo News, July 31, 2014). The demonstration work seek to lay the groundwork for resuming forestry business and reducing anxiety among evacuees hoping to return to hometowns as well identify effective methods of decontamination and ways to minimize workers' exposure to radiation.

According to some experts the undertaken large-scale decontamination by the authorities and at grass-room level[188] would create new environmental problems such as: huge amounts of

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

[187] 30ha in Tamura city's Miyakoji district (evacuation order lifted in April, 2014); 10ha each in Minamisoma city's Odaka district and Iitate village's Nimaibashi district; and 30ha in Kawauchi village's Modo district (last 3 areas preparing for lifting of evacuation orders). Locations are privately owned where central government is to undertake decontamination.

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

radioactive waste, removal of top soil, damage to wildlife habitat[189] and soil fertility, increased erosion on scraped bare hillsides and forests, and intrusion by people and machinery into every ecosystem scheduled for remediation etc. (Bird, 2012).

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

In July 2014 TEPCO reported that it recovered about 80% of a radioactive substance that leaked with contaminated wastewater in 2013[190]. The substance with the highest concentration in the water was radioactive strontium with an estimated 45 trillion becquerels of radioactivity (HNK World, July 2014). Most strontium has been recovered by collecting soil soaked with the contaminated water while remaining 20% likely seeped into soil below tanks and other facilities. According to TEPCO the substance remains in soils and it is highly unlikely that it was carried into the sea by underground water.

TEPCO revised its storage plan [191] with planning to build additional tanks to store 100,000 tons of radioactive water at the nuclear plant. Tanks at the cite can store about 480,000 tons of radioactive water, but 90% of the 1000 storage tanks are already full (NHK World, April 4, 2014). Company expects the amount of contaminated water to be less than 800,000 tons by March 2016. More tanks are added in case the planned one are not enough or preventative measures (including frozen underground walls) do not work as well as planned (NHK World, July 14, 2014).

In April-November 2014 TEPCO tried to freeze radiation-contaminated water in underground tunnels in order to prevent water used to cool melted-down fuel to leak out of reactor buildings into tunnels where it mix with ground water,seep into the ground and end up in the sea[192]. In Novemberthe company gave up

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

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

[191] Previous plan was to build tanks to store 830,000 tons of water by the end March 2015.

[192] Utility tunnels between the 2 and 3 reactors and the sea are estimated to hold a total of 11,000 tons of radiation-contaminated wastewater. TEPCO hopes to

that plan (water did not freeze) and announced that underground tunnels containing radioactive water will be blocked off by newly developed cement [193] (NHK World, November 21, 2014). Nevertheless, initial results indicated that new method has also not been entirely successful (NHK World, December 26, 2014).

A separate and larger project has been underway to freeze soil and create a wall of ice 1.5 km stretch around the four reactor buildings. TEPCO lays 1,500 meters of pipes around the four reactor buildings and completed the construction work recently and circulating refrigerant of minus 30 C started[194]. The ice walls are intended to prevent groundwater from coming into the reactor building basements, which are filled with highly contaminated water from operations to cool the overheating reactors. The work was delayed due to a suspension in freezing the water in the tunnels as part of the work areas overlap. Nevertheless, recent inspection by government officials found out that the ground is frozen and leakage of contaminated water stopped (NHK World, November 9, 2016).

There has been also many technical problems such as failures in cooling systems, multiple leakages, high radiation at the plant cite, delays and/or changes in plans, etc. (NHK World, April 4, April 13, May, 31, June 4, June 9, June 10, June 19, June 22, July 8, October 22, October 30, December 26, 2014). All that has been coupled by high uncertainties on state of affairs and risks, and likely effects of undertaken actions.

For instance, the effects of the groundwater bypass operation[195] intended to reduce the amount of radiation-tainted water at the plant has been apparently having limited effects (The Japan News, June 28; NHK World, July 25, 2014). In the first 2 months water levels at observation wells near the reactor buildings[196] dropped by

remove wastewater from tunnels around all reactors in fiscal 2014 (NHK World, June 16, 2014).

[193] Plan will not affect larger project to freeze soil and create a wall of ice around reactors.

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

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

[196] 3 wells located 70 to 150m from the reactor buildings.

only around 10 cm at most. Water levels tend to rise after rains and it is vital to reduce the amount of rainwater infiltrating the soil but little progress has been made due to a delay in land leveling[197]. It has been also found that Cesium in groundwater rises at plant after storm as well water near the embankment was more than 3 times higher (251,000 becquerels of cesium per liter) the level before heavy rainfall from Typhoon Phanfone (NHK World October 15, 2014).

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

Experts have also pointed out the need to purify contaminated water before discharging it into the ocean (The Japan News, June 6, 2014). Advanced Liquid Processing System (ALPS) introduced for that purpose has continued to malfunction[198]. Recently TEPCO has unveiled an improved system (sophisticated ALPS) for decontaminating radioactive water[199]planning to put 3 systems into full operation in December 2014 treating 2,000 tons of water daily (NHK World, October 16, 2014).

TEPCO hasshowed a system to remove radioactive substances from tainted underground water before releasing it into the sea.The utility plans to discharge well water from around reactor buildings at the facility to stem the buildup of contaminated water[200]. The officials say the system removed most radioactive materials to undetectable levels in trial runs but its plan has met opposition from local fishermen (NHK World, October 16, 2014).

One of the TEPCO's engineers properly described the progress as "trial and error continues" since dealing with new technology

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

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

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

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

and equipment, making mistakes, and are unknown results (NHK World, July 4, 2014).

Furthermore, the process of decommissioning the nuclear reactors is at the beginning stare and is expected to last 30-40 years[201] and associated with many challenges such as lack of experiences, available technologies, uncertainties and risks, public concerns, lack of disposal site, etc. (NHK World, August 2, 2014; Reconstruction Agency, 2016). For instance, there is a lots of uncertainty related to the state and schedules of operations – e.g. it is extremely difficult to remove melted fuel from the No.1 to No.3 reactors. Operation schedule is to start work at the No.1 and 2 reactors in fiscal 2020, and at the No.3 in fiscal 2021, but workers still do not know where or in what state the fuel lies as a result of the meltdowns at the 3 reactors (NHK World, October 22, 2014).

In October 2014 it was announced that the decommissioning of Fukushima reactors may be further delayed (NHK World, October 16, October 22, 2014). The work was to begin in July 2014, but have been delayed after radioactive dust from the plant was blamed for contaminating rice paddies when the operator removed debris from the plant's No.3 reactor in August 2013[202].

The No.1 reactor building has a cover to prevent massive amount of radioactive material from spreading. TEPCO began drilling holes in the ceiling and spraying chemicals inside to stop dust from spreading, planning partiallyto remove the cover in late October.The operator hopes to begin full-scale dismantling of the cover in March 2015 and complete the task in about a year[203].The government and TEPCO set a timetable for removing fuel out of the storage pool at the No. 1 reactor from the reactor building after April 2017, but delays are also likely.

Last but not least important, up to date, it has been difficult to secure cites for long-term and permanent disposal of radioactive waste (NHK World, April 7, June 15, 2014; The Japan News,

[201] With first stage (removal of 270 tons of fuel from 3 melted reactors) around 20 years and disposal and dismantling another 15 years. Decommissioning work has progressed fastest at No.4 (all fuel rods removed by end 2014). Removal of fuel from No.3 reactor building is to begin in FY2015, and No.1 and 2 buildings in FY2017. Radiation is extremely high in No.2 building and no schedule for removal there (NHK World, October 22, 2014).

[202] Recently NRA announced that it is highly unlikely that radioactive particles from Fukushima plant contaminated rice fields (NHK World, October 31, 2014). Removal work released dust particles with 110 billion Bq with relatively large diameters of several micrometers. They hadeco-impact only in plant compound and rice paddy contamination may have come from river and ground water (NHK World, October 31, 2014).

[203] Debris removal is planed to begin before October 2016.

March 8, 2014). 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 (The Japan News, December 9, 2014; 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 a huge amount of contaminated soils, debris, incinerated ash, mud from sewage, straw, etc. located in Tokyo and 11 other prefectures. In the end of March 2014 there are a total of 143,689 tons of materials defined by the Government as “designated waste”[204] (The Japan News, July 9, 2014). The later contain radioactive substances measuring more than 8,000 Bq/kg, and according to law[205] should be handled in the prefecture where it originated under the responsibility of the central government.

A site for the final disposal of radioactive waste has not been chosen yet. There is a government plan to build interim storage facilities in Okuma and Futaba to store contaminatedsoil, waste and ash from burned contaminated materials[206]. These sites are to operate for up to 30 years but residents of candidate places continue to suspect that they will eventually be used for final disposal facilities and insist for safeguards (NHK World, May 27, June 8, 2014). Some residents are also against since the storage facilities would harm the towns' image and make it difficult to restart farming due to consumers concerns about safety of agricultural products (NHK World, June 2, 2014). Besides, some residents complained about the offered price, saying it's not enough to rebuild their lives[207] elsewhere but government has no revised the planned purchase prices (NHK World, October 14, 2014).

[204] Containing radioactive substances measuring more than 8,000 Bq/kg.

[205] On special measures concerning the handling of pollution from radioactive materials.

[206] They will accommodate waste to fill Tokyo Dome more than 20 times and dispose waste containing up to 100,000 Bq/kg. Government plans to purchase 16 square km of land in the area and initially planed to start transporting radioactive soil to the facilities in January 2015 (it is delayed due to the prolonged procedures).

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

Meanwhile, Government is proceeding with the planseeking residents' understanding while briefing residents about safety measures related to transportation and storage of radioactive wastes (NHK World, May 28, June 7, June 15, September 30, 2014). Late August 2014 the prefectural government formally accepted the construction of storage facilities on its territoryfollowed by approval of tow host towns (NHK World, January 2015).

In November 2014 both Houses of the Diet approved Fukushima waste bill for the construction of temporary storage facilities[208] for radioactive waste near the crippled nuclear plant (NHK World, November 4, 19, 2014). The bill obliges the government to ensure to ensure the waste is safely stored in the facilities and complete within 30 years the final disposal of radioactive waste (including contaminated soil) after moving it outside Fukushima prefecture.

Furthermore, the governmentannounced it will set superficies (surface) rights for land allowing landowners to keep property rights for the land[209] to be used for building temporary storage facilities (NHK World, July 28, 2014; The Japan News, July 29, 2014). Inaddition, 820-million dollars of grants will be handed over directly to the 2 towns as a part of the 3 billion dollars in subsidies that will be given to the prefecture and municipalities to help rebuild communities and peoples' lives (NHK World, August 26, 2014).

A little progress has been also made in deciding on final disposal facilities locations for handling more than 146,000 tons radioactive waste from the Fukushima nuclear crisisin Tokyo and 11 other prefectures (Figure 20).For instance, up to date one of the warehouses storingrice straw (supposed to be used as livestock feed) covered in sheets of silver foil to protect against the sun's rays, stands in area of farming paddy in Tome, Miyagi Prefecture[210] (The Japan News, September 12, 2014).

The central government[211] plans to construct a safe concrete double-walled structure underground to contain buried designated waste. Waste will be put into containers and bags, which will then

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

[209] Initially, government planned to buy land for temporary facilities to ensure stable management but some landowners refuse to sell. Localsare attached to ancestral land and fear that temporary facilities would become final disposal sites if land is nationalized.

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

[211] Central government is responsible for disposal of "designated waste" in each prefecture.

be stored inside a concrete double walled structure to be buried underground, and after being buried that the structure will be covered with a second layer of concrete and soil[212] (The Japan News, July 9, 2014).

The government has been considering locations to newly build final disposal in five prefectures (Miyagi, Tochigi, Ibaraki, Gunma and Chiba) because there are large amounts of "designated waste"[213] (The Japan News, July 9, 2014). Local residents have been strongly opposing to the construction of facilities due to fears about radiation, environmental threat, and risk that agricultural products will become unsellable. In 2014 the Environment Ministry officials held meetings with officials from Miyagi prefecture and the three "candidate" municipalities (Kurihara, Taiwan and Kami) on one of which territory it aims to construct the final disposal facilities but all municipalities opposed.

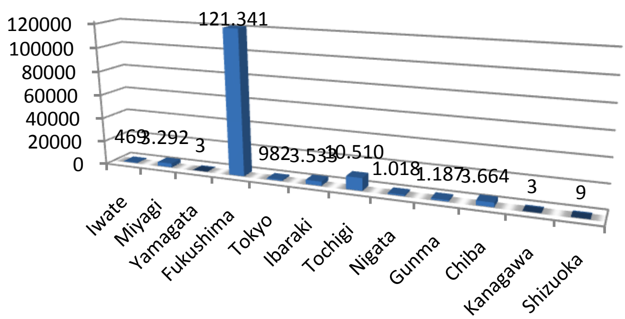


Figure 20. *Amount of Designated waste in Japan, June 30, 2014 (tons)*
Source: Ministry of Environment

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

212 Additional radioactivity along premises borders is expected to be less than 0.01 mSv a year and "health risk negligible" (average radiation dosage in nature is 2.1 mSv per year).
213 Material from the Fukushima nuclear accident that has radiation levels exceeding 8,000 Bq/kg. For prefectures with small amounts of designated waste plans are to bury the waste underground in existing disposal facilities (The Japan News, September 12, 2014).

the sewage facility on a "temporary basis", with a time limit set for the end of March 2015 (The Japan News, July 9, 2014).

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

The government needs to create the disposal facilities[214] because storage is reaching capacity in 5 prefectures (NHK World, July 30, 2014). In response to the failure of previous administration to select cites "without consulting local residents", the current government revised the process as municipal councils were set up in every prefecture to decide on selection methods while taking into consideration local residents preferences (The Japan News, July 9, 2014).

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

The government has also chosen a state-owned property in Shioya town, Tochigi prefecture as a possible final disposal site for radioactive waste (NHK World, July 30, August 18, 2014). The local government and citizens have been opposing saying it will have a negative effect on natural water resources and local agricultural and food products [215] .The mayor suggested a counterproposal on radioactive waste[216]calling for all radioactive waste to be stored at an intermediate facility in a no-entry evacuation zone on the Daiichi plant compound (NHK World, November 7, 2014).

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

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

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

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

The Atomic Energy Agency is reported to be looking at the direct disposal of spent nuclear fuel instead of reprocessing it[217] (NHK World, July 29, 2014). The government has long maintained the policy of reprocessing all spent nuclear fuel[218] and conducted few studies about disposing it as waste. A basic energy plan adopted in April 2014 upholds the nuclear fuel recycling policy but for the first time it called for studies on ways to directly dispose of spent fuel without reprocessing it (NHK World, July 25, 2014).

A series of challenges led to the later move: a reprocessing plant in Rokkasho Village, Aomori prefecture has suffered numerous troubles being unable to start full operation more than 20 years since construction began; nuclear power plants have accumulated 17,000 tons of spent nuclear fuel; fast breeder reactor Monju, Fukui prefecture is designed to use recycled plutonium but facility has been plagued by troubles[219] and its future is uncertain.

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

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

Until now only one local government (Toyo, Kochi prefecture) has announced its candidacy (2007) but its efforts have been buckled under opposition from local residents. In December 2013

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

[218] Extract plutonium and reuse it as fuel at nuclear power plants.

[219] Including a fire and failed inspections.

the central government switched to a policy in which it would play a leading role in narrowing down prospective candidate sites beforehand and then requesting two or more municipal governments to accommodate the facilities.

The central government plans for radioactive waste to be mixed with glass, and the vitrified waste to be stored in metal containers buried at least 300 m deep underground[220]. Some in the government voiced a cautious view that presenting candidate sites before the local elections next spring will cause disarray, and the candidate sites will most likely be presented after that (The Japan News, July 23, 2014).

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

A 2014 government report points out that the release of radioactive materials following the Fukushima nuclear accident remains Japan's biggest environmental problem (NHK World, June 6, 2014).What is more, Japan emitted the largest amounts of greenhouse gases on record[221] in FY2013 (a 1.6% climb since 2012) blamed on the increased use of fossil fuels (including coal) since the 2011 nuclear disaster (NHK World, December 5, 2014).

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

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

[221] 1.395 billion tons - most since comparable data are available (1990) and 1.3% up from the 2005 levels. By 2020 the target is to cut emissions by 3.8% from the 2005 levels.

Part 2.
Impacts on Agri-Food Organizations, Products, Markets and Regulations

Chapter 6. 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.

The total number of damaged Agricultural Management Entities[222] of different type (private farms, corporate entities, cooperatives, local public bodies, etc.) reached 37,700 or around 16% of all Agricultural Management Entities in the affected eight prefectures (Table 14).

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

[222] Defined as entities engaged in or entrusted to conduct agriculture production activities where area and number of feed livestock of production or operation are above a certain size - 30 ares of managed cultivated land; 15 ares of planted land for fields vegetables; 350 square meters of planted land for vegetables in facilities; 10 ares of planted land for fruits trees; 10 ares of planted land for fields flowers and ornamental plants; 250 square meters of lanted land for flowers and ornamental plants in facility; 1 milking cow; 1 fattening cattle; 15 pigs; 150 layers; 1000 broiler chickens shipped in a year; total sales of 500,000 yen of agricultural products (Ministry of Agriculture, Forestry and Fisheries).

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

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

Source: Ministry of Agriculture, Forestry and Fisheries *subject to status confirmation

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 (Figure 21). 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[223]. 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 22). 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 bellow 3 ha (Figure 49). 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).

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

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

Note: *includes tsunami-damaged land (to be restored) in Reconstruction Master Plan for Agriculture and Farming Villages), and other damaged land due to cracks, liquefaction, burial, sediment inflow, etc. as well as minimal tsunami-damaged land not included in Master Plan
Source: Ministry of Agriculture, Forestry and Fisheries.

The biggest number of damaged municipalities has been in

[223] Including both unaffected and damaged Agricultural Management Entities.

Fukushima prefecture (34, including 10 tsunami-damaged), followed by Miyagi prefecture (31, including 15 tsunami-damaged), and Iwate prefecture (20, including 11 tsunami-damaged).

According to the latest data almost 56% of the traditional agricultural hamlets[224] in Miyagi prefecture have been damaged by the disasters, including 20.1% tsunami-damaged (Ministry of Agriculture, Forestry and Fisheries, 2014). Particularly severely have been hit Tagajo, Higashimatsushima, Kawasaki-cho, Yamamoto-cho, Matsushima-machi, Shichigahama town, Rifu-cho, Yamato-cho, Osato-cho, Tomiya Town, Ohira village and Onagawa, where every one of the agricultural communities has been damaged by the disasters.

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. Harshly affected by the disasters have been Fukushima's Kagamiishi Town, Izumizaki village, Nakajima Village, Yabuki-machi, Naraha Town, Tomioka, Kawauchi Village, Okuma-machi, Futaba-cho, Namie-machi, Katsurao Village and Iitate, where each agricultural community has been damaged.

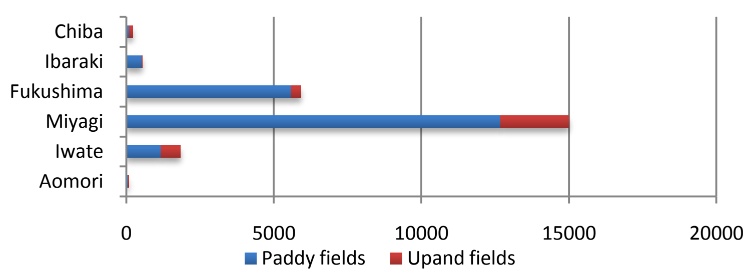


Figure 21. *Areas of farmlands washed away or flooded by tsunami (ha)*
Source: Ministry of Agriculture, Forestry and Fisheries

There have been registered damages in 36,092 places including: damaged agricultural land in 18,186 areas, damaged agricultural facilities (mainly storage reservoirs, drains, pumps, shore protection facilities for agricultural land) in 17,317 points, damaged coastal protection facilities for agricultural land in 139

[224] Shuraku – ancient agricultural community organization still vital in Japan. In 3 most affected prefectures there are 10,737 agricultural hamlets, including 3,652 in Iwate, 2,797 in Miyagi and 4,288 in Fukushima (Ministry of Agriculture, Forestry and Fisheries, 2014).

points, and damaged facilities for daily life in farming villages (mainly community sewerage) in 450 points (Ministry of Agriculture, Forestry and Fisheries, 2014).

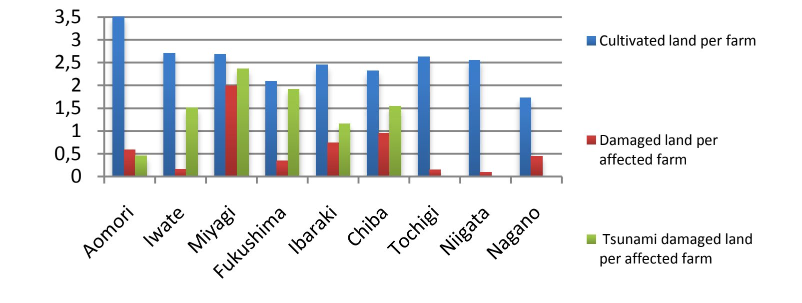


Figure 22. *Size of farms, damaged land tsunami damaged land per affected AME*
Source: MAFF

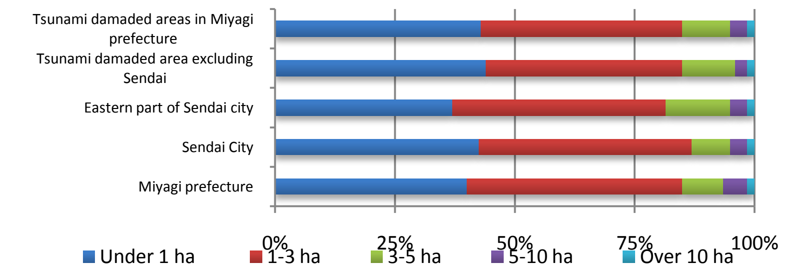
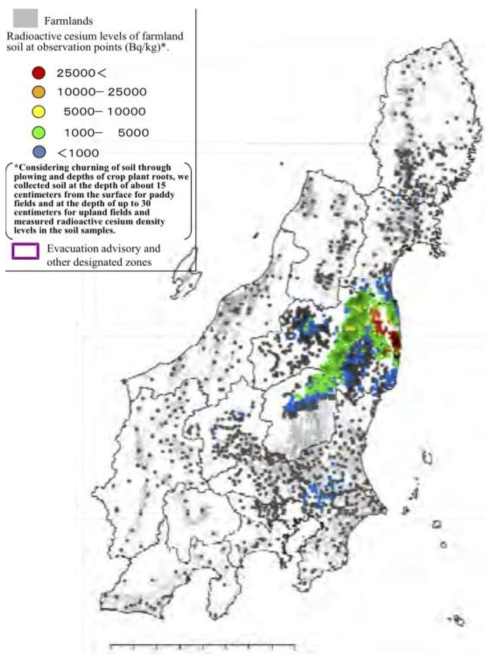


Figure 23. *Size of agricultural holdings in tsunami-damaged areas in Miyagi*
Source: Fuyuki 2013

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 11). 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 16). 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 11. *Farmland soil radiation (March 23, 2012)*
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). In Aomori, Iwate and Miyagi prefectures registered livestock damages include 187 dairy heads (171 drowned and 16 crushed or starved), 458 beef cattle (466 drowned and 12 crushed or starved), 5,850 hogs (4,037 drowned and 1,813 crushed or starved), and 4,549,620 poultry (174,800 drowned and 4,374820 crushed or starved) (Tohoku Agricultural Administration Office, 2011).

Table 16. *Share of contaminated with Cs farmlands, as of December 28,*

2012 (percent)

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

Source: Ministry of Agriculture, Forestry and Fisheries

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. For instance, in JA Soma the damaged area from the nuclear accident reaches 5,439 ha and the damaged farmlands is 4,155 ha (Nagashima, 2013). Consequently, in the evacuation area the number of farms decreased from 364 to 101, and the livestock heads from 4864 to 2261.

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

The official estimate for the inflicted damage on agriculture by the 2011 earthquake is 904.9 billion yen[225] (Figure 24). 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%).

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

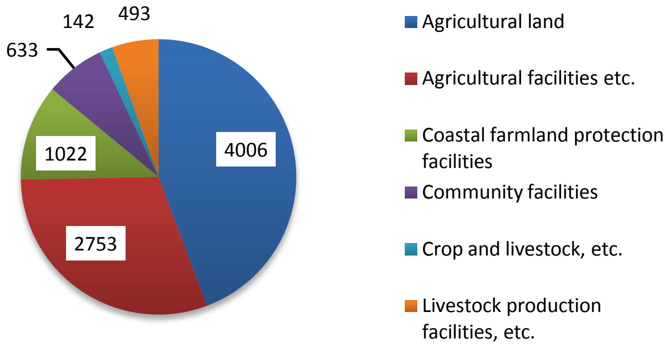


Figure 24. *Damages to agriculture from 2011 earthquake as of July 5, 2012 (100 million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

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.

The greatest amount of damage has incurred in Miyagi prefecture representing 56.5% of the total worth (Figure 25). 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.

In Miyagi, Fukushima, Nagano and Iwate prefectures the damages on agricultural land take the greatest segment in the registered prefectural amounts. In Kanagawa, Shizuoka, Gunma, Chiba, Yamagata, Ibaraki, Tochigi, Nagano, and Nigata prefectures the damages on agricultural facilities etc. dominate. In Iwate prefecture most of the damages are on coastal farmland protection facilities. In Akita prefectures damages on rural community facilities are the largest. In Saitama and Yamagata prefectures the crops and livestock losses are the biggest, while in Saitama and Aomori the damage on livestock facilities etc. are the most important.

Early studies estimated the tsunami disaster losses in rice field in Miyagi and Fukushima prefectures to 1932.52 ha and 718.43 ha respectively, which are expected to cause a decrease in annual rice yield by 9,472.60 tons in Miyagi prefecture and by 2,939.10 tons in Fukushima prefecture, equivalent to a total annual loss of $US 1,411 million (Liou *et al.,* 2012). It was also estimated that such loss would be undoubtfully enlarged by several orders of magnitude when the contamination of nuclear radiation is considered.

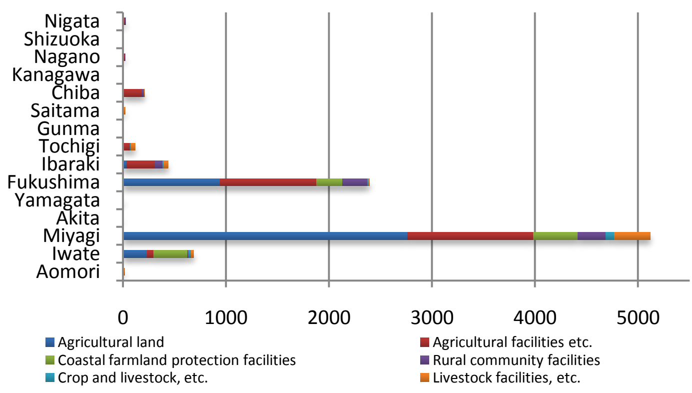


Figure 25. *Damages to agriculture in different prefectures from 2011 earthquake as of July 5, 2012 (100 million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

A survey on 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 26).

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 27).

There have been 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.

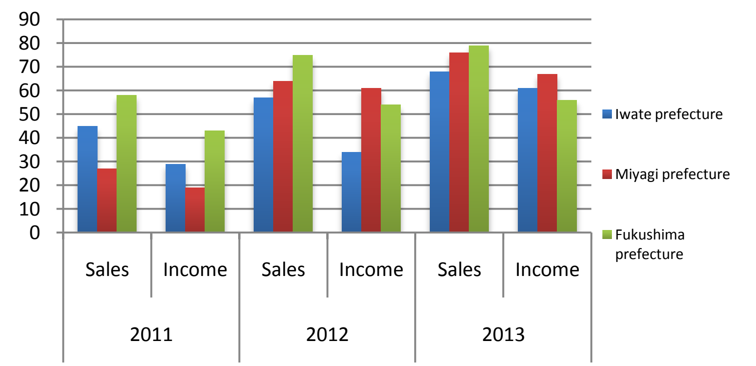


Figure 26. *Evolution of agricultural sale and income of agricultural management entities in tsunami-damaged areas (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

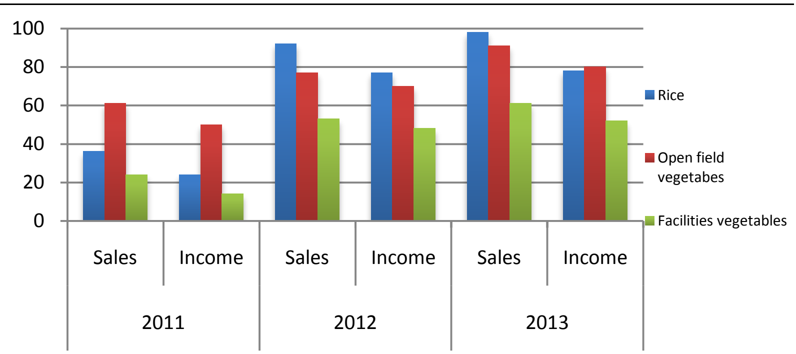


Figure 27. *Evolution of agricultural sale and income of agricultural management entities with different specialization in tsunami-damaged areas (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

There 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 (Figure 28). 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).

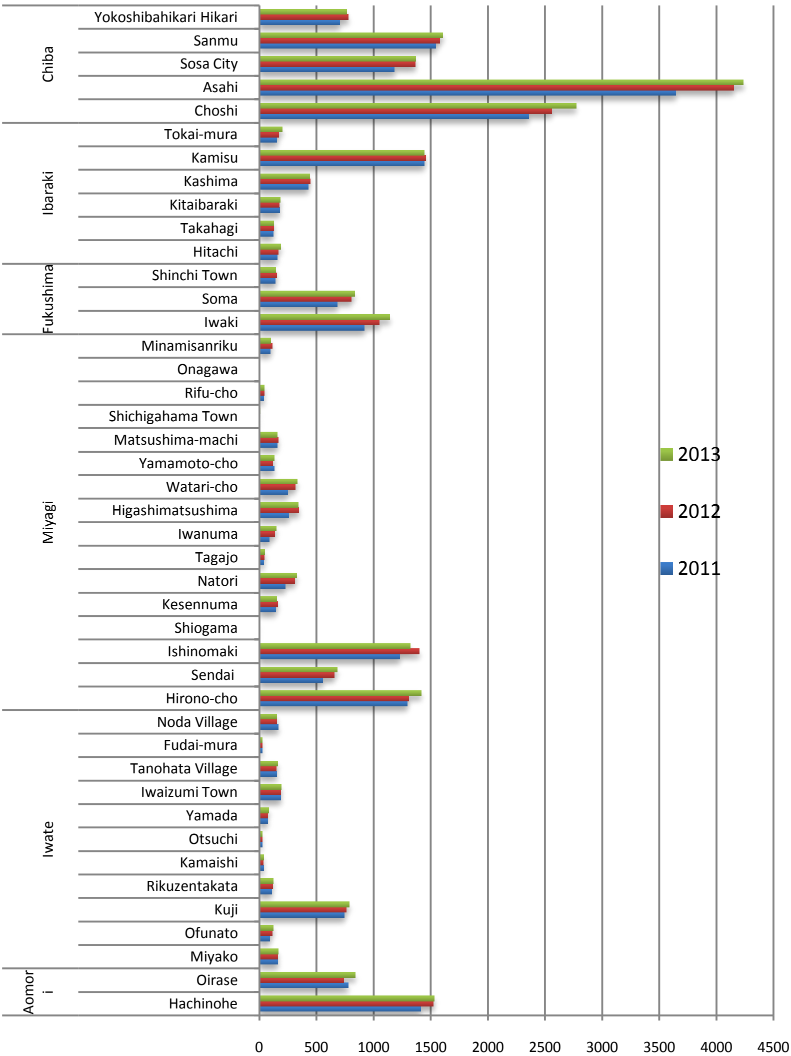


Figure 28. *Evolution of agricultural output value in tsunami-damaged municipalities (10 million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

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% (Figure 56). 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[226].

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 17). 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.

Table 17. *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

Above 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).

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

[226] E.g. in 2012 there was no or very low output in Onagawa, Shiogama, and Shichigahama Town, Miyagi prefecture due to enormous tsunami destruction and farming suspension (no annual progression in the firsttwo cases, and 80% reduction in the last one). On the other hand, a small output progression (0.8%) in Kamisu, Ibaraki prefecture expresses maintaining of a relatively high 2011 level.

in quantitative (e.g. monetary) terms (Bachev & 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 2013a, 2013b; Ujiie 2011 and 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 29). 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 30). 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.

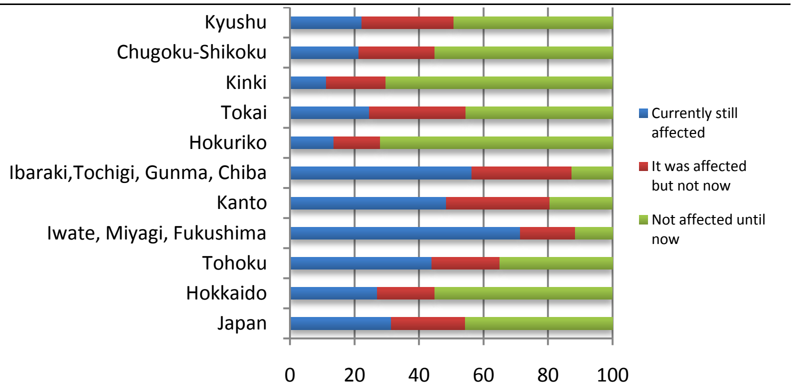


Figure 29. *Adverse effect of Great East Japan Earthquake on farm management in different regions of Japan (March 2012)*
Source: Japan Finance Corporation

There are also huge differences in the most affected sectors in each region of the country (Table 18). 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.

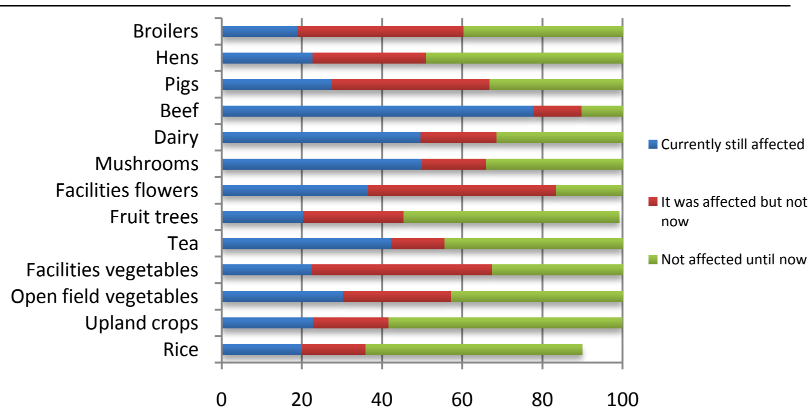


Figure 30. *Adverse effect of Great East Japan Earthquake on farm management in different subsectors of Japanese agriculture (March 2012)*
Source: Japan Finance Corporation

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 (Table 19). 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 (Table 20). 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.

Another nationwide survey on farms performance reviled that there is significant differences in the dynamics of sales volume and income in of individual and corporate farms (Japan Financial Corporation, 2013). For instance, there was a considerable decline in the income of vegetable producing Corporate Farms in 2012 comparing to 2011 (11.2% for open field and 34.1% for facility vegetables) with simultaneously improved performance in the Individual Management Entities. At the same time, declined in the income in Individual Farms was much higher than in the Corporate Farms hen produces (69.8% and 30% accordingly) and the opposite for the broilers producers (2.6% and 20.3% accordingly).

Table 18. *Adverse effect of Great East Japan Earthquake on different subsectors in most affected regions (March 2012)*

	Iwate, Miyagi, Fukushima			Ibaraki, Tochigi, Gunma, Chiba		
	Currently still affected	It was affected but not now	Not affected until now	Currently still affected	It was but not now	Not affected until now
Rice	64.2	18.9	16.9	44	24.5	31.4
Upland crops				46.2	23.1	30.8
Open field vegetables	38.5	23.1	38.5	64.3	26.8	8.9
Facilities vegetables	70.3	21.6	8.1	35.3	59.8	4.9
Fruit trees	69.6	8.7	21.7	48	36	16
Facilities flowers	64.3	17.9	17.9	54.1	45.9	
Mushrooms	87.5	12.5		92.9	7.1	
Dairy	95.2	4.8		79.8	19.3	0.9
Beef	98.6	1.4		92.6	7.4	
Pigs	54.1	45.9		41.8	41.8	16.4
Hens				38.1	33.3	28.6
Broilers	42.1	52.6	5.3			

Source: Japan Finance Corporation

Table 19. *Reasons for those who are currently adversely affected in different regions (August, 2011; January 2012)**

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

Note: *multiple answers
Source: Japan Finance Corporation

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.

Table 20. *Reasons for those who are currently adversely affected in different subsectors(August 2011; January 2012)*

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

Note: *multiple answers
Source: Japan Finance Corporation

Chapter 7. State of restoration of agricultural organizations, lands, and infrastructure

The Ministry of Agriculture, Forestry and Fisheries worked out a "Strategy for the Revitalization of the Agriculture, Forestry, and Fisheries" (2011) aiming to rapid restoration and resuming of farming in disaster affected regions. What is more, in line with the Government priority the strategy and accompanied measures have intended to rebuild economy, industry, and local communities with resilient structures through a "qualitative shift" towards a new socio-economic growth. The Basic Guidelines for Reconstruction called for reconstruction to make agriculture in Tohoku "serve as a model for the nation" (Ministry of Agriculture, Forestry and Fisheries, 2011).

The Government reconstruction strategy incorporated seven basic principles:

- country's revitalization will underpin the reconstruction of East Japan, and the reconstruction of East Japan will serve as a trailblazing example for Japan's revitalization;
- establish economic and social structures that are fortified against enormous risks;
- maintain confidence in public finances and social security, Japan brand;
- concentrated allotment and concentrated investment in new growth under resource restrictions, such as those on financial resources and electric power;
- realize local empowerment and private sector vitality;
- revitalize economy in an open manner by strengthening

"kizuna" (the bonds of friendship);

- promote understanding in Japan and overseas regarding Japan's revitalization.

The Ministry of Agriculture, Forestry and Fisheries strategy has been supported by a series of supplementary budgets including: subsidizing part of the cost necessary to recover farm land, granting aid to resumption of farming, and providing interest-free loans for the afflicted farmers and businesses. It also considers projects for integrated development of residential zones, agricultural zones and other zones, including conversion from residential to agricultural zones.

In addition, there has been easing in approval standards under the Agricultural Land Act and other laws, and one-stop procedure for zoning, approval and project planning in affected areas. Further enlargement of the loans with a credit line of 100 billion yen and interest-free loan under the "Act on Temporary Measures on Financial Support of Farmers has been introduced. Subsequently, farms having 30% and more harvest reduction and over 10% of property damages can apply up to 2 million yen for persons and 20 million yen for companies with 3-6 years redemption period. For special cases the individual loans have 2.5 million yen ceiling and extending period of redemption of 4-7 years under the "Special Financial Aid Act for Heavy Disaster" (Ministry of Agriculture, Forestry and Fisheries).

The government measures aimed at both recovering and increasing farm efficiency. Particularly, they have been contributing to accelerating farmland transactions and expanding farm operations. The "new" policy encourages communities in the afflicted area to discuss and submit "master plans" for farmland use. Citizens have been faced with a task of discussing land use for public, commercial, residential, farming and other purposes in order to rebuild communities. That made it possible for agricultural commissions with participation of stakeholders and citizens to discuss farmland use marking land zones clearly and effectively. The later gave opportunity to adjust land uses and aggregate farmland while concentrating residence and commercial/communal facilities into uplands, which allow improving farmland efficiency and building a disaster-resistant community.

The government pays 30 thousand yen for every 0.1 hectares of farmland to retiring farmers, non-farmer inheritors, etc. if they lease out land under certain conditions (period more than 6 years, land to be blindly entrusted to government-approved agencies taking part in farmland aggregation projects, etc.). The later created incentives to increase farmland transactions within the afflicted area as well as opportunities for farm managers to expand production by borrowing consolidated land plots from farmland aggregation agencies.

There has been also a huge public support for decontamination efforts – e.g. national budget for decontamination for the period of 2012-2013 comprises 1.1482 trillion yen (Koyama, 2013). There has been increased public (national, prefectural, local) support to farms and agri-business in the affected regions. The Government established the Nuclear Damage Liability Facilitation Fund to support nuclear damages payments. By March 2012 agricultural damages payments associated with the nuclear disaster totaled about 106.2 billion yen (Ministry of Agriculture, Forestry and Fisheries).

The Government support to prefectures and farmers to recover from the disaster has been substantial. For instance, farmers that have conducted complete inspection of all cattle and feed lots are paid 50,000 yen per head of cattle. In places where shipping restrictions are imposed funds have been provided for the purchase and disposal of the beef in distribution chains or facing delayed shipment. Similar measures have been applied to other farm products as well.

Last but not least important, there has been a significant support from diverse agricultural (such as agricultural cooperatives), business, academic, non-governmental and international organizations. All they intensified their activities in the affected regions and multiplied relations with individual farmers and agri-business companies. That has been associated with an increased "outside" service supply and likely positive effects on activity, innovations, incomes, etc.

A good progress in removal of debris, restoration of damaged agricultural lands, and resumption of farming has been achieved with concerted efforts of government agencies, prefectural and local authorities, agricultural cooperatives, farmers, private companies, volunteers, etc.

In order to remove the salt from soils following procedures have been applied – construction of temporary diversion canals or creasing cannels, pouring lime soil conditioner, mole draining, reverse plowing/soil crushing and flooding for removing salt (Ministry of Agriculture, Forestry and Fisheries, 2011).

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 31).

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[227] for complete restoration of tsunami-damaged farming set by the Basic Guidelines for Reconstruction of Agriculture and Rural Communities after the Great East Japan Earthquake (Table 21). Consequently, a half of the affected by the tsunami farms resumed agricultural production or preparations for it (Ministry of Agriculture, Forestry and Fisheries, 2013).

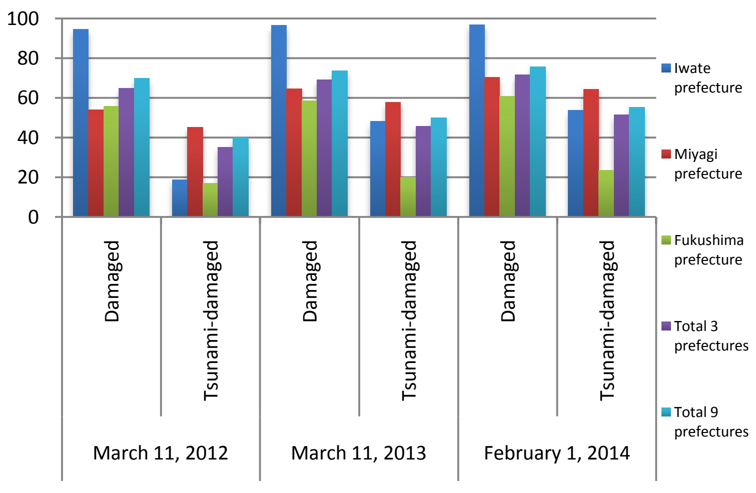


Figure 31. *Share of Agricultural Management Entities, which resumed farming (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

[227] Published on August 26, 2011 (concequently revised several times) specifying farmland restoration measurs and schedule.

Table 21. *Master plan for restoration of tsunami-damaged farmland, June 2014 (ha)*

Prefectures	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015*	FY 2016 or later*	Evacu-ation order area	Diversion	Total
Iwate	10	100	150	190	40	190	-	50	730
Miyagi	1,220	5,450	4,240	1,120	540	1,140	-	630	14,340
Fukushima	60	400	890	280	240	890	2,120	580	5,460
Aomori, Ibaraki, Chiba	810	140	-	-	-	-	-	-	950
Total	8,100		5,280	1,590	820	2,220	2,120	1,260	21,480
Share (%)	38		25	7	4	10	10	6	100

Note: *including scheduled enlargement of farmlands (710 ha in 2014, 1,570 ha in 2015)
Source: Ministry of Agriculture, Forestry and Fisheries

The latest figures indicate that 63% of the tsunami damaged agricultural land has been made available for farming (Reconstruction Agency, 2014) and more than 55% of the affected farms resumed operation.

In the three most affected by the disasters prefectures approximately 72% of the damaged farms and 52% of the tsunami-damaged farms resumed operations. The biggest progress in restoration of the damaged farms has been achieved in Iwate prefecture, and for the tsunami damaged farms in Miyagi prefecture. Despite that agricultural land in Miyagi prefecture was planned to be fully recovered by 2015, the officials announced that it might be delayed by a few more years (Fuyuki, 2013).

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 & 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 32). 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.

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 33). 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".

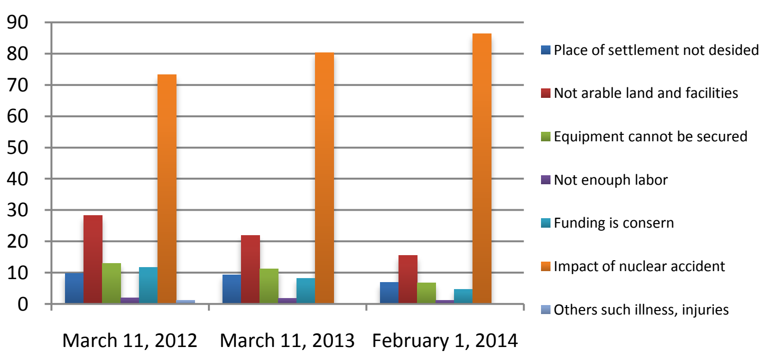


Figure 32. *Reasons for not resuming farming in Iwate, Miyagi and Fukushima prefectures, multiple answers (% of farms)*
Source: Ministry of Agriculture, Forestry and Fisheries

The aging of farmers and the lack of successors in business has been a serious problem in the disaster areas and nationwide. For instance, presently a significant portion of the regular farm male workers in the tsunami-damaged areas of Miyagi prefectures are part-time farmers and older than 65 (Figure 34). 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.).

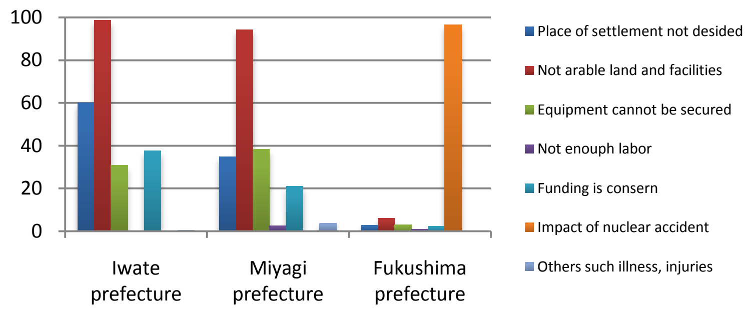


Figure 33. *Share of farms with diverse reasons for not resuming farming, multiple answers (%)*
Source: Ministry of Agriculture, Forestry and Fisheries

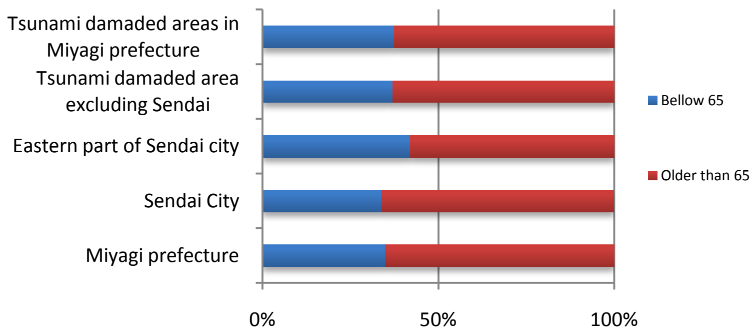
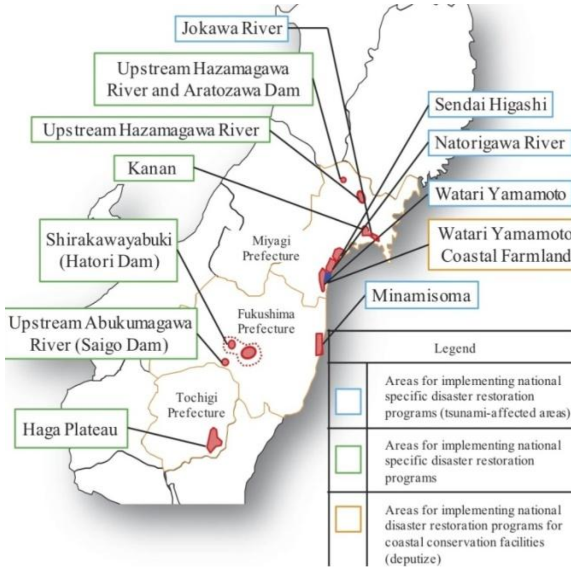


Figure 34. *Age of regular male farm workers in different parts of Miyagi prefecture*
Source: Fuyuki, 2013

The Ministry of Agriculture, Forestry and Fisheries launched the National Specific Disaster Restoration Programs for Farmlands and Farming facilities in FY2011 (Map 11). In efforts to secure reconstruction after land restoration, it is implemented to enlarge partitions of farmlands to achieve economies of scale and farming efficiency (Figure 35). In March 2013 the later include 9,400 ha in Iwate, Miyagi and Fukushima prefectures, funded by the Great East Japan Earthquake Reconstruction Grants and the like (Ministry of Agriculture, Forestry and Fisheries, 2013). The national specific restoration program of farming facilities in Minamisoma city, Fukushima Prefecture started in FY2012.



Map 11. *Districts for implementing national specific disaster restoration programs*
Source: MAFF

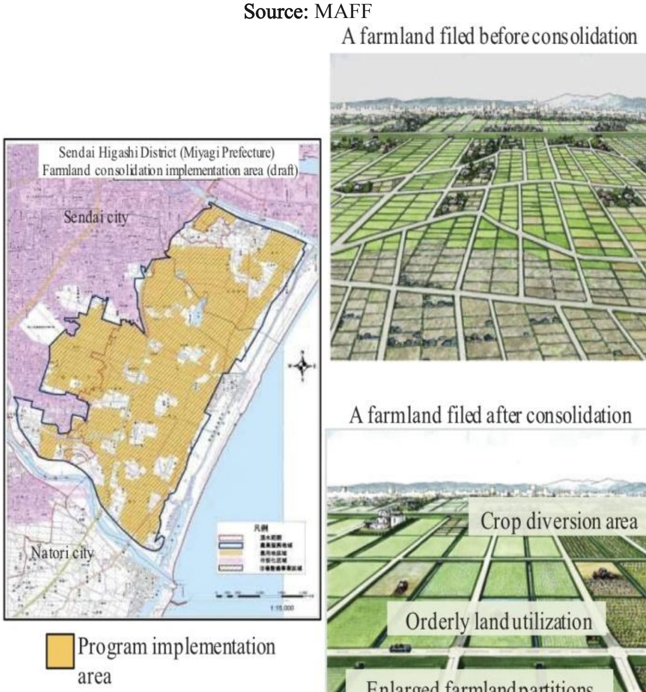
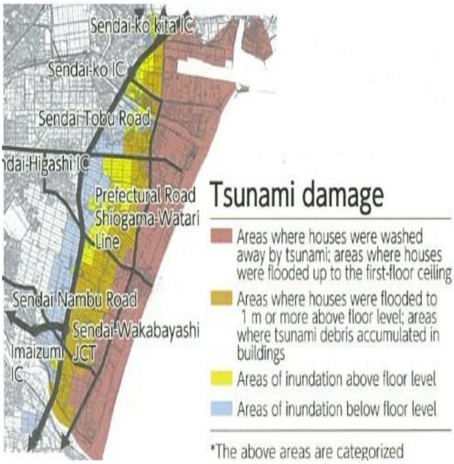


Figure 35. *Overview of farmland enlargement in Sendai Higashi District*
Source: MAFF

The process of reconstruction of devastated by the earthquake and tsunami East Sendai agriculture is a good example for the efficiency of implementing strategy[228] and programs.

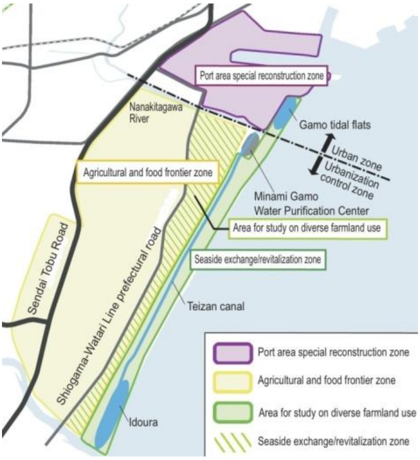
The strategy and the Plan for reconstruction of agriculture is an essential part of the ten year "Sendai City Disaster Reconstruction Plan" for restoration, recovery and revitalizing of all aspects of social life and economies, and enhancing safety of residents and communities. The later include as major components the reconstruction projects such as: "Tsunami reduction and housing reconstruction project", "Residential area rebuilding project", "Life recovery project", "Agricultural and food frontier project", "Seaside exchange and revitalization project", "Model development project for a disaster-proof Sendai", "Energy-saving and new energy projects", "Sendai economy development project", "Exchange promotion project", and "Earthquake disaster memorial project" (City of Sendai, 2011).

The Eastern Sendai agricultural zone includes four districts - Takasago, Miyaguno-ku, Shishigo, Wakayabashi-ku, Rokugo, Wakayabashi-ku, and Shiromaru, Taihaku (Map 12). The total area is 4,633 ha, population of 21,966 in 8,086 households, and number of buildings 12,277.



Map 12. *Tsunami damaged East-Sendai agricultural zone*
Source: City of Sendai

[228] Goals and progress presented in "Fresh Breeze of Change in Agriculture Starts Here" [Retrieved from].



Map 13. *Plan forland use in Eastern Sendai*
Source: City of Sendai

The total cultivated land in East Sendai is 2,300 ha, 78% of which was damaged by the tsunami, including 1600 ha rice paddies and 200 ha vegetable fields (City of Sendai, 2014). Furthermore, 2,400 tractors, rice planting machines and other equipment were lost, 10 ha greenhouses destroyed, 4 draining pumping stations completely collapsed, many buildings and houses heavily damaged or demolished, Sendai Agricultural and Horticulture Center flooded, and many water canals and farm roads were submerged.

The economic damage to agriculture was enormous – it is estimated at 72,1 billion yen, including 39,6 billion yen for damaged farmland, 10.6 billion yen for damaged machines and facilities used in agriculture, and 21.9 billion yen for damaged land improvement facilities (City of Sendai, 2014).

Few days after the disaster (on April 5, 2011) the Liaison Meetings between the city authority and diverse actors (representatives of farmers, agricultural cooperatives, Land districts, etc.) was established, and discussions on agriculture restoration and development started.

Developed Reconstruction Plan includes as an essential part a new land use in East Sendai envisaging: Agricultural and food frontier zone, Seaside exchange and revitalization zone, Port area special reconstruction zone, and Sites left after collective relocation for urban infrastructure redevelopment (Map 13).

The Agricultural and Food Frontier Project has been undertaken to support recovery from the disaster and development of agriculture in East-Sendai agricultural zone. It is centered on four targets: farmland consolidation and improvement; supporting farmers in enhancement of management base; promoting "cross-industry diversification" (integrating farming with related industries such as food processing and sales), and improving support center facilities (Figure 36).

The cleaning up, restoration and recovery of farmlands have been an enormous task mobilizing efforts of the local and central authorities. The work included removal of large amount of debris and desalination of huge areas of farmlands.

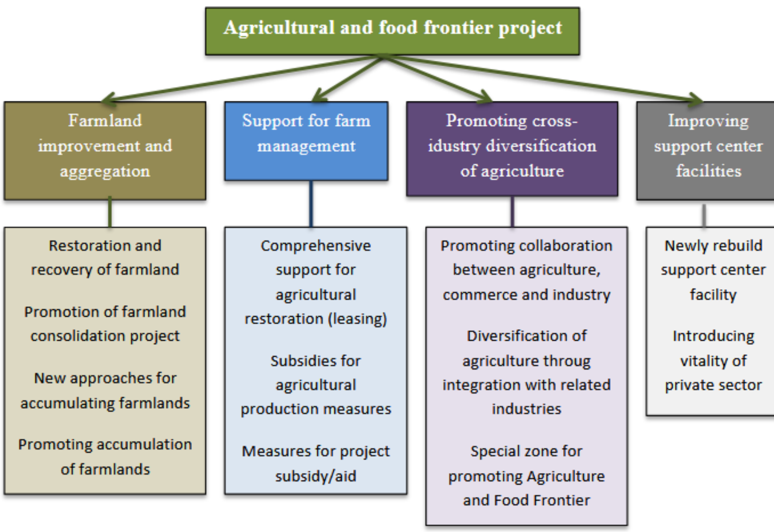


Figure 36. *City of Sendai "Agricultural and Food Frontier Project" components*
Source: City of Sendai

The Debris Removal Project was carried out between July 1 and December 28, 2011 on 1,800 ha flooded farmland (City of Sendai, 2014). It included clean-up of damaged buildings, woody debris and cars swept into farmland, farm roads and irrigational channels. The project employed 1,202 farmers who were victims of the disaster (with additional 64 registered for employment).

The Soil Desalination Project was conducted from March 25, 2011 until April 30, 2014 on 1,860 ha. It was proceeded by detailed surveys on extent of soils salinations and designing of feasible countermeasures for land improvement. By the end FY 2012 around 30% (560 ha) of damaged farmland were restored and made available for resuming farming, while farming restarted on 60 ha (10.71%). Until March 2013 around 80% of the damaged farmlands was restored and the majority of farms resumed operations (Photo 2). According to the officials the quality of harvested rice was at level equal to that before the disaster and the former rural landscape is steadily returning.

Photo 2. *Successfully reconstructed East-Sendai agriculture*
Source: City of Sendai, 2014

Figure 37. *Conceptual plan for farmland development in Eastern Sendai*
Source: City of Sendai, 2014

Simultaneously, restoration of irrigation and drainage channels has been conducted. The Temporary Restoration Drainage Pumping Stations Project was carried out from May 2011 until June 2012 and all 11 stations timely restored as the pre-disaster capacity (19 m^3/s) reached. The full-scale restoration continues taking into account the degree of ground subsistence (approximately 50 sm).

The Farmland Consolidation Project has been currently promoted and involves readjusting small traditional plots to form new larger ones (Figure 37). The process is guided by a Council including representatives of different stakeholders – authority, farmers, agricultural cooperatives, Land districts, etc. Before the aggregation farms plots were small and farm roads narrow which was obstacle for the efficient agricultural practices. Poor draining made it difficult to plant wheat, soybeans and other crops. Consolidation raises the farm efficiency, expends crop possibility, and allows farmland borrowing and lending to progress smoothly.

The East Sendai District Farmland Consolidation Project covers 1,979 ha out of the 2,244 ha District area including farmlands, roads and irrigation/drained channels (City of Sendai, 2014). The operational expenses are 19.7 billion yen and planed project period from FY2012 to FY 2016. The ratio of the landlords consent for farmland consolidation is 94.6%.

The Natori District (Shiromaru area) Farmland Consolidation Projects covers 708 ha (91 ha of the Shiromaru area) out of the 809 ha District area (including 100 ha Shiromaru area). The project period is from FY2013 to FY2015, the operational expenses 10.6 billion yen, and there is 98.8% of by landlords consent for farmland consolidation (including 100% in Shiromari area).

New approaches for accumulating farmlands have been also reviewed. The goal is to promote land accumulation by leasing farmlands to current or future farm operators. The traditional approaches for farmland consolidation include: transfer of ownership (buying and selling farmlands), replotting by exchanging farmlands (constructing the farmland use rights through implementing land consolidation), lease contract (establishing farmland use rights though a contract to commissioning farming), and commissioning farm work (borrower farmer is commissioned to cultivate rice in paddy fields from plowing dry soils, tilling irrigated soils and transplanting rice seedlings to harvesting rice).

Since April 2013 Sendai city in collaboration with the JA Sendai introduced a new approach to “bulk management of farmland” (Figure 38). Sendai city and JA Sendai act as intermediary by implementing bulk lease management practices of farmlands in the relevant areas so that borrower farmer are able to cultivate consolidated land according to the scale and status of operations.

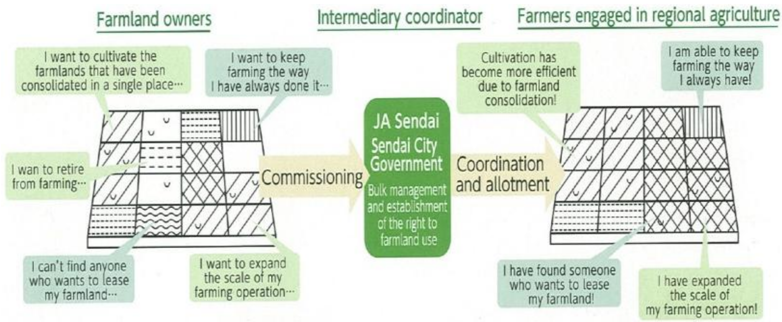


Figure 38. *Bulk management approach for farmland consolidation in East-Sendai*
Source: City of Sendai

The city authority has also created "Sendai Agriculture Enhancement Plan" (Master plan for resuming Agricultural Management) based on the discussions held in communities and areas in the 14 districts of the city, including East-Sendai District. Among other things the Future Vision of the Regional Agriculture incorporates:

- recognizing regional agriculture so that farmers who operate large farmland plots play a central role;
- encouraging associations for rice-crop diversion practice to form group-farming organizations based on integrated cultivation of rice and other crops;
- fostering community-based incorporated farming bodies as a model by establishing the right to bulk use and re-allotting farmlands to farm operators.

The Ido and Arahama Districts have been selected as model districts, and measures to establish the rights of bulk use and re-allotment of farmland to farm operators started in 2013. According to the progress and experiences obtained, the farmland accumulation will be promoted in all relevant areas.

A variety of support measures have been also provided to lender and borrower farmers in order to put the plan into action. Support funding for 2013 include Farm Accumulation Support Fund (Central Government) and Project to Promote Accumulation of Farmlands for Use (Sendai city government). The former provides support funds to farmland owners who are listed in the "Sendai City Agricultural Infrastructure Enhancement Plan" when they newly commission JA Sendai to lease-out land "giving full authority" (a contract without designating a borrower).

Concerning the tsunami-affected farmlands recovered for farming after April 1, 2012, subsidies are offered to both "farm lender disaster-victims” and “borrowing farmers” when they made a new contract for leasing farmland or commissioning farming that extend over a period of three years.

The Comprehensive Support Project for Agricultural Restoration in Disaster-stricken Areas (Leasing) give opportunities through the Reconstruction Grant Project for community farming organizations to lease free-of charge large machines (tractors, rice planters, combines, etc.) and facilities (plastic greenhouses for raising seedlings, machinery store houses, etc.) in the disaster-stricken farmlands assisting farming resumption. In FY 2012 the target area covered Okada (Shinhama, Minami-gamo), Yotsuya, Sasayasaki, Kamiyashiki, Fujita, Arahama, Sambontsuka, Futaki, Ido, Nambu (Tanetsugi, Fujitsuka), and included 43 tractors, 24 rice planting machines, 32 combines, rotaries, harrows for soil paddling, seeders, plastic greenhouses for razing seedlings, wells, storehouse for agricultural machines, and various other machines. In FY2013 similar items are included as well.

The Great East Japan Subsidy for Agricultural Production Measures include financial support by the national, prefectural and municipal governments to groups which are organized by farmers, agricultural producers cooperative corporations etc., so that they can install common facilities, do repair and renovations, and lease agricultural machines and materials.

In 2011, 2012 and 2013 the amounts of such subsidies have been accordingly 603 million yen, 1,528 million yen and 1,386 million yen. The subsidy ration has been less than 82.5%. In 2011 and 2012 the number of projects were accordingly 51 and 28 with total project costs of 787 million yen and 603 million yen.

The Measures for Project Subsidy/aid includes: (1) Emerging Installation of Plastic Greenhouses for Vegetables and Flowers, and (2) Project to Support Disaster-stricken Farmers to Resume Farming.

The first one comprises (city government) subsidies of the part of expenses of the disaster-stricken farmers (farming groups, certifies farmers, eco-farmers, etc.) for installing plastic greenhouses to resume farming. The subsidy ration is less than 50% of the project costs with a limit of 2,650 yen per 1 m^2. In 2011 and 2012 the number of projects was accordingly 15 and 11 for areas of 11,769 m^2 (78 buildings) and 24,172 m^2 (135 buildings). The total amounts of projects and subsidies in 2011 were 55.5 million yen and 26.5 million yen, while in 2012 it was 139.9 million yen and 62.5 million yen. The budget for FY2013 is 66.3 million yen.

The second project provides subsidies to farmers who jointly establish a recovery association to remove fine debris, weeding or clearing so that farming can be resumed. It covers tsunami inundation areas and provides unit grant aid per 0.1 ha for rice paddy of 35,000 yen and vegetable fields of 40,000 yen. In 2011 target areas, where associations were established, were four (Takasago, Shichiro, Rokugo, Nakada), and in 2012 three (Takasago, Shichiro, Rokugo). In 2011 and 2012 the number of farmers involved was accordingly 1,573 and 1.085, while the total amount of grant was 641 million yen and 401.6 million yen. In FY2013 the budget for this measure is 141.3 million yen.

Another major aspect of the Agricultural and Food Frontier Project is the Promoting Diversification of Agriculture by integrating it with Related Industries such as Food Processing, Distribution and Sales. It includes three measures:

a/ Promoting Collaboration between Agriculture, Commerce and Industry - it aims to encourage regional industries based on agriculture by arranging business “matching” opportunities and supporting activities to develop high value-added products and services. The idea is that the later can be done with the collaboration of agriculture, commerce and industry, and mutual utilization of resources, technologies and networks. Support measures include: seminars for promoting collaboration between agriculture, commerce and industry; support for development of new products (4 in 2012 and 4 in 2013); and project for supporting the model to employ farmers based on collaboration between agriculture, commerce and industry (3 in 2011, 3 in 2013, and 1 in 2013).

b/ Diversification of Agriculture through Integration with Related Industries such as Food Processing, Distribution and Sales. Measures are carried out to promote “cross-industry diversification of agriculture” – e.g. farmers independently enter the businesses of food processing, distribution and sales, and collaborate with the secondary and tertiary industries to produce and develop new competitive products and services[229]. It also fosters young farmers who play a major role in management of cross-industry diversification. Support measures include: fostering human resources capable of developing the cross-industry diversification of agriculture; and support for promoting the cross-industry diversification of agriculture (3 in 2012, and 4 in 2013).

c/ Special Zone for Promoting Agriculture and Food Frontier

[229] Example for so called “six industry” is the Cotton Project where some farmers grow cotton on salted fields cooperating with a textile company (Fuyuki, 2013).

Project – set up in East Sendai as a part of the central government special reconstruction zone program. It allows farm operators in the area to receive special tax provisions so that they can acquire machinery and facilities, start new incorporated businesses and other projects without difficulties.

The target area covers approximately 3,000 ha in the tsunami-affected Miyagino-ku, Wakayabashi-ku and Taihaki-ku. Target businesses includes incorporated entities or small independent companies that contribute to creating employment opportunities and promote agriculture or operate businesses that correspond to cluster industries in approved area. Twenty different businesses are designated including: agriculture, food processing, distributing and sales-related industries, renewable energy-related industry, research and testing-related industry. The preferential measures include: special tax provisions, tax credit or special depreciation against taxes (income tax and corporate tax), exemption from prefectural tax (corporate tax and real property acquisition tax), exemption from municipal tax (fixed assets tax). Presently, 18 operators are developing businesses, which have been designated for the special zone project.

Finally, the Renovation and Remodeling of the Support Center Facility has been under way. The goal is to rebuild and modernize the Sendai Agriculture and Horticulture Center as a support center to promote Agriculture and Food Frontier Project. The Center facilities include vegetables greenhouses, food-processing facilities, an allotment garden for "amateur farmer" city residents, direct sales shop, multipurpose open areas, and restaurant.

The center supports development of lucrative agricultural business by providing training sessions to expend agricultural diversification, integration, and multiple management. It exhibits operations of its horticulture and food processing facilities, foster human resources and conveys information on the progress of recovery of Eastern Sendai agriculture. It organizes a variety of events where visitors have hands-on experience with agriculture and opportunities to meet farmers.

According to a December 2011 survey the majority of East Sendai farmers wanted the new paddy field to be plotted by blocks of 0.3 (33%) or 0.5 ha (24%) while merely 22% preferred 1.0 ha (Tohoku Regional Agricultural Administration, 2012). Furthermore, a quarter of farmers wanted to retire or cut back on farming (most likely because they do not have a business successor) while 11% wanted to expand or start out from the scratch. Therefore, the authority has to persuade farmers into large-scale operation by explaining the merits, efficient means to aggregate retiring farmers' land, and supporting farmers' moves toward corporate or community farming (Hori, 2012).

Preventing farmland from being left uncultivated is a task common for all tsunami-afflicted areas and country as a whole (Hori, 2012). While the government has already come up with incentives for retiring farmers, it should also consider providing incentives to farmers who would expand operations in the afflicted areas - ones who are expected to play a major role in agricultural recovery.

Experts suggest that government should learn from the experience in farming modernization in the afflicted areas and apply the suggested measures nationwide to prevent further decline of Japanese agriculture (Hori, 2012). That would require a fundamental modernization of agricultural policies allowing consolidation of farm management in bigger more competitive structures, removal of restrictions on farmland transactions, new entrants and corporative management, easing approval of farmland diversion to other uses, reforming agricultural cooperatives, further liberalization of internal and international trade, changing costly for tax-payers subsidy system for producers, and introduction of new forms of public support to agriculture, etc.

Namely, the agricultural reform incorporating some of the above measures have been an essential part of the growth strategy of new Abe administration (The Japan News, June 14, June 18, June 25, October 20, 2014). More and more people support that new agricultural policy of the Government. Recent nationwide survey has found out that the policy of large-scale farming is supported by 73% of respondents, 79% backed the abolition of rice paddy reduction program, 64% support easing of regulations on buying and selling farmland to make it easier for corporations to own farmland, 76% agree on abolishing the Central Union of Agricultural Cooperatives (JA-Zenchu) control on regional agricultural cooperatives, 78% are for encouraging farmers to change from mainly cultivating rice to producing other products (such as vegetables and fruits), and 43% support participation in the Trans-Pacific Partnership multilateral free trade agreement with nations in the Asia-Pacific region (The Japan News, July 15, 2014).

There is no official data on whether farmers have been able or not to harvest any produce on officially restored land in affected prefectures. However, there are reports that some of already desalinated and restored tsunami-damaged farmland is still unproductive.

For instance, farmers have been unable to harvest any soybeans in a 30-hectare area out of planted nearly 45-hectare field in Rokugo, Eastern Sendai (Ishikawa & Ishikawa, 2014). According to farmers remained high salt concentration in the farmland soils might have been reason for that.

Similar complaints have also been heard from farmers in Iwate Prefecture who have seen seawater flowing back to 5 km in the upper stream of some rivers due to land subsidence (Ishikawa & Ishikawa, 2014). Even after restoration work is done, people in Ofunato have been unable to harvest crops on some farmland because of the lack of freshwater.

Not all farmers are able to join the government projects (including many medium and small-scale operators) and recover in lines with the government priorities[230]. For instance, in tsunami-damaged areas of Miyagi prefecture most farmers are elderly (over 65), small-scale (under 1 ha), part-time and single crop (paddy only) farmers (Fuyuli, 2013).

Nevertheless, some severely damaged farming communities recovered earlier than in others – e.g. Fujitsuka Hamlet of the Wakabayashi Word has been supported by a non-for-profit organization Re-Roots, which members[231] work on farmlands and sell output in temporary shop in Sendai (Fuyuli, 2013).

The process of reconstruction and rebuilding communities progress differently in individual places. Iwanuma was among the first municipality that initiated a collective relocation project[232] (Pushpalal, 2013). The plan is to relocate 348 coastal homes and build 156 public housing unit in 20 ha Tamaura Nishi District by April 2014[233]. Agriculture was the largest industry in Tamaura but most workers were aging part-time farmers in predominately rice production. Enormous losses of houses, workshops, machineries etc. have made it difficult to restart farming, 90% of farmers left the industry[234], and citizen group decided to focus on large-scale agriculture revitalization. On the other hand, in Natori relocation

[230] E.g. to integrate with downstream industries.
[231] Primarily students from Tohoku University.
[232] Cost of purchasing land is born by the government while most residents bear construction costs and partial subsidies are also available. Those who cannot buy are offered to rent public housing.
[233] Plan was approved in March 2012 with estimated project costs of about 10.8 billion yen. Out of 400 households 300 are planning to move to new relocation cite, while remaining chosen to live elsewhere (Pushpalal, 2013). A major downsize of group relocation was "all-or-nothing decision" since people who do not follow the plan might not receive financial support from autority (Koch, 2013).
[234] Damagedagricultural land (1,200 ha) accounted for 65% of the total farmland. Merely one eight of the later was cultivated in 2012 and one fifth in 2013.

plans have been delayed due to the conflicts of residents who want to return to previous neighborhood and who are against it[235].

One of the important issue affecting new land development is the disaster areas is that more than 40% of residents in the three most affected prefectures hope to sell their land or move away from areas subject to land use reallocation projects (The Japan News, March 9, 2014)). Residents are concerned that widespread reluctance to return could turn redeveloped areas into vacant towns. Many municipalities are also worried over revisions to the project plans, and say that more residents will leave if town rebuilding continues to be delayed.

Land development in residential areas is planned on 1,315 hectares in 40 areas across 16 municipalities in Iwate, Miyagi and Fukushima prefectures (The Japan News, March 9, 2014). In surveyed 15 of the designated municipalities (covering 998 ha in 38 areas subject to land rezoning) 43% of the respondents[236] indicated they want to sell the land or move away from the areas. Meanwhile, a half of respondents answered they "want to continue living there," or "want to keep the land", 9% are still "undecided" and the number of leaving could rise.

In Sendai there are two projects – group resettlement in the "High Hazard Risk Zone" (funded by the central government) and City support Zone as a complementary program (financed by the city government). The plan[237] covers 3,860 households (1,560 under the relocation project and 2,300 under city support program) from 7 places in the east coastal zone to be resettled in 14 residential estates in the inner part (Yonekura, 2013).

Major problems associated with the planning and implementation of relocation has been: opposition of part of affected population, financial burden to individuals[238], different treatment and splitting of communities due to demarcation rule, unequal capability of local government for additional assistance for covering replacement costs, delays in land procurement, deficiency of traditional land registration and related disputes, inadequate manpower in authority[239], mortgage status of some lands[240],

[235] In spring 2013 as much as 25.2% of all residents still intended to "return to their native home" down from 34.1% in the summer of 2012 (Pushpalal, 2013).

[236] Around 90% (12,223) of residents and landowners in the areas responded, with multiple answers permitted in certain municipalities.

[237] Approved in December 2011, total project costs of 57.7 billion yen, be committed in fiscal 2015.

[238] E.g. huge (6 times) differences in the land price in disaster (10,500-17,800 yen per m^2) and new settlement (60,000-81,500 yen per m^2) areas .

[239] To complete land ownership investigation, land surveys and registration.

different regulations for alternative resettlements, complicated procedures and higher costs for individuals, etc. (Yonekura, 2013).

For instance, costs differences for individuals in the alternative resettlement schemes (Group Relocation Project, Land Consolidation Project, and Non-project Zone) in Natori are presented in Table 22. Sendai city implemented 7.1 billion yen support program for reducing the burden of individuals including: costs of purchasing new houses in area outside of the Group Relocation Project, rebuilding houses in disaster area and moving to resettlement estate[241]; inclusion of displaced persons moving outside Sendai; and establish community support institutions (NGOs) (Yonekura, 2013).

Another major problem has been that a significant portion of land plots is the "property of unknown persons" since information in the real estate registrations is out of date due to inheritors not properly changing registration[242], known owners are dead or moved to urban areas abandoning land, population decline, etc. (The Japan News, August 5, 2014). Consequently, authorities have been hindered in conducting reconstruction works since they cannot obtain approval from landowners[243].

For instance, in Tokura district of Minami-Sanriku, Miyagi prefecture, the prefectural government plans to buy land around disaster-damaged dikes to repair and improve them. It has found a 300-square-meter plot for which 53 people are registered as common owners (in 1924) and about 300 people having inheritance rights. Some of the right holders are great-grandchildren of original owners with unknown whereabouts while approval has to be obtained by the end of next fiscal year given the

[240] E.g. in Sendai a quarter of land was under mortgage and cannot be sold to government as of group relocation arrangement. By end 2012 most banking institutions accepted request by the Financial Service Agency to release mortgages on land (Yonekura, 2013).

[241] Government covers interest on loans up to a maximum of 7.08 million yen for rebuilding a new housing as well as costs for moving, which amounted 780,000 yen in Sendai.

[242] Due to hight costs or other reasons (multiple owners, disputes) – e.g. relatives have to pay ¥500,000(commission fees for judicial scrivener and transport expenses) to change land ownership (The Japan News, August 5, 2014). There are 1.7 million ha land that worth less than cost of changing ownership and titles would not be changed.Ownership of 400,000 ha of abandoned arable land and 1 million haforests owned in common would not be changed since inheritance procedures with multiple owners tend to be complicated.

[243] Property rights are guaranteed by Constitution and Civil Code. Real estate registrations protect personal property and changing ownership registration is left to each owner.

construction period.

Table 22. *Household cost estimation of alternative resettlement schemes in Natori (thousand yen)*

Alterna-tives	Type of resettle-ment	Buy land price	Rebuilding cost	Sellland price	Subsidy housing loan	Support moving costs	Total costs
	Buying project land	9,700	20,000	3,420	4,300	200	21,700
Group Reloca-tion	Rental of city land	0	20,000	3,420	2,630	200	13,750
Project	Buying land by individuals	11,200	20,000	3,420	4,380	200	23,200
Land Consol-	Rebuilding on owned land	0	20,000	0	0	0	20,000
idation Project	Land selling and resettlement	11,200	20,000	6,280	0	0	24,920
Non-project Zone		0	20,000	0	0	0	20,000

Source: Yonekura, 2013

Furthermore, decontamination of lands, houses, roads etc. in the affected areas has been a complex and slow process. Inevitably, priority has been given to decontamination of residences, public facilities and their surroundings, rather than farmlands (Watanabe, 2013).

Appropriate radioactive decontamination technologies have been applied according to the radioactive cesium density levels in farmland soil: up to 5,000 Bq/kg - inventing plowing, radiation transfer reduction cultivation, topsoil removal (unplowed land); 5,000-10,000 Bq/kg - top soil removal, inverting plowing, padding with water; 10,000-25,000 Bq/kg - topsoil removal; more than 25,000 Bq/kg - using soil hardener for topsoil removal (Ministry of Agriculture, Forestry and Fisheries, 2012).

Results of farmland decontamination demonstration projects show that the topsoil removal reduced the radioactive cesium levels in plow layers by about 80-90% and air dose rates at a height of 1 meter above surface about 60-80% (Ministry of Agriculture, Forestry and Fisheries, 2013). Similarly, inverting plowing reduced the radioactive cesium in plow layers by about 60% and air dose rates at 1 meter above surface about 30%. All results of test cropping on farmlands decontaminated under these projects[244] have been below the minimum detection limit.

Various trials have been made at grass-root level[245] and some new plant introduced such as rape blossom seeds, sunflower etc. which reduce contamination of soils and air (JFS, 2011; NHK World, December 9, 2013, March 10, 2014).

Likewise, a number of measures were used to reduce

[244] 5.7 ha of rice and 1 ha of vegetables in Iitate, and 6.4 ha of rice in Kawamata.

[245] E.g. recovery group “Resurrection of Fukushima” established 3 months after accident. There are 250 members, including researchers in the fields of physics, IT, and agriculture, as well as volunteers from all over the country (NHK World, December 9, 2013).

radioactive materials in farm trees and crops such as: removal of rough bark in apple, pear and other fruit trees with rough bark; high-pressure washing for peach and other fruit trees having no rough bark; and for tea - pruning (deep skiffing and medium level cutting) covering leave layers, and at non-pruned tea fields puning branches to increase leaves for cutting (Ministry of Agriculture, Forestry and Fisheries, 2011).

Diverse measures to reduce the transfer of radionuclides from soil to crops have been also recommended such as: changing crop structure; application of potassium-based fertilizers (such as potassium silicate) and zeolite (natural mineral effective in improving soil quality); using combines for harvesting in order to reduce adhesion of soil; abating the impact of ambient radiation by avoiding the practice of drying harvested rice plants naturally in the sun; transition to organic farming; bioremediation of farmlands, etc. (NHK World, March 10, 2014; Moqsud & Omine, 2013; Watanabe, 2013).

In relation to livestock and livestock products, different measures have been promoted for preventing grass from absorbing radioactive cesium. Until the end of FY2012 such measures were completed for 17,000 ha (44.73%) out of the 38,000 ha in grassland subjected to the measures (Ministry of Agriculture, Forestry and Fisheries, 2013). Consequently, the frequency of exceeding the maximum limit of radionuclides in farm and livestock products has declined substantially.

Similarly, new crops, products and technologies have been introduced such as plant factory, IT and smart innovations, biodiesel fuel made from sunflower and camellia seeds, land-sharing for crop and solar energy productions, etc. (Fukushima Minpo News, April 24, 2014; Cyberpunk World, January 8, 2014; The Mainichi Shimbun, April 4, 2012; NHK World, June 12, 2012, July 15, 2013).

Decontamination of farmlands outside the evacuation zone has been completed and farming resumed in most places. According to the officials the appropriate reduction of radiation has been achieved to allow the safe production. The later has been confirmed by the multiple safety checks up and removal of restrictions on production and shipments of major farm produce. For instance, a farmer (Mr. H. Kikuchi) in Shinchi town resumed shipping “shiitake” mushrooms cultivated on logs for the first time in three years[246] following the lifting of shipment restrictions[247]

[246] Shipments had been restricted since July 2011.

(Fukushima Minpo News, July 26, 2014).

According to experts still there are many hot spot with excessive contamination. Since October 2012 a soil screening project[248] has been going on in Fukushima-shi on 28,382 ha with 24,721 agricultural cooperative members. Seven full time stuff and many volunteers do mapping with modern instruments (equipped with GPS) measuring contamination of soil and air. Samples are taken in 3 points of each of the 28,392 paddy fields and 10,058 orchards. Current results show a great variation of radioactivity - between 1,000-3,000 Bq/kg in paddies and up to 10,000 Bq/kg for orchards (Interview with the project leader Mr.Park, June 17, 2013).

Experimental rice production on some farmlands in the evacuation zone started in 2012 [249] and it has been gradually expending (Fukushima Minpo News, December 14, 2013; Ishii, 2013; Kageyama, 2012). After restrictions were lifted in the spring 2014[250] farmers in 6 municipalities have resumed rice planting in about 2% of available rice fields (NHK World, June 11, 2014). Most of the rice planting has resumed in Minamisoma City (111 hectares or 3.4% of the total available area), followed by Tomioka Town (0.2%), Namie and Okuma towns (0.1%), and Katsurao Village (0.06%)[251]. Officials in 5 of the 6 municipalities say that full-scale rice farming will be resumed after planting rice on experimental basis and confirming the impact of radioactivity on crop.

The first public cow pasture (Shibayama pasture) has reopened in Iwaki city, Fukushima prefecture after a closure of 2 years and 4 farmers brought 10 cows that had to raise in a shed (NHK World, July 14, 2014). Radiation level fell below the limit in 7 ha of the 50-ha land after workers cut down some grass, sowed seeds, and removed surface soil.

Insufficient decontamination of farmland and irrigation canals,

[247] Levels of radioactive Cs detected in mushrooms stood at a maximum of 5 Bq/kg.

[248] Expected to complete in April 2014 and continue afterwards if funding is available.

[249] In 2012 in Minami Soma next to no-go zone 135 farms were granted special permission to plant rice on condition that it will be destroyed (Kageyama, 2012). In 2013 in Miyakojimachi district, Tamura within 20 km evacuation zone (decontamination completed) 3 farms planed 6 ha rice intended for sale (The Japan Daily Press, May 20, 2013).

[250] Restrictions and self-imposed suspensions on rice planting were lifted on about 5,200 hectares of land since radiation levels declined and the ban on entering the areas lifted.

[251] Rice planting has not resumed yet in Futaba Town.

decreased motivation among farmers, and local anxiety over rumors about contaminated harvests are major reasons for the low resumption rate of farming in the former evacuation zone (NHK World, June 11, 2014). It has been also difficult to farm efficiently (e.g. water control in paddy fields) since farmers were not allowed to stay permanently, there has been uncertainty associated with marketing of output (high contamination, unwillingness of buy the region), and radioactive water runoff from mountains to reservoirs for irrigation and/or paddy fields[252].

A survey in Fukushima prefecture found 8,000 Becquerels or more per kilogram of radioactive substances in the soil at the bottom of agricultural dams and reservoirs in 568 out of the 1,940 dams and reservoirs inspected between June and December 2013 (NHK World, March 22, 2014). Only 108 of them were in the evacuation zones around the Fukushima nuclear plant, and 460 were further away. Officials detected 370,000 Bq/kg in the soil of a reservoir 58 km away from the plant, which is the highest reading recorded outside the evacuation zones[253].

Rain may have carried radioactive substances into the waters from surrounding forests. Water from the reservoir with the highest reading outside the evacuation zones is being used for rice paddies nearby. However, radiation levels exceeding food safety limits in locally produced rice has not been found, probably because radioactive substances in the soil barely dissolve in water. Residents were told they will not be exposed to radiation as long as there is water in the reservoir but they fear radioactive levels may surge if it dries up.

The central and prefectural governments are set to resume the supply of dam water for agricultural use to the Odaka district of Minamisoma city (designated as evacuation area) in fiscal 2017 (Fukushima Minpo News, July 12, 2014). The supply of water from the Ogaki dam in the town of Namie has been suspended after the nuclear power accident. The city office is aiming to have residents return to the district in April 2016 and dam restoration and resumption of agricultural water supply[254] are expected to go a long way toward helping local people resume farming. Around

[252] Later has been issue beyond evacuation areas as well (HNK World, March 10, 2014).

[253] More than 46 times the government limit of 8,000 Bq for radioactive waste.

[254] Thatwill be first case among 10 dams for agricultural water in no-go zone. Radioactive levels in surface water are below lower detectable limit, and authority intends to use only surface water and take no water when level declines or water becomes turbid (heavy rain).

1,613 farming families used to receive dam water to irrigate 1,531 ha of farmland before disaster.

Nevertheless, many farmers have been refusing to return back to homeland even after decontamination is completed because of the high radiation (residential areas, forests around houses and farms, hot spots) and unrestored infrastructure (shops, hospitals, schools etc.). Also once farms are abandoned “it is really tough, mentally and physically, to start all over again, especially when many farmers are aging” (The Japan Times, March 7, 2012).

According to the official it is not clear when thousands of evacuated farmers will return back to their land (interview with Ma. Satou, June 17, 2013). A survey of the Fukushima prefectural government found out that as much as 50% of farms do not return back to their land. In JA Futaba, where all farmers were evacuated, merely 25% of the farmers “want to farm their own land again” (Nagashima, 2013). Even combining with farmers who “continue farming in other lands” those who want to continue farming is just 38% and who do not is a third.

Many farmers still fear that “disaster is not over” and they do not want to return to their land. For instance, one of the interviewed by us farmer Mr.Tanaka said: “I think no matter how we decontaminate and make ND products, it means nothing if we cannot make the consumers trust us and consume our products. Also the nuclear power plant disaster is still continuing. I think people are afraid that something could happen again and refrain from investing or restarting the farm” (June 14, 2013).

The Plan for Revitalization in Fukushima Prefecture (Fukushima Prefectural Government, 2012) envisages “building a safe, secure and sustainable society free from nuclear power”[255]. It includes a number of priority projects for revitalization in three major areas (Figure 39) with specific measures for each region (Map 14). The First Version of the Plan (Second Version released in December 2012) focused on 38 specific measures and 729 major projects, out of which 235 priority projects. The Plan also contains communication, cooperation, legislating, adjustment and monitoring measures to secure efficiency.

[255] The prefecture is calling on decommission all nuclear reactors in Fukushima.

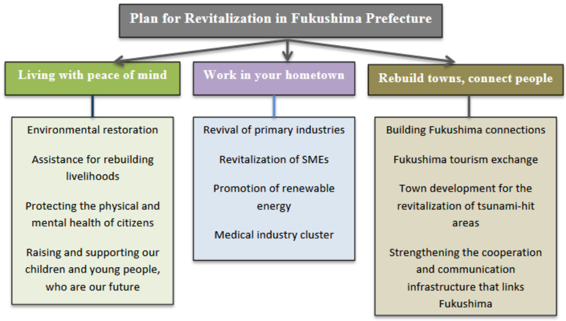


Figure 39. *Priority Projects in Plan for Revitalization in Fukushima Prefecture (Second Version)*
Source: Fukushima Prefectural Government, December

Different projects have "agricultural and food dimension" as well. For instance, the Environmental Restoration Project encompasses: Decontamination, Ensuring food safety, Waste disposal, and Establishment of environmental creative strategy hubs. The Primary Industry Revival Project include measures for farming revitalization; the Renewable Energy Promoting Project comprise expansion of agricultural related solar, wind, and biomass energy; etc.

Map 14. *Specific measures areas in Plan forRevitalization in Fukushima Prefecture*
Source: Fukushima Prefectural Government, 2012

Furthermore, the Industrial Reconstruction and Revitalization Plan (2013) underlines specific initiatives for Agriculture, Forestry and Fisheries aiming at "Create affluent and attractive rural districts and supply safe and trusted agricultural, forestry and fisheries products" through decontamination, improvement of production bases, efforts to help those engaged in agriculture, forestry and fisheries resume business, development of next generation of farmers and fishermen, stable supply of agricultural, forestry and fisheries products, branding and added value creation including the development of 'sixth-order' local industry, and development of the Fukushima Prefecture Coastal Agriculture Revitalization Research Center.

Among specific Industrial reconstruction and revitalization projects are:

- Opening up Demand for Products and Services using the Regionally Based Collective Trademark System to establish Fukushima brands renewed (Nango tomatoes; Tsuchiyu Hot Spring; Aizu miso; and Soma ware) and new (Aizu Tajima asparagus), as charges, etc. are halved;
- Developing original new species and building new brands such as Paddy rice (four types); strawberries; asparagus; peaches; nashi pears; apples; gentians; and calla lilies as application fees, etc., reduced by 75%.

In the proposed fiscal 2013 budget of the central government a special attention has been given to Fukushima (Reconstruction Agency, 2014). The government plans to set aside JPY50.3 billion to create temporary communities for the Fukushima evacuees, using funds to build public infrastructure including housing, schools and improved roads. A further JPY10 billion is to be budgets to improve the living environment for families with children. As part of efforts to revitalize the local economy, JPY14.8 billion has been allocated for renewable energy related initiatives as well as promoting tourism and agriculture. Particular focus is to be placed on maximizing the benefits of renewable energy initiatives, as well as research and development in the area of pharmaceuticals and medical devices, with the aim of nurturing new globally competitive industries.

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

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

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

For instance, rice paddies and farming equipment in the Nobiru district, Miyagi prefecture was ravaged by the tsunami and a large number of rice growers given up farming leasing out paddies to a local farming corporation (NHK World, June 12, 2012). Before disaster, the corporation managed 55 ha of 49 farmers but area increased to 81 ha of 46 more farmers after disaster.

In addition, to a great variety of brand name rice with the name of the district where it was grown, there have appeared new brand name rice associated with the environmental conservation and social contribution. The later include Fukko-mai[256], which is Sasanishiki rice grown in disaster area of the Great East Japan Earthquake (The Japan News, October 16, 2014).

In Iwate prefecture farmers had to give up tea production in the aftermath of the Fukushima nuclear disaster since long-term contracts were canceled. Innovator from Kunohe village managed to overcome challenges introducing a new special organically grown sweet tea (“ama-cha”) caffeine, tannin and calories free (NHK World, August 20, 2014). The new developed product, with enhanced quality and packaging (tea bags), won a gold medal among 8000 products in UK and it is planned to appear on markets in 2015.

Plant “no-soil” factories have been developing in Japan for many years and now about 130 on them grow lettuce, herbs, tomatoes, strawberries, etc. (Japan Finance Corporation, 2012). Expansion of this new technology has been perceived as an efficient way to overcome some of major challenges associated with the post-disaster recovery in the affected regions with degradated (salinized or radioactive) soils, destructed farms and equipment, lack of employment and income opportunities, aging farm population, insufficient integration in supply chain, etc.

A large futuristic vegetable plant has been opened led by

[256] “Fukko” means happiness, but also has implication of reconstruction from the disaster.

Fujitsu Ltd. (Aizuwakamatsu Akisai Vegetable Factory) and uses renovated 2,000 m^2 idle semiconductor-manufacturing clean (free of environmental contaminants and pests) room facility of the company in Aizuwakamatsu, Fukushima Prefecture (Fukushima Minpo News, 26 January 2014). Production technology is chemical-free and completely controlled to maintain optimal growing and atmospheric conditions.

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

Produced in a clean-room environment, output features few bacteria and a longer shelf life. Main customers include hospitals and department stores in and outside Fukushima. Annual sales are targeted at about 150 million yen in the initial fiscal 2014 year and 400 million yen in the third year (fiscal 2016). The plant's production is more expensive than the common varieties, but they have medical value, grow year around, they are organic and most importantly radiation-free (Lisa, 2014).

Similar factory has been built in Natori, Miyagi prefecture where the tsunami inundated more than half of the farmland. A 5,900 m^2 plant factory producing 1.4 million bulbs of lettuce in a year and costing 4.3-million dollar was built on tsunami-hit area by 3 farmers after their farms were devastated (NHK World, June 12, 2012). Soil salt contamination has not been not a problem because the crops are grown in water while water temperature is controlled to enable year round production. Output is sold to a nationwide restaurant chain operator. The biggest challenge was the high construction cost since the Government subsidies covered 80% and farm group had to borrow one million dollars. Farmers expect to pay back the borrowed money in 7 years.

A newly formed agricultural corporation Michisaki built indoor hydroponic "plant factories" on a just under seven acres rented land where tomatoes, spinach, and other vegetables grow under precisely regulated conditions since April 2013. It hires 10 full-time and 50 part-time workers, and market the produce to convenience stores and chain supermarkets. Using recycled heat from a nearby sewage treatment plant and fish byproducts from the port as fertilizer is also planned (Bird, 2013).

Another example is the state-of-the-art “Domed” Indoor Farms in Rikuzentakata, Iwate prefecture that harnesses solar energy and water to grow lettuce (Reconstruction Agency, 2014). The facility was built on 1.8 ha of land that was devastated by tsunami and transformed into a sustainable agriculture project with eight 5-by-30-meter domed indoor farms that utilize a number of innovative energy efficient features to reduce costs and improve production. This public-private partnership project was developed through a joint venture between Granpa Co. and Tobishima Corporation with support of a JPY300 million subsidy from Ministry of Economy, Trade and Industry.

The facility was established in July 2012 and immediately began shipping produce. Each dome produces about 450 heads of lettuce per day, which is supplied to supermarkets, major sales retailers and fast-food chains. In addition to the solar power capabilities, the facility's innovative features include air conditioning system that uses an exhaust opening in the ceiling to improve energy efficiency during the summer and winter months.

The facility also incorporates a unique layered seedling planting design, which maximizes efficiency of space, increase production capacity and reduce labor and energy costs. Since lettuce produced at the facility is natural and guaranteed to be free from any forms of pollution, it is regarded as a promising new agricultural model that can appeal to customers while contributing to local revitalization. The project contributes to local economy by creating 20 new jobs and establishing sustainable business model of partnership with major food-chain actors.

Due to the project's success the same model has already been adopted in Minamisoma in Fukushima Prefecture where municipality plans to build 7 plant factories over the 3 years in the hope that local farmers can make a fresh start (NHK World, June 12, 2012).

For instance, a Kawauchi farmer and a local government official (Takeo Endo) leads a group that farm in a sealed-off hydroponics factory with a technique where plants are grown using minerals and nutrients dissolved in water without using soil (The Japan Daily Press, May 12, 2013). Aluminum-clad, soccer field-sized building was completed in April 2013 and produce 8,000 heads of lettuce for every farming cycle. The lettuce factory use filtered ground water, which is proven to be free of contaminants. Operations started with 25 employees providing jobs to unemployed idle farmers while produce sold in Fukushima's supermarkets “Kawauchi”.

Some young entrepreneurs have seen new business opportunities in the most devastated areas. For example, Kei Watanabe was living in Tokyo but nuclear disaster instilled in him a determination to return to Kawauchi village and help set up a state-of-the-art hydroponic vegetable factory (Landline, 2013). The sealed-off factory costs $6 million, has a size of a soccer field, uses LED lights and a water solution infused with fertilizer, and is able to produce 8,000 heads of lettuce a day which are sold in supermarkets across Fukushima.

Another example is the innovative Luxury Strawberry Farms in Yamamoto, Miyagi prefecture where March 2011 disaster wiped out nearly all strawberry farm greenhouses (Reconstruction Agency, 2014). An IT specialist Hikoki Iwasa, who combined a technology expertise with a passion for reviving hometown agriculture, has realized the project. He established the General Reconstruction Association (July 2011) and rebuilt the strawberry industry using advanced IT systems creating something new. The business uses technology to optimize the climate for growing strawberries by automating windows and sprinkler systems.

Local strawberry farmers, who lost their jobs have been hired and their expertise used to enhance product quality and secure knowledge digitally for future generations. The business led to the stabilization of the strawberry industry in Yamamoto and helped building a high-quality luxury brand image. The unit price has more than tripled from about ¥980 per kg before the tsunami to ¥3,000 per kg with the luxury "migaki-ichigo" strawberries selling for ¥1,000 per piece.

The plant factory technology has a number of advantages: capacity for stable year-round production; possibility to be installed on non-farmland areas (industrial parks, vacant stores etc.) in shopping districts; safe and high-quality agricultural produce with no or minimal pesticide use; employ novice farmers due to the light workload and the ease of standardizing procedures; comfortable work environment in which the elderly and people with disabilities can work with ease.

Comparative survey shows that the consumers' awareness of plant factory has increased in recent years (from 69% in 2009 to 76% in 2012) while the purchase experience also raised (from 9% to 17% accordingly) (Japan Finance Corporation, 2012). Furthermore, consumers find superiority in the plant factory vegetables over the conventional farming in terms of safety, looks, ecology, etc.

Financial institutions (such as Japan Finance Corporation) provide long-term financing with fixed, low-interest rates, taking into account unique business characteristics such as long investment recovery periods and unstable incomes influenced by the weather risk. Besides, the Japan Finance Corporation serves as a safety net for agriculture, providing quick and flexible finance for disasters, etc.

In response to March 11 disaster the Japan Finance Corporation established an interest-free Special Earthquake Loan for those who suffer from direct or indirect damages by the earthquake or tsunami. The Agricultural Improvement Loan is an interest-free financing program that supports farmers' challenges such as when they adopt a new crop or technology. For eco-farmers the maximum repayment periods can be extended from 10 years to 12 years and the maximum loan amount from 80% to 100% of total project costs.

In order to support further challenging projects the institution also provides Capital Subordinated Loan. The latter is not recognized as debt but as capital in borrowers' financial statement because there is no need to repay principal for the first 8 years and interest rates are reviewed regularly according to the financial performances.

There a number of challenges associated with that new technology such as: high building and running costs, difficulties in establishment of cultivation technique, and securing of human resource development, difficulties to use existing food certification system (because fertilizers for nutriculture are used to the water prepared for breeding and cultivation)[257], etc. Under the new technology plant factory produce is a little more expensive (less competitive) than products grown outdoors or in greenhouses. Key to success is to secure stable outlets for marketing the output through close vertical integration.

Another prospective technology applied in the disaster-hit area is "solar sharing" - a process in which farmers generate solar power on the same land where they grow crops.

Farmers in Fukushima prefecture have been testing that new technology and hope to sell power to help improve farmland or cover losses in income (Asiaone News, June 26, 2013). In Minami-Soma, the prefectural government has begun a model project - 2,000 square meter piece of farmland in the city's Odaka district is an example of solar sharing. On the farmland, 500 solar panels, each 70 centimeters by 1.6 meters, are installed atop 1.9-metre poles. Below the rows of panels, eggplants, chili peppers

[257] Since March 2012, a new third-party certification system evaluating the safety of vegetables produced in plant factories has been introduced.

and produce are grown on an experimental basis.

The prefectural government set up the project to determine how the use of the panels affects plants. An increasing number of farmers affected by the nuclear plant crisis want to convert land into mega solar power plants while continuing to grow crops on the same land. Farmers can sell the electric power to the utilities because (since July 2012) there is a system that obliges electric power companies to buy power generated by renewable energy sources at fixed prices. However, government sets some conditions for farmers wanting to use land for solar sharing –they must continue to cultivate land, and annual crop volume cannot fall 20% or more compared with the regional averages after introducing solar sharing.

Eco Ene Minami-Soma Kenkyu Kiko, an incorporated foundation, plans a solar sharing project on about 600 m^2 of farmland. According to the foundation about 1 million yen of annual revenue is expected from selling the electric power generated in the project (Asiaone News, June 26, 2013). Rapeseed has been already planted because its oil is free of contaminants even though the plants themselves take in some radioisotopes such as those of cesium.

In the end of 2013 the community run project Renewable Energy Village boasted 120 photovoltaic panels generating 30 kilowatts of power (Gilhooly, 2013). Plans are afoot to put wind turbines on some of the land. Recreational and educational facilities as well as an astronomical observatory will also be built if further funding can be secured.

Generous feed-in tariffs (renewable energy payments) set by the government support the project. While the proceeds from the crops and energy will be ploughed back into the project, the Renewable Energy Village's creators hope local farmers will mimic the model.

Other large-scale solar projects[258] treat farming traditions since if farmers sell up land entire communities will be wiped off. The Renewable Energy Village model offers a way around – it protects farmland and communities and creates increased prosperity (two parallel revenues).

Minamisoma's Solar Agripark opened in spring 2013 and combines a 500KW solar power facility with indoor plant farms (Reconstruction Agency, 2014). A new children's park is being

[258] Since feed-in tariff was introduced, several large-scale solar parks in Japan are announced or already in operation, but none uses solar sharing. Mosthave solar panels resting on ground (including largest in Minamisoma) making growing crops impossible.

created, where youth affected by the disaster can receive hands-on learning experience featuring renewable energy and advanced agriculture, helping to educate the future leaders on the importance of sustainability. This project is supported by a JPY115 million investment from Toshiba and subsidies from the Ministry of Agriculture, Forestry and Fisheries (totaling JPY90 million). Energy generated from the solar facility is used to power the indoor farms, while surplus energy sold back to the grid.

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

Various areas in Tohoku have been also considering rapeseed as a source of bioenergy for the future (NHK World, July 29, 2013). The recovery project called Nanohana or Rapeseed Project is run by a company. The oil extracted from the rapeseed is processed into motor fuel and for one liter about 30 kilograms is needed. Concerned about environmental problems, this company started manufacturing biodiesel several years ago from used cooking oil that was collected through cleaning services. Now they apply the same technology, for processing rapeseed oil into biodiesel fuel. Since the rapeseed is being grown on a very small scale the process is far from turning a profit.

Test runs on diesel vehicles have been completed and hope is to produce and sell the biodiesel for use in ordinary vehicles. The main problem is the lack of farmland to grow rape and members of the Project are focusing on farmland contaminated by saltwater. It is believed that if salt-resistant rapeseed could be grown there, the businesses could take off, which would also bring considerable relief to the farmers.

Meanwhile Tohoku University scientists have been conducting research on rapeseeds, their resistance to salt, application and improvement. The leafy part of the rape plant called nabana, is edible so it can be sold as food. Farmers can earn income from this plant by extracting the oil or selling it as food. The oil can be used to make soap, candles or biodiesel fuel so the plant can be used according to the needs of each farm. The project is expected to take a minimum 10 years before achieving practical results.

Furthermore, Nonprofit body Koriyama Area Technopolis Promotion Organization (KATPO) has been set to begin a demonstration test of a hybrid renewable energy system combining geothermal and solar power generation for the heating of agricultural greenhouse at the Iwase Ranch in Kagamiishi, Fukushima prefecture (Fukushima Minpo News, January 21, 2014). Two greenhouses are built for flower and vegetable plantation starting March 2014, with one of the facilities set aside for the hybrid energy system.

The experiment is implemented under the Fukushima prefectural government's project for the development of next generation technology for renewable energy. KATPO is the coordinator and study is done by Nihon University, Naito-Kogyosho Co. of Koriyama, Suzuki Seisakusyo Co. of Tanagura, Rhizome of Koriyama, and SK Electronics Industry Co. of Sukagawa. A budget of 50 million yen has been allocated to the experiment. The period of demonstration is expected to be around three years. Expertise and comparative data (on energy efficiency and cost of heating) will be made available to farmers after cost effectiveness has been confirmed.

In the years after Fukushima nuclear accident an increase interests in renewable energy introduction has been reported, including in the sector “Agriculture”. In most affected regions and nationwide the later has been motivated by the new opportunities of development (including Government support measures) as well as souring costs of energy supply.

A 2014 survey has found that 11.6% of the Agricultural Management Entities already use renewable energy, 10.2% of them are planning to do so, while 57.3% of all report interests in introduction of renewable energy (Japan Finance Corporation, 2014). The highest rate of application or plans for introduction of renewable energy are among agricultural producers of Kyushu and Kanto regions (Figure 40). In Tohoku farms the transition to renewables is among the lowest in the country but there is a high interest in introduction of this type of energy in future. On the other hand, the greatest are shares of farms with “No interest to renewables” from Hokuriko and Chugoku-Shikoku regions.

The highest rate of usage or planning of introduction of renewable energy is in Broilers, Dairy and Tea productions, while the lowest is in Rice cultivation (Figure 41). At the same time the largest shares of farms with “Interests” in renewable energy is among Rice, Vegetables in facilities and Mushrooms producers. On the other hand, the greatest portion of producers with no interest in that issue is among the Hence farms.

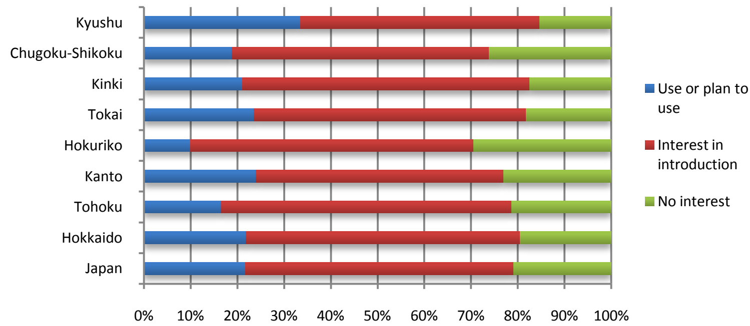


Figure 40. *Interests for renewable energy introduction in agriculture in Japan (January, 2014)*
Source: Japan Finance Corporation

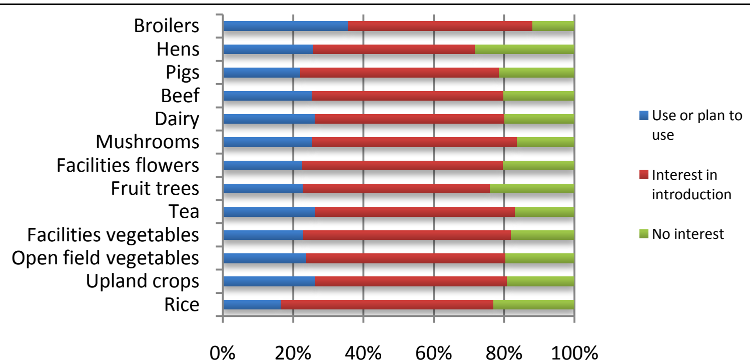


Figure 41. *Interests for renewable energy introduction in different subsectors of Japanese agriculture (January, 2014)*
Source: Japan Finance Corporation

There is a great variation in the interests in the type of renewables by producers in general and in different regions on the country (Figure 42). The "Solar" energy is reported by the greatest number of agricultural producers who use, plan to or are interested in introduction of renewable energy in all regions of the country. The Tea and Upland crop producers are particularly strongly using or interested in that energy source (97% and 95% of them accordingly) while the Broilers producers relatively less (82.1%).

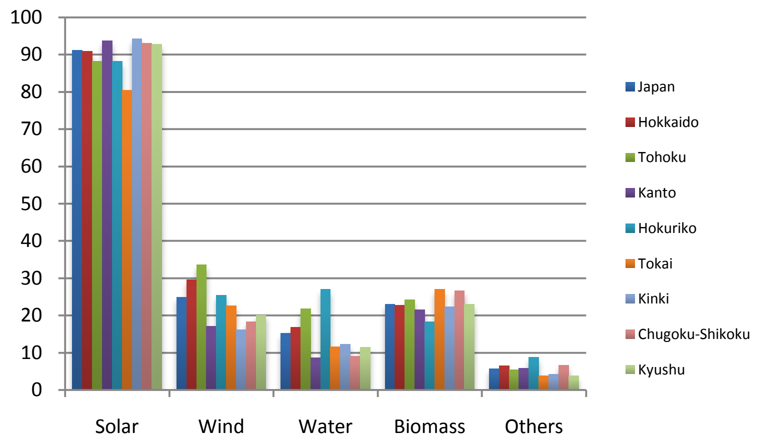


Figure 42. *Interests in different renewable energy among farms* using, planning or interested in introduction of renewables in Japan (January, 2014)*
Note: * up to 3 selections
Source: Japan Finance Corporation

Almost every forth of the farms using, planning or interested in introduction of renewable also report Wind energy. The biggest interest to this energy source is shown by the farmers in Hokuriko region while the lowest interest in Kanto region. Above a third of interested farms from Tohoku region also indicate that source of energy. The application or interest to that energy source is the highest among Rice producers (31.3%) and lowest in Mushrooms producers (8.7%).

The third most important source of energy in agriculture is Biomass and the biggest interest to that energy source which is shown by the farms in Tokai, Chugoku-Shikoku and Tohoku regions. Usage and interest to biomass is the highest among Pig, Broilers, and Dairy farms (58.7%, 57.1%, and 55% of them accordingly) and lowest in Tea producers (6.1%).

Relatively good portions of producers in Hokuriki and Tohoku regions are also interested in Water as a renewable energy source. The application of or interests of hydro energy is the highest among rice producers (23.8%) and weakest in Hence farms (1.7%).

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

The demand for proper measurements have induced numerous smart innovations for agriculture and related industries. For instance, a team of researchers from Fukushima University, PerkinElmer Japan Co. (a Japanese subsidiary of U.S. technology firm PerkinElmer Inc.), Japan Atomic Energy Agency, and Japan Agency for Marine-Earth Science and Technology has developed a new system that can quickly analyze the density of strontium 90 in soil (Fukushima Minpo News, September 19, 2013). The new system cuts the time of analysis to only 20 minutes (from the existing one of two weeks to one month) and the smallest amount of strontium detectable in soil is about 5 Bq/kg (a figure that is sufficient to be deemed a risk to humans).

Similarly, a team of scientists developed a car borne radiation measurement method for the farmland and roads in the Minamisoma Ota area of Fukushima, and a community led radiation measurement framework was established and implemented (Furutani *et al.,* 2012). As a result, radiation measurements and visualization for farmlands, paddies, and forests, which had been conventionally unachievable, has been made possible. Verification of the effect of decontamination also became possible by feeding back radiation measurement results before and after decontamination to residents.

Another example for rapid cooperation for disaster recovery has been initiated by a nonprofit organization promoting intelligent transportation systems. The day after the massive quake and tsunami, ITS Japan, requested related companies such as Toyota Motor Corp., Honda Motor Co., Nissan Motor Co. and car navigation system maker Pioneer Corp. to provide it with probe data including information such as the roads driven by the vehicles. On the same day, Honda and Pioneer began providing probe data to users of their products while Toyota began providing probe data on March 16. On March 19 ITS Japan began providing consolidated probe data compiled from Toyota, Honda, Nissan and Pioneer. Drivers get the data from either the car navigation systems in their cars or ITS Japan's website via smartphones or personal computers.

New use of probe data helps speed up Japan's recovery[259]. Truck drivers could not have delivered the necessities of life to evacuees who lost homes after the quake and tsunami without knowing which roads were clear of debris. Road information from cars that

[259] On April 28, 2011, ITS Japan stopped providing probe data to public in Tohoku region due to declining demand as drivers became aware of which roads were clear of debris.

had already driven in the coastal area was helpful for those who were to come later to continue delivering food, blankets and other goods for months. According to users the system was really helpful and it would have been even better if the data showed the breakdown of the size of trucks that had driven each road.

Individual carmakers had already developed a system in which drivers share probe data. Consolidating the system from multiple companies was essential because more probe data give more precise information to drivers. The probe cars have data-sending functions installed in navigation systems. Drivers who volunteer to offer the data obtain the function when they purchase sophisticated types of navigation systems[260]. Currently, approximately one in every several hundred cars is a probe car in the Tohoku area, while the rate is higher in urban areas.

Optimism of business prospects in the post-disaster years could be demonstrated with the statement of one of the interviewed by us experts - Mr.Kishi, running a processing company: "Currently there are many subsidies supplied in Fukushima. We think that we could change this to a chance by producing new product from Fukushima. Our company is now on work for next year's new product and planning for capital investment (June 5, 2013).

[260]ITS Japan originally anticipated probe data to be used to mitigate traffic jams and notify drivers of spots with frequent accidents as it show places probe cars putbrakes/stopped.

Chapter 8. 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. (Ministry of Agriculture, Forestry and Fisheries, 2011).

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 43).

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 44). 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).

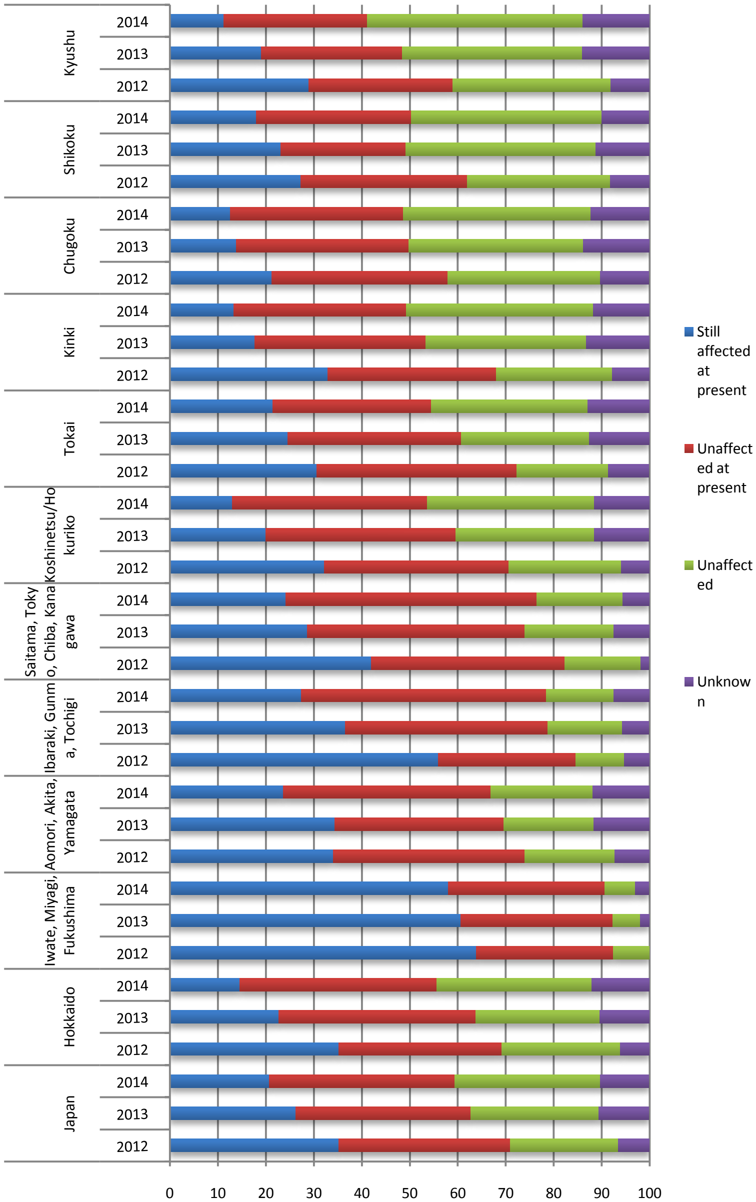


Figure 43. *Earthquake-tsunami disaster effects on food industry in Japan (January, 2012, 2013, 2014)*
Source: Japan Finance Corporation

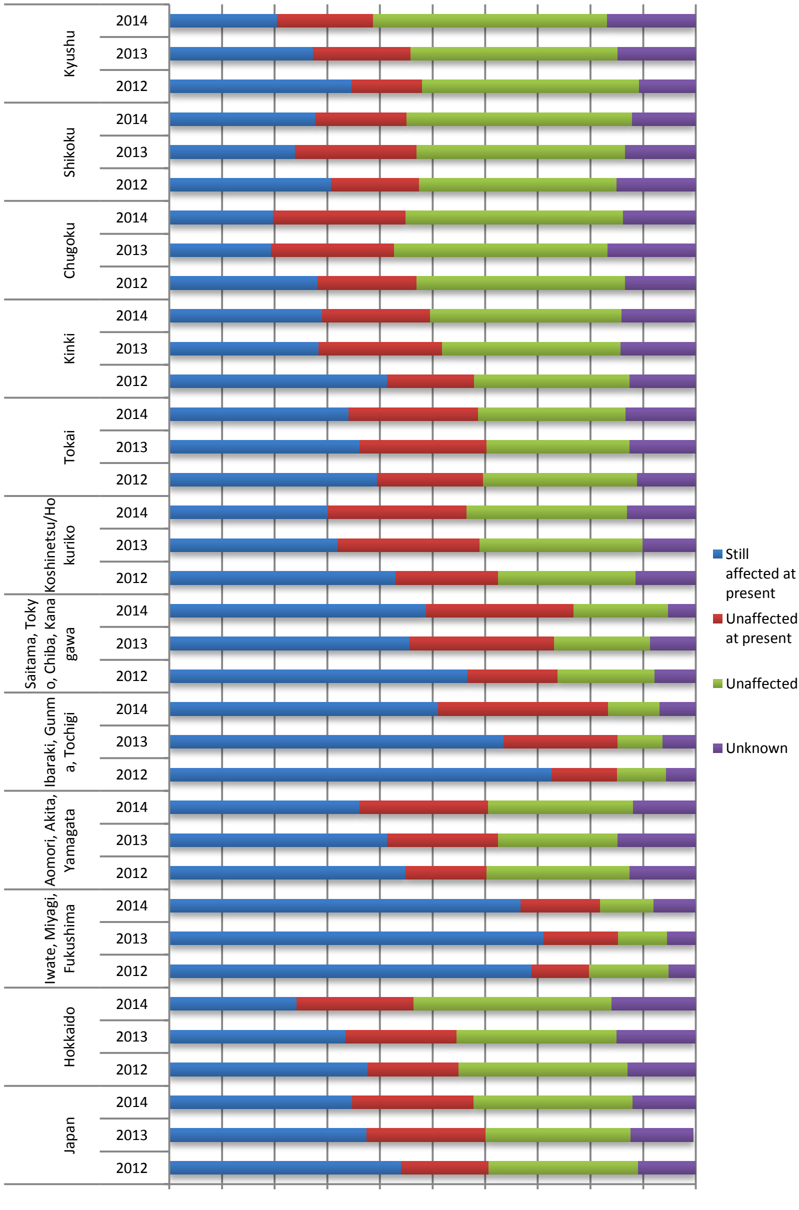


Figure 44. *Impact of Fukushima nuclear power plant accident on food industry in Japan (January, 2012, 2013, 2014)*
Source: Japan Finance Corporation

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 (Figure 45). 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.

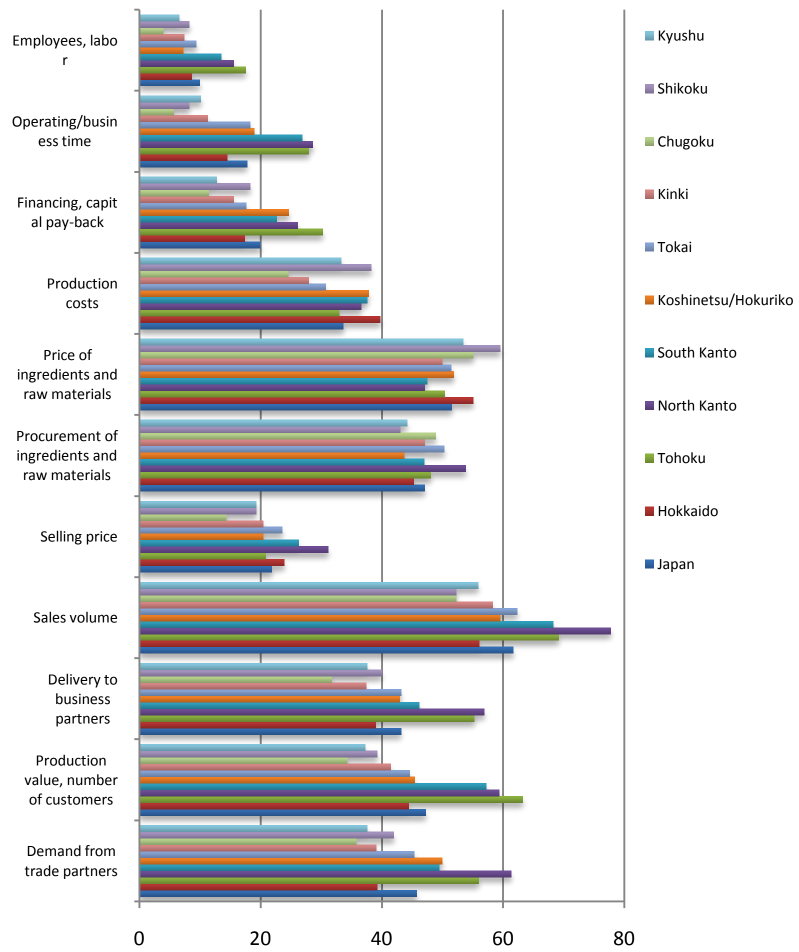


Figure 45. *Share of food industry companies in Japan affected by Great East Japan Earthquake (September, 2011)**
Note: * "increase" Price of ingredients and raw materials, Production costs, "decrease" all others
Source: Japan Finance Corporation

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 46). 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.

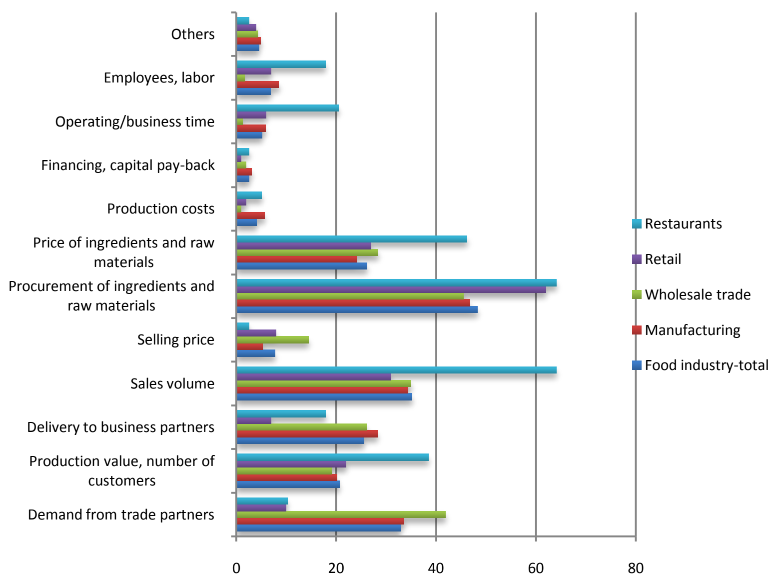


Figure 46. *Impact of earthquake and tsunami on overall management of food industry in Japan (January, 2014)*
Source: Japan Finance Corporation

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 47). 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.

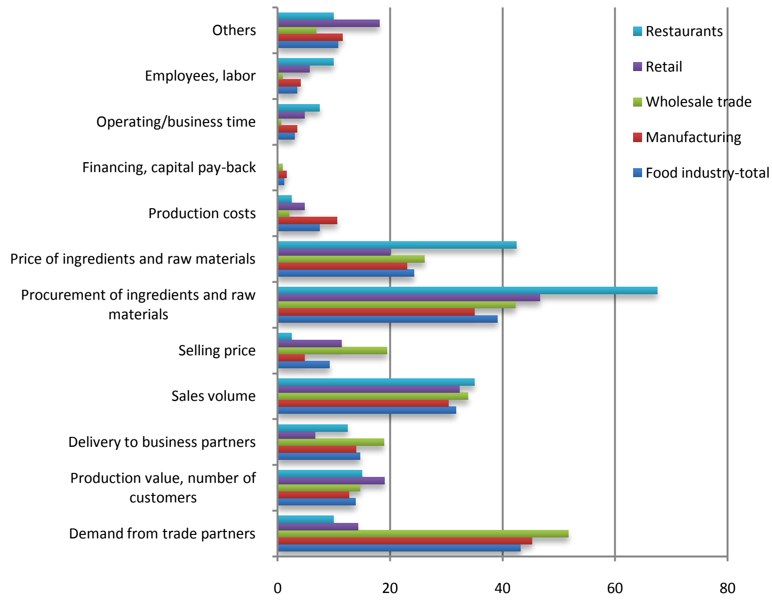


Figure 47. *Impact of Fukushima nuclear plant accident on overall management of food industry in Japan (January, 2014)*
Source: Japan Finance Corporation

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 48). 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.

Table 22. *Impact of 2011 nuclear disaster on food industry companies in Fukushima prefecture (February 2013)*

	Companies with changes in sales						Companies with changes in income		
	No	Decrease				Incr-ease	Incre-ase	Decrease	No
		≤ 10%	11-20%	21-30%	31-40%				
%	7.3	29.1	23.6	21.8	5.4	12.7	3.6	83.6	12.2
Subsectors	grocery, milk, fermen-ted milk drink , wrap-ping	pickles, canned food, breed, confectionary, noodles, ramen, liqueurs, sake, flours, soya source, chicken and pork meat	ramen, pickles and delicatessen, milk and milk drink, chi-cken meat, flours, delica-tessen, fruits and vege-tables, wrap-ping	pickleshoney, peach, cucu-mber, dried persi-mmon, sake, noodle beer, milk and yogurt, miso	kimchi, chi-cken meat, soya sauce	cut vege-tables, miso, pickles fish proce-ssing, sake, ice cream and frozen des-serts, kon-nyaky and took-roten, meat	meat, konnyaky and tokoroten, liqueurs	pickles, ice cream and frozen desserts, honey, ramen, delicatessen, flours, noodles, confectionary, sake, peach, cucumber, dried persimmon, milk, milk drinks, yogurt, chicken and pork meat, beer, soy source, miso, cut vegetables, canned food, kimchi, breed and confectionary, fruit juice, ramen, miso, fish processing, fruits and vegetables, wrapping	grocery, noodles, sake, wrapping,

Source: Fukushima Food Industry Organization

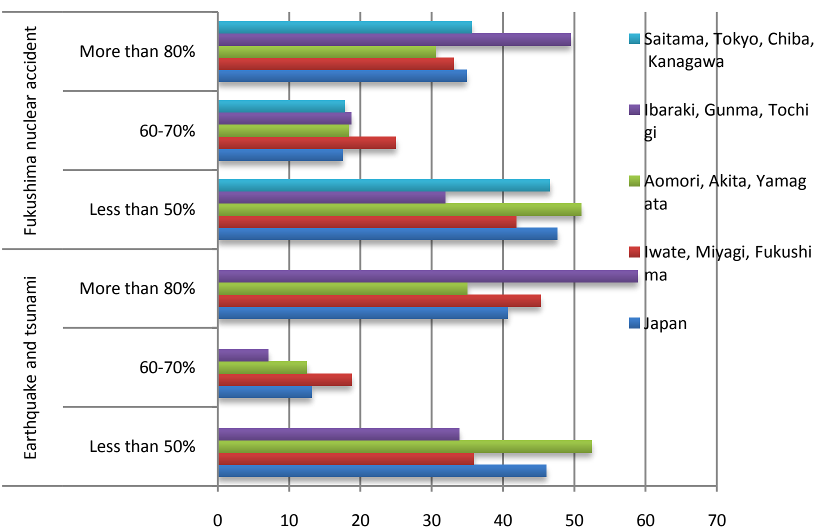


Figure 48. *Extent of food industry recovery from Great East Japan Earthquake effects (January, 2013)*
Source: Japan Finance Corporation

Chapter 9. Radioactive Contamination of Agri-Food Products

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 18, 2011 the radioactive iodine exceeding the provisional regulation limit[261] was detected in raw milk produced in Fukushima prefecture (Ministry of Agriculture, Forestry and Fisheries, 2011). On the next day 54,100 Bq/kg of iodine-131 was found in a sample of spinach, taken in Hitashi, Ibaraki prefecture (approximately 120 km south of the nuclear plant) (Institute for Radiological Protection and Nuclear Safety, 2012). In a kukitachina sample (local leafy vegetable) taken on March 21 in Mitomiya, Fukushima prefecture (70 km west of the plant) was detected 41,000 Bq/kg of Caesium-134 and 41,000 Bq/kg of Caesium-137 (Institute for Radiological Protection and Nuclear Safety, 2012).

On March 21, 2011 restrictions on food distribution were

[261] Provisional regulation values for radioactive substances under the Food Sanitation Act were set up for drinking water and agri-food products on March 17, 2011 and for fish and shellfish on April 5, 2011 (Ministry of Health, Labor and Welfare, 2011).

launched by the Director General the Nuclear Emergency Response Headquarters[262]. 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.

According to reports virtually all milk and vegetable samples taken in Fukushima (March 18–21) and Ibaraki (March 16–22) prefectures were above the safe limit (International Atomic Energy Agency, March 24, 2011). Samples from Chiba, Ibaraki and Tochigi prefectures also had excessive radiation levels in celery, parsley, spinach and other leafy vegetables. In addition, certain samples of beef mainly taken on March 27–29 showed concentrations of iodine-131 and/or caesium-134 and caesium-137 above regulatory levels.

On April 8, 2011 the "Policy on rice planting" was announced and restrictions on rice planting on 11,200 ha imposed (April 22, 2011)[263] in 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[264].

Other agricultural products from Tochigi and Ibaraki prefectures were also found to exceed the government limits such as pasture grass collected on May 5, approximately 11 times the state limit of radioactive cesium (NHK, May 13, 2011). Hay and straw were found contaminated with Cesium[265] 80 kilometers from the nuclear reactors.

Contaminated beef was traced on farms as far as 100 km away from the Fukushima nuclear plant. The cesium was found in meat from animals fed by contaminated rice straw[266]. By July 26, 2011 it was known that more than 2,800 cows fed with cesium-contaminated food were shipped to markets in 46 of the prefectures

[262] Shipment restrictions are lifted if radioactive substances fall bellow the regulation valued in three consecutive weekly inspections (implemented from April 8, 2011).

[263] On farmland that contained more than 5,000 Bq/kg per of radioactive cesium.

[264] With areas under mandotoy ban it makes 8.9% of all paddies in Fukushima prefecture.

[265] No Iodine-131 was detected after mid-May (IRPNS, 2012).

[266] Such contamination did not affects pigs and chickens - they are not fed with rice straw.

(exception Okinawa)[267]. Measurements of some animals shipped form Miyagi prefecture were 1,150 Bq/kg.

All shipment of beef raised in Fukushima prefecture was prohibited after July 19, 2011, from Miyagi prefecture on July 28, and Iwate prefecture on August 1. Later on the shipment of cattle and meat was only allowed after examination, and when the level of cesium is below the regulatory standard[268]. On August 3, 2011 the local government in Shimane prefecture decided to conduct radiation checks on all beef cattle to ease consumer concerns about food safety[269]. Authority introduced testing on all beef heads for radionuclides in 4 prefectures (Fukushima, Iwate, Miyagi & Tochigi) and testing on all farms in 3 other prefectures (Ibaraki, Gunma, & Chiba)[270].

The Ministry of Agriculture, Forestry and Fisheries urged farmers and merchants to renounce the use and sale of compost made of manure from cows that may have been fed the contaminated straw. The measure also applied to humus from leaves fallen from trees. That "voluntary ban" could be lifted after developing guidelines for safety levels of radioactive cesium in compost and humus (JAIF, July 26, 2011).

On August 19, 2011 radioactive cesium (at one-tenth of the government limit) was found in a sample of rice from Hokota, Ibaraki prefecture about 160 km south of the nuclear plant. On September 16, 2011 measurements of radioactive cesium in rice conducted in 17 prefectures found radioactive materials in 94 locations (4.3% of the total). The highest level detected in Fukushima prefecture was 136 Bq/kg.

On September 23, 2011 radioactive cesium in concentrations above the government safety limit was found in rice samples collected in the northeastern part of Fukushima prefecture. Rice-samples taken before the harvest showed 500 Bq/kg in Nihonmatsu. The government ordered a two-way testing procedure of samples taken before and after the harvest. Pre-harvest tests were carried out in nine prefectures of Tohoku and Kanto regions.

[267] Even in July radioactive beef was found on sale in 11 prefectures (until then testing was performed on skin and exterior of livestock while animal feed and meat cuts not checked).

[268] All cattle have to be checked for radiation before shipment, and government asked prefecture to temporarily reduce number of shipments to match its inspection capability.

[269] Late July at one farm rice-straw was discovered with radioactive Cs levels exceeding safety limit. Traders started to avoid all cattle from Shimane and beef prices plummeted.

[270] In practice, all heads of cattle are tested in meat processing plants throughout Japan.

Farmers who already started harvesting were ordered to store crop until the post-harvest tests is available (JAIF, September 25, 2011).

On November 16, 2011 radioactive cesium of 630 Bq/kg was detected in rice harvested in the Oonami district of Fukushima city (NHK World, November 17, 2011). All rice of the fields nearby was stored and none sold to the market. All 154 farmers in that district were asked to suspend shipments of rice and tests were ordered on rice samples from all farms. Five more farms were found with cesium-contaminated rice at a distance of 56 km from the disaster reactors with the highest level of cesium detected of 1,270 Bq/kg.

On November 28 cesium-contaminated rice up to 1050 Bq/kg was reported in samples of 3 farms in Date, 50 km from the Fukushima nuclear reactors. Consequently prefectural government decided to control more than 2,300 farms in the whole district. On 29 November orders were given to 2,381 farms in Nihonmatsu and Motomiya to suspend part of rice shipments in addition to already halted shipments at 1,941 farms in 4 other districts (including Date), totaling 4,322 farms (The Mainichi Daily News, November 29, 2011).

On May 11, 2011 cesium levels in tea leaves from Kanagawa prefecture were reported to exceed government limits (Osawa, 2011). On September 3 radioactive cesium exceeding the government's safety limit was also detected in tea leaves in Chiba and Saitama prefectures. One type tea leaves from Chiba prefecture contained 2,720 Bq/kg of radioactive cesium. A maximum of 1,530 Bq/kg was detected in 3 kinds of tea leaves from Saitama prefecture. Tea producers were asked to recall their products when that is necessary (JAIF, September 4, 2011).

In the end of spring, summer and autumn high levels of Cesium 134 and 137 were fund in Fukushima bamboo shoots (several hundreds of Bq/kg) and fruits like Japanese apricots (up to hundreds of Bq/kg), yusu (up to 2,400 Bq/kg), kiwi (up to 1,100 Bq/kg), pomegranates, chestnuts etc. (Institute for Radiological Protection and Nuclear, 2012).

On October 13, 2011 Yokohama city terminated the use of dried shiitake mushrooms in school lunches after tests had found radioactive cesium up to 350 Bq/kg. In shiitake mushrooms grown outdoors on wood in Ibaraki prefecture, 170 km from the nuclear plant, samples contained 830 Bq/kg of radioactive cesium. Radioactive contaminated shiitake mushrooms above safety limit were also found in two cities of Chiba prefecture. Consequently, restrictions were imposed on shipments from these regions.

On October 29, 2011 it was announced that shiitake mushrooms grown indoors at a farm in Soma (north from nuclear plant) contained 850 Bq/kg of radioactive cesium: Mushrooms were grown on beds made of contaminated woodchips mixed and 1,070 (100-gram) packages of them had been shipped to supermarkets (The Mainichi Daily News, September 25, 2011).

In March and October food was served in Yokohama city with highly contaminated dried shiitake-mushrooms[271] that came from a farm near this town (250 km away from Fukushima). On November 10, 2011, in Tochigi prefecture, 120 km away southwest from the Fukushima reactors, 649 Bq/kg of radioactive cesium was measured in kuritake mushrooms. Four other cities in that region already stopped sales and call back their mushrooms (NHK World, November 11, 2011).

On February 7, 2012 noodles contaminated with radioactive cesium (258 Bq/kg) were found in Okinawa (The Mainichi Daily News, February 13, 2012). "Okinawa soba" was apparently produced with water filtered through contaminated ashes[272] from wood originating from Fukushima prefecture. On February 10, 2012 the Ministry of Agriculture, Forestry and Fisheries set out a warning not to use ashes from wood or charcoal, even when the wood contained less than the governmental set maximum of 40 Bq/kg for wood or 280 becquerels for charcoal.

In mid-November 2011 radioactive cesium up to 30.8 Bq/kg was found in milk-powder for baby-food produced by Meiji Co. While this level was under the governmental safety-limit it could be harmful for young children. Previous tests in July-August on 25 baby products did not reveal any contamination (The Mainichi Daily News, December 10, 2011).

On March 20, 2011 radioactive substances were detected in tap water in Tokyo, and Tochigi, Gunma, Chiba and Saitama prefectures (The Japan Times, March 20, 2011). Permissible levels of iodine-131 were exceeded in drinking water samples taken in Fukushima and Ibaraki Prefectures and in Tokyo from 17 to 23 March (IAEA, March 24, 2011).

On March 24, iodine-131 was detected in 12 of 47 prefectures, of which the level in Tochigi prefecture was the highest (110 Bq/kg). Caesium-137 was detected in 6 prefectures but always below 10 Bq/kg. On March 25, 2011, tap water was reported to have reduced to 79 Bq/kg and to be safe for infants in Tokyo and Chiba prefecture but still exceeded limits in Hitachi and

[271] Test-results of mushrooms showed 2,770 Bq/kg in March, 2011 and 955 Bq/kg in October, 2011 (JAIF, November 5, 2011).

[272] It is a custom to use ashes when kneading noodles or to take away a bitter taste, or "aku" from "devil's tongue" and wild vegetables.

Tokaimura. On April 27, 2011 the radiation in Tokyo's water supply fell to undetectable levels for the first time since 18 March (Inajima & Nakayama, 2011). On July 2, 2011 in samples of tap water taken in Tokyo Shinjuku ward radioactive caesium-137 with concentration 0.14 Bq/kg was detected for the first time since April.

Voluntary restraint on planting tobacco were also imposed in Fukushima prefecture in 2011 (Watanabe, 2013). Furthermore, some tests found a high radiation level in wild mushrooms (28,000 Bq/kg of cesium) and a wild boar (6 times above the safety limit) (JAIF, September 12, 2011).

Many farm related services such as eco-tourism, eco-farm, etc. were suspended in the most affected areas. For instance, Mr. K. Yamauchi farm in Kitakata, Fukushima prefecture were popular with green tourism before the nuclear disaster, and accepted students from 10 schools from and outside prefecture to experience agriculture. However, no students visited the farm in 2011 and 2012 due to public concern over radiation[273] (Fukushima Minpo News, May 16, 2013).

In March 2012 radioactive cesium was detected in yamame (landlocked masu salmon) caught in Niida river near Iitate town, which was over 37 times the legal limit (The Mainichi Shimbun, March 30, 2012). Fishing cooperatives were asked to refrain from catching yamame fish from this river and all streams adjacent to it, and no fish was sold on market. Moreover, no fishing was allowed in the river Nojiri in the region Okuaizu in Fukushima after-mid March 2012. Although this river is located 130 km from the damaged reactors the caught fish contained 119-139 Bq/kg of cesium. In 2011 the fish measured only 50 Bq/kg but fishing was not popular.

On March 28, 2012 smelt caught in the Akagi Onuma lake near Maebashi city in Gunma prefecture was found to be contaminated with 426 Bq/kg of cesium (The Mainichi Shimbun, April 4, 2012). In April 2012 radioactive cesium concentrations of 110 Bq/kg were found in silver crucian carp fish caught in Tone river, north of Tokyo, 180 km away from the nuclear plant. Six fishery cooperatives and 10 towns along the river were asked to stop all shipments of caught fish. In March 2012 fish and shellfish caught in a pond near the same river were found to contain levels above the new legal safety limits (JAIF, April 26, 2012).

High levels of radioactive cesium were found in 23 varieties of freshwater fish sampled at five rivers and lakes in Fukushima

[273] On May 15, 2013 when students visits started again.

prefecture between December 2011 and February 2012 and in 8 locations on the open sea. On July 2, 2012 the authority announced finding radioactive cesium between 61 to 2,600 Bq/kg in a kind of goby caught in Mano river flowing from Iitate village to Minamisoma city (north of the nuclear plant). Water bugs, common food for freshwater fish, also showed high levels of 330 to 670 Bq/kg.

All coastal fishery and trawl fishing offshore Fukushima, except trial fishing[274], have been voluntarily suspended since the accident at the nuclear plant. After detection of radioactive cesium above legal limits in Sand lances caught off the coast of Ibaraki, prefectural government banned fishing (NHK, May 13, 2011). Marine fish was found less contaminated and showed levels between 2.15-260 Bq/kg since it might be more capable of excreting cesium from bodies (saltwater fish have the ability to excrete salt).

Radioactive cesium was also found in high concentration in plankton in samples taken up to 60 km from the coast of Iwaki city in July 2011 as up to 669 Bq/kg was measured in animal plankton 3 km offshore (JAIF, October 15, 2011). Occasional incidents of caught fish with enormous amount of cesium have been reported since the nuclear accident – e.g. radiation 2,540 times the legal limit for seafood was measured in a 'murasoi'-fish caught in January 2013 at the coast of Fukushima prefecture (Bullones, 2013).

Forestry industry has been also severely affected by the nuclear accident. For instance, Fukushima's broad-leaf forest area is one of country’s leading producers of mushroom growing logs (Fukushima Minpo News, September 26, 2014). After the nuclear accident, radioactive cesium levels exceeding the maximum standard (50 Bq/kg) were detected in many log producing areas and in 2012 only 300,000 logs were produced or 6% of the pre-disaster level[275].

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

[274] Test-fishing began in 2012 for limited species of marine products. It targets 27 species of which redioactive cesium concentration has been remarcably decreased and they are cought on a trial basis at the limited offshore area (20 km away from the nuclear station) and sold after inspection of each landing for each species (Fishery Agency, 2014).

[275] In 2010 Fukushima prefecture produced about 5 million such logs (nearly 3 million sold outside prefecture) earning forestry industry about 1 billion yen in annual sales.

prefectures (Figure 49).

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%).

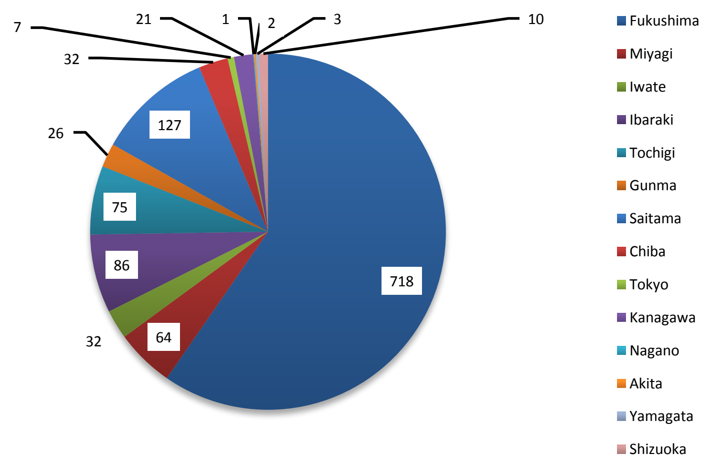


Figure 49. *Number of agri-food samples above radiation safety limit detected until March 31, 2012*
Source: Ministry of Health, Labor and Welfare

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.

The mandatory and voluntary restrictions on shipment covered a number of products from designated areas of affected regions. In addition, there was a ban on rice planting on 8,000 ha of paddies in evacuation (95%) and other contaminated areas (Ministry of Agriculture, Forestry and Fisheries, 2012). Several municipalities (Minami-shi, Hirono-machi, Kawauchi-mura and Tamura-shi) also called for voluntary restraints on planting of paddy rice on total area of 5,600 ha.

In order to meet growing public safety concerns since April 1, 2012 new 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 August 2012 officials reported that cesium levels had dropped to undetectable levels in most cultivated vegetables from the affected areas, while food sourced from forests, rivers or lakes in the Tohoku and northern Kanto regions were showing excessive contamination (Aoki, 2012). Reported contamination mostly involved fish (landlocked salmon and flounder) and seafood, Shiitake-mushrooms, and meat of wild animals. Radiation levels remained especially high in species like cod, sole, halibut, landlocked kokanee, carp, trout, and eel.

In the last two years the number of (official, collective, private) food inspections has multiplied in the 17 most vulnerable prefectures[276] and around the country.

Officially tested food items doubled in 2012, 0.85% of all samples were found exceeding safety limit for radionuclides, and a few highly contaminated items were detected in 4 more prefectures (Aomori, Nigata, Yamanashi and Hiroshima) (Figure 50). 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.

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

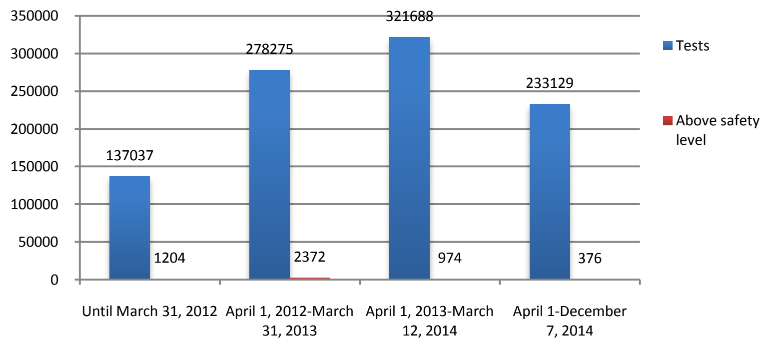


Figure 50. *Number of radionuclide food tests and items above safety standard in Japan*
Source: Ministry of Health, Labor and Welfare

In FY 2013 the number of inspections increased further but only 0.30% of samples were found with level higher than the safety standard[277]. 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

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

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 23).

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.

The test data for marine fishery products radioactive contamination also indicate that the number of cases above safety limit has dropped considerably (Figure 51).

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

Products	March, 2011 - March 31, 2012			April 1, 2012 - March 31, 2013		April 1, 2013 - March 31, 2014		April 1, 2014 - March 31, 2015	
	Num-ber of sam-ples	Above provi-sional limit	Above new limit	Number of sam-ples	Above max-imum limit	Num-ber of sam-ples	Above max-imum limit	Num-ber of sam-ples	Above max-imum limit
Rice	26,464	39	592	10.4 million	84	11 million	28	11 million	2
Wheat and 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 and wild edible plants	3,856	228	779	6,588	605	7,583	194	8,557	103
Tea/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	
Egg	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

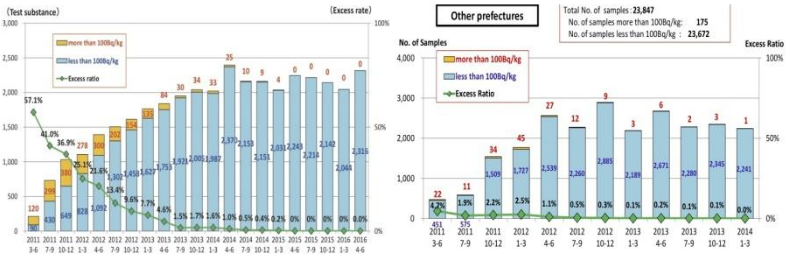


Figure 51. *Monitoring results for marine fishery products radioactive levels in Fukushima prefecture and other prefectures*
Source: Fishery Agency

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.[278] 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.

Most recent data show that 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.

The Fukushima Agricultural Technology Center performs regular tests on 461 agricultural and food items from Fukushima prefecture with the state of the art equipment. For the period March 19, 2011-March 31, 2014 as many as 109,853 agricultural and food items were tested at the Center's laboratories (Fukushima Agricultural Technology Center, 2014). Until the first anniversary from the nuclear accident (end of FY2011) contamination above provisional safety limit was found in 3.58% of checked samples (Table 24). One third of all highly contaminated items were fish, 23.8% livestock forage, 18.6% mushrooms and wild plants, 21.3%

[278] After 2nd quarter of 2012, monitoring is focused on species with more than 50 Bq/kg.

vegetables and fruits, a small portion other products, and no detection for meat, eggs and brown rice.

During the second years after the accident (FY 2012) the share of detected items above safety limit dropped to 1.83% almost three quarter of them being fish. The portion of highly-contaminated fish, and mushrooms and wild edible plants was considerable (14.6% and 8.3% accordingly), no detection was reported for meat, milk and eggs, and insignificant portion of contaminated items for others.

During the last year (FY2013) only 1.48% of tested samples exceeded the safety limit. The majority of highly contaminated items were fish (56.6%), mushrooms and wild plants (19.1%) and cereals (19.8%). The radiation detection in mushrooms and wild plants, fish and cereals has been relatively high (5.8%, 2.9% and 1.6% respectively), merely 0.8% for forage for livestock, and none for all other products.

The latest data show that a high contamination still remains in certain Fukushima products like edible wild plants attributed to radioactive substances on mountains surfaces (NHK World, May 14, 2014). Out of 383 samples tested during the last season 4.2% exceeded the safety limit[279].

Furthermore, a survey has found that the levels of radioactive cesium in home-cooked meals in Fukushima prefecture are mostly below the maximum allowable limit (Fukushima Minpo News, March 7, 2014). Out of 100 households surveyed during period November 2013 - February 2014 using meals prepared over two days, only 4 showed measurements slightly above the limit for radioactive cesium (the one with the highest level of 2.6 Bq/kg for Cesium 137 and 1.1 Bq/kg for Cesium 134). Household members were also tested for internal exposure to radioactive materials by a whole-body counter, and all screened persons (82) had counts below the 300 Becquerel threshold for human radiation exposure.

Table 24. *Results of inspections on radioactivity levels in agri-food*

[279] On May 13, 2014 Fukushima prefecture restricted shipment of 7 varieties of edible wild plants after detecting high levels of radioactive contamination – 700 Bq in fiddleheads, 430 Bq in varieties of bracken, and 460 Bq in Japanese spikenard (NHK World, May 14, 2014).

products in Fukushima prefecture

Products	Items	June 1, 2011 - March 31, 2012		April 1, 2012 - March 31, 2013		April 1, 2013 - March 31, 2014	
		Number of samples	Above provisional limit	Number of samples	Above the maximum limit	Number of samples	Above the maximum limit
Brown rice	1	1,724	0	35,238	71	601	28
Cereals without rice	8	607	3	2,169	10	4,428	55
Vegetables and fruits	232	6,010	145	7,264	7	5,806	0
Milk	1	651	15	441	0	405	0
Meat	5	5,001	0	6,310	0	4,888	0
Eggs	1	221	0	144	0	133	0
Forage for livestock	-	773	162	1,664	48	2,368	19
Fish	146	3,330	227	6,037	879	8,282	237
Mushrooms and wild plants	64	922	127	1,090	90	1,377	80
Others	3	51	2	68	1	63	0
Total	461	19,290	681	60,425	1,106	28,351	419

Source: Fukushima Agricultural Technology Center

Currently there are still a number of products from certain areas of 17 prefectures, which are subject to mandatory or voluntary shipment restrains (Table 25).

Table 25. *Agricultural and fishproducts subject to shipment restraints in designated areas of Japanese prefectures (January, 2016)*[280]

Prefec-tures	Mandatory	Voluntary
Aomori		Wild mushrooms
Iwate	Shiitake, Nameko and Kuritake mushrooms grown on Raw Log (open fields); Koshiabura; Fiddlehead fern; Wild Bracken; Wild Japanese parsley; Bamboo shoots; Wild mushrooms; Cattle*; Japanese seaperch; Japanese black porgy; Iwana mountain trout; Japanese dace	Dried shiitake mushrooms grown on Raw Log in 2011 and spring 2012; Shiitake mushrooms grown on Raw Log; Wild Kusasotetsu; Wild Taranome; Wild Uwabamisou; Wild butterbur; Wild Sanshou; Hiratake, Bunaharitake and Mukitake mushrooms grown on Raw Log (open field); Kuwai (open field); Natural Yamame
Akita		Wild Nemagaridake
Miyagi	Shiitake mushrooms grown on Raw Log (open fields); Kusasotetsu; Bamboo shoots; Koshiabura; Fiddlehead fern; Wild mushrooms; Cattle*; Takifugu pardalis; Japanese seaperch; Japanese black porgy; Yamame (except cultured); Sweetfish (except cultured); Iwana mountain trout (except cultured);	Mukitake mushrooms grown on Raw Log; Nameko mushrooms grown on Raw Log (open field); Wild Taranome; Wild Bracken; Shiitake mushrooms grown on Raw Log (mushroom facilities); Natural Eel; Iwana mountain trout (except cultured)

[280] Updates on requests for shipment restrains and other measures are available on: [Retrieved from].

	Japanese dace	
Yamagata		Koshiabura
Fukushi-ma	Non-heading leafy vegetables; Heading leafy vegetables; Bud vegetables belonging to brassicaceae; Kabu; Japanese plum; Yuzu; Japanese chestnut; Kiwi; Shiitake and Nameko mushrooms grown on Raw Log (open field); Shiitake mushrooms grown on Raw Log (mushroom facilities); Wild mushrooms; Bamboo shoots; Kusasotetsu (open field); Wild Taranome; Wild butterbur sprout; Wasabi (grown in fields); Koshiabura; Fiddlehead fern; Bracken; Wild Bracken; Wild butterbur; Wild Uwabamisou; Cattle*; Raw milk; Yamame (except cultured); Sweetfish (except cultured); Iwana mountain trout (except cultured); Carp (except cultured); Japanese dace; Fat greenling, Red tongue sole, Ikanago (except for fry), Stone flounder, Sebastes thompsoni, Surfperch, Brown hakeling, Fox jacopever, Black cow-tongue, Jacopever, Japanese black porgy, Sea raven, Okamejei kenojei, Masu salmon, Poacher, Sebastes cheni, Japanese seaperch, Nibe, Starry flounder, Slime flounder, Takifugu pardalis, Bastard halibut, Red gurnard, Spotted halibut, Common Japanese conger, Yellow striped flounder, Marbled sole, Flathead, Pacific cod, Roundnose flounder, Spotbelly rockfish, Frog flounder, Stimpson's hard clam, Northern sea urchin, Long shanny, Barfin flounder, Starspotted smooth-hound, Shosai-fugu; Japanese halfbeak, False kelpfish; Crucian (except cultured); Eel	Loquat; Walnuts; Japanese persimmon; Dried shiitake mushrooms; Wild Udo; Wild Sanshou; Koshiabura; Bamboo shoots; Wild Taranome; Chocolate vine; Mokuzugani; Honmokoro (cultured); Himemasu; Weather loach
Ibaraki	Shiitake mushrooms grown on Raw Log (open fields); Shiitake mushrooms grown on Raw Log (mushroom facilities); Bamboo shoots; Wild koshiabura; Sebastes cheni, Japanese seaperch, Nibe, Okamejei kenojei, Pacific cod; Bastard halibut; Stone flounder; Channel catfish (except cultured), Carassius auratus langsdorfii (except cultured); Eel	Wild mushrooms; Bamboo shoots; Shiitake mushrooms grown on Raw Log; Dried shiitake mushrooms; Wild Taranome; Ikanago; Takifugu poecilonotus; Natural iwana mountain trout; Natural Carassius cuvieri
Tochigi	Shiitake mushrooms grown on Raw Log; Nameko and Kuritake mushrooms grown on Raw Log (open field); Wild Taranome; Bamboo shoots; Wild Kusasotetsu; Wild Koshiabura; Wild Sanshou; Wild fiddlehead fern; Wild bracken; Wild mushrooms; Japanese chestnut; Cattle*	Dried shiitake mushrooms grown on Raw Log); Shiitake mushrooms grown on Raw Log; Uwabamisou; Wild Myoga; Wild Momijigasa; Yamaguri; Natural fishes in mountain streams
Chiba	Shiitake mushrooms grown on Raw Log; Bamboo shoots; Silver crucian carp; Natural carp	Bamboo shoots; Dried shiitake mushrooms; Shiitake mushrooms grown on Raw Log (open fields); Japanese seaperch; Stone moroko; Crucian carp; all kinds of fish and shellfish; Silver crucian carp; all species of fish and shellfish except for Freshwater prawn; Eel
Tokyo		Eel
Gunma	Wild mushrooms; Yamame (except cultured); Iwana mountain trout (except cultured); Eel	Dried shiitake mushrooms grown on Raw Log; Bamboo shoots; Nameko mushrooms grown on Raw Log (open field); Wild Taranome; Natural Japanese

		smelt; Natural Japanese dace; Natural carp; Natural iwana mountain trout; Natural yamame
Saitama	Wild mushrooms	Natural catfish; Eel
Nagano	Wild mushrooms	Koshiabura; Taranome
Kanaga-wa		Shiitake mushrooms grown on Raw Log (open fields)
Nigata		Wild mushrooms
Yamana-shi	Wild mushrooms	
Shizuoka	Wild mushrooms	Dried shiitake mushrooms (picked and processed after March 11)

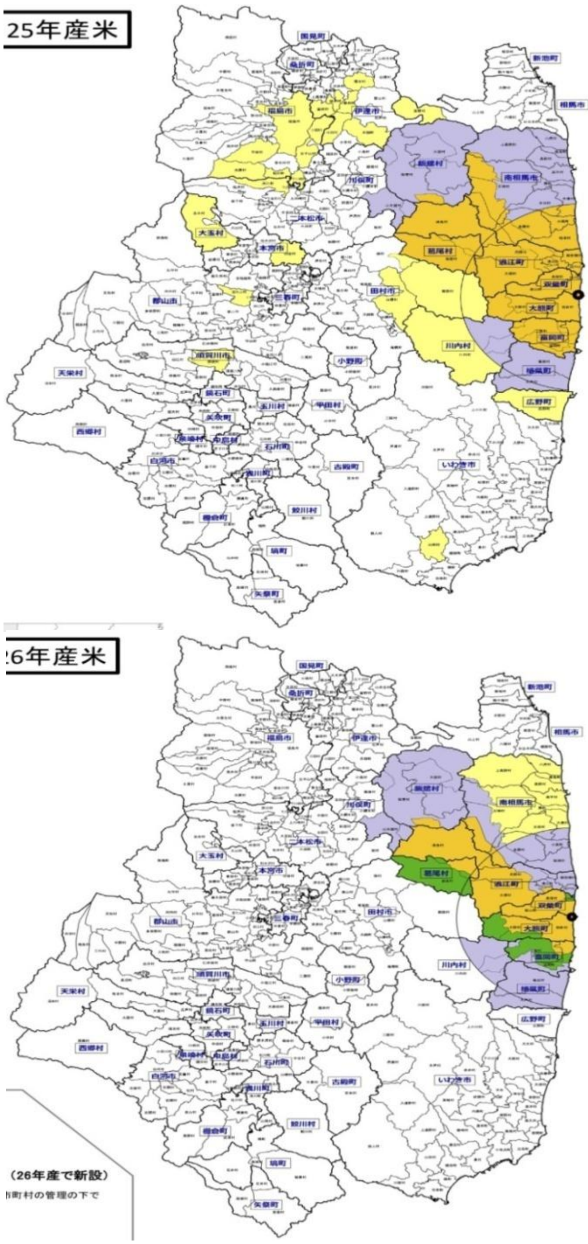
Note: * whole area, from other prefecture (except less than 12 months), shipping to slaughter houses, exclude cattle controlled by shipment inspection policy of Prefectural Government
Source: Ministry of Agriculture, Forestry and Fisheries.

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 (Table 26, Map 14). Consequently, Fukushima rice paddy acreage has yet to recover to the level before the accident standing at 84.61% of 2010 level in 2014 (Ministry of Agriculture, Forestry and Fisheries).

Table 26. *Target areas of rice planting restrictions (ha)*

Type	2013	2014
Planting restrictions	6,000	2,100
Farmland preservation and cultivation test*	-	700
Planting resume preparation	6,200	5,100
Total volume production delivery management	5,200	4,200

Note: * set in the new “Policy on the planting of the 2014 annual rice”
Source: Ministry of Agriculture, Forestry and Fisheries



Map 14. *Target areas* for planting restrictions of 2013 and 2014 annual rice*

Note: * orange - areas with a ban on rice planting; green - farmlandpreservation and cultivation test; blue - areas planting to restart; yellow - rice planted allowed

Source: Ministry of Agriculture, Forestry and Fisheries

In other prefectures the mandatory and voluntary shipment restrictions mostly concern mushrooms, wild plants, and fish.

For most contaminated areas of Fukushima prefecture there are still requests for intake restraints for a wide range of non-heading leafy vegetables (such as Spinach, Komatsuna, Kakina etc.), heading leafy vegetables (Cabbage, Hakusai, Heading lettuce, Brussels sprout etc.), bud vegetables belonging to brassicaceae (Broccoli, Cauliflower, Stick Broccoli etc.), shiitake mushrooms grown on Raw Log (open field), wild mushrooms, and non cultured Yamame (MAFF, 2014).

The challenges associated with the agri-food contamination continue all the time. For instance, in 2014 Date farmers renewed shipments of popular dried permission but not all produce have been cleared (NHK World, November 12, 2014). Despite decontaminations the radiation level of some lands' output is still above the legal limit since drying increases the concentration of radiation 4-5 times.

It has been also found out that the rice paddies located about 20 km from the Fukushima nuclear plant were with radioactive cesium blown by the wind (NHK World, July 14, 2014). The prefectural government revealed that 2013 year's harvested rice from 14 locations in the city of Minami Soma contained more than 100 Bq/kg of cesium. Initially there was a speculation that debris removal work at the nuclear station (conducted in August 2013) may be one of the reasons for the contamination[281]. Recently the officials announced that it is highly unlikely that radioactive particles from the nuclear plant contaminated rice fields and it may have come from river and ground water (NHK World, October 31, 2014).

[281] Neither the government nor TEPCO informed Minami Soma City officials the work at the plant may have contaminated the crop.

Chapter 10. Effects on markets, consumers and international trade

In the days after the 2011 disasters there was destruction of supply of potable water, foods and other necessities in most affected regions (Ministry of Agriculture, Forestry and Fisheries, 2011; Watts, 2011). What is more, food shortages spread beyond the worst affected areas as many people were panic buying after the nuclear crisis (Figure 52). Unprecedented for the post war period situation of food rationing and empty stores shelves was prevailing in the days after the crisis across the disaster areas and big cities like Tokyo.

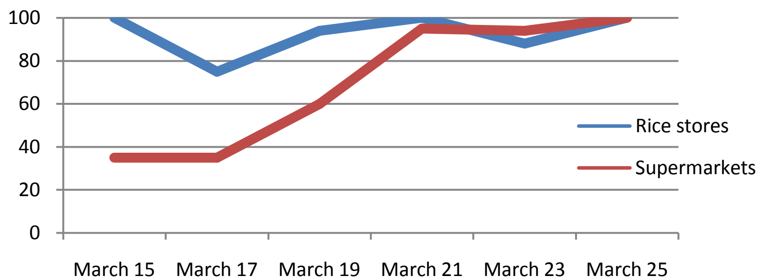


Figure 52. *Stores with over-the-counter rice inventories in Tokyo and its vicinity (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

The Government implemented swift measures to procure and provide emergency food, beverages, fuel etc., and rapidly restored damaged agri-food production and distribution facilities. During the period March 11 - April 20, 2011 the Ministry of Agriculture, Forestry and Fisheries procured and delivered 25.84 million packs of meals, 7.62 million bottles of drink (3.81 million liters) and 53 thousand cans formula milk for infants (Ministry of Agriculture, Forestry and Fisheries, 2012).

"Normal" food supply to all affected by the disasters people was quickly restored and important infrastructure (production and storage facilities, wholesale markets, transportation network, etc.) rebuilt. Nevertheless, there have been numerous restrictions on production, sells, shipments and consumption of basic agricultural and food products in the affected by the nuclear accident regions. All they stopped, delayed or significantly reduced the effective supply of a great range of local agri-food products.

Furthermore, 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 & Ito, 2013). The "reputation damage" has been particularly important factor for the big agri-food producing regions like Fukushima, Ibaraki, etc. which products have been widely rejected by consumers (Futahira, 2013; Fukushima Minpo News, May 11, 2014; Koyama, 2013; Watanabe, 2013; NHK World, July 14, 2014).

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. For instance, regardless of the good result from the Ministry of Agriculture, Forestry and Fisheries emergency inspection for radioactive contamination of rice[282] the circulation of all rice produced in Fukushima prefecture stopped in 2011-2012 (Koyama, 2013).

The marketing problems of farms in the most affected areas has been further enhanced due to the fact that a large number of them (used to) practice direct trade at wholesale markets and direct sells to consumers, retailers, and processors (Figure 53).

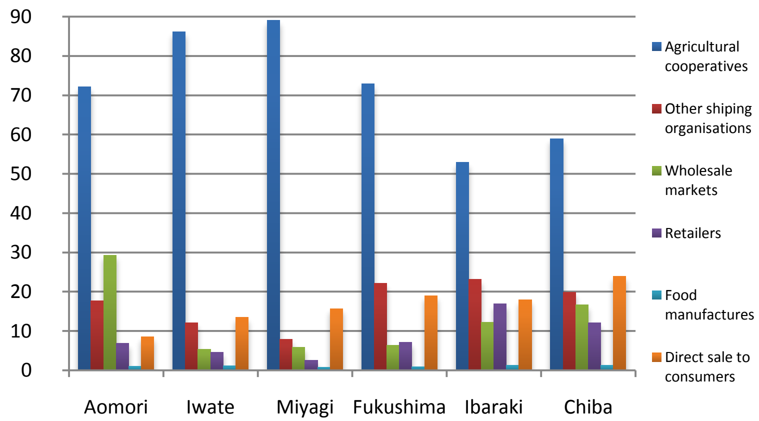


Figure 53. *Share of Agricultural Management Entities by shipping destination of agricultural products in 2010 (percent)*

Source: Ministry of Agriculture, Forestry and Fisheries

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

[282] Product with levels exceeding safety limits accounted merely for 0.3% of the total rice produced (2.3% for new standard of 100 Bq/kg).

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). A very popular across Japan organic rice of an agricultural corporation from Nihonmatsu (customer base of 4,000 people) has got no orders from 60 % of customers (NHK World, March 10, 2014).

Similarly, sales of vegetables as ingredients for school lunch in Fukushima prefecture have decreased; only 3 out of 16 farmers market recovered the sales (positive trends are mostly for markets in the South part of the prefecture), most of the sales decreased by 30%, some (like in Date) still struggle at 40% of the pre-disaster level, and one was closed; sales of meat started to recover but it is still below the pre-disaster level, etc. (Nagashima, 2013).

Fukushima labels and brands for agri-food produce which once representing top quality and safety after the accident brought rejections and significantly less than usual market value[283].

The same has been experienced by many food processors in the affected regions. For instance, manufacturers of natto[284] from Mito were seeking compensation from TEPCO because their sales in April–August 2011 fall by 50% and losses risen up to 1.3 million dollars (JAIF, August 13, 2011). According to one of the interviewed by us experts - Mr.Kishi, running a small company for frozen desserts (ice creams, puddings, and jellies) in Fukushima city "for school lunch there are still harmful rumors and factories in Fukushima are unable to join the tender in some areas. His company is doing well since it supplies all ingredients outside prefecture and has a proper safety control system put in place (June 5, 2013).

Some popular food chains such as Sukiya have introduced "no Fukushima beef" policy in their restaurants around the country, including in Fukushima prefecture.

[283] Fukushima products continue to top different competition - 2 farmers from prefecture won gold awards while others other awards in annual international rice tasting competition in Shichikashuku, Miyagi (Fukushima Minpo News November 25, 2013). Three brands of rice (Koshihikari and Hitomebore from Aizu region, and Hitomebore from Nakadori area) were among 38 top level "Special Grade A" brands in Japan Grain Inspection (Fukushima Minpo News, February 14, 2014). For the second straight year Fukushima-brewed sake brands got top award at Annual Japan Sake Awards as 17 out of submitted 39 brands were awarded Gold Prize (Fukushima Minpo News, May 21, 2014).

[284] Fermented soybeans normally packed in rice-straw.

Before the nuclear accident Fukushima prefecture had been a favorite tourist destination both for local and outside visitors. After the accident the number tourists sharply declined - visits by local tourists dropped more than a half and all visits more than 40% comparing to the same periods in 2010 (Fukushima prefectural government, 2012). That has been a severe blow for the related farming and food products supplying tourists with numerous local specialties. The (agri and rural) tourism started to recover in 2012 but it is still struggling to reach pre-the disaster levels.

Some research has also proved that consumers' attitude toward the agricultural products from the affected regions has changed dramatically (Burch, 2012; Ujiie, 2011, 2012, 2013). Almost 38% of the surveyed in 2012 consumers indicated that they do not purchase fresh foods produced in the affected by the nuclear accident areas, and only 8.4% said they buy (Japan Finance Corporation, 2012). A different survey has found out that a half of consumers in Tokyo and Osaka would not buy Fukushima and Ibaraki products with "contamination less than the official criteria" and another 30% said they would not buy if products were "not contaminated at all" (Ujiie, 2012). A follow up 2013 survey reviles that while consumers still maintain the high risk conscious, the "origin of product" factor is playing less important role is the choice.

Even residents and producers of Fukushima prefecture tend to avoid buying local products, and local produce has not been used in school lunches[285]. A 2013 consumer survey shows that this is particularly true for some segment of population (e.g. family with children) as well as for certain products (such as mushrooms and seafood) (Interview with Prof.Komatsu, June 17, 2013).

One of the interviewed by us farmer Mr.Takahashi said: "As a producer in Fukushima, I am suffering to find the way to promote consumption of Fukushima products to local citizen. While the consumption in Fukushima do not return, there is no meaning to promote safeness and trustworthy of Fukushima products to other prefectures" (June 14, 2013).

A countrywide survey found out that more than a third of surveyed Japanese farmers (Figure 54) and almost of 38% of food industry personnel (Figure 55) indicate that "Sales slackened because consumers tended to refrain from buying food products". The later figures are much higher for the most affected by the

[285] Insofar the "grow local, eat local" movement not taken off in Fukushima prefecture, and it is difficult to sell agricultural produce outside the prefecture (Koyama, 2013).

disaster regions. A substantial number of food industry companies point out that they "switched from agriculture, forestry and fisheries products in areas with radioactive contamination fears to areas in Japan for their purchasing" and that amounts for more than 57% in Fukushima prefecture.

There has been significant change in the purchase behavior of a great number of consumers after disasters. A July 2011 survey found out that a good share of consumers decreased the purchased amount of fresh (10.6%) and processed (9.8%) food, ornamental flowers (21.6%), confectionary (15.2%), etc. (Figure 56). On the other hand, there is an increase in purchase mineral water (17.6%). All these changes were more dynamic in the worst affected East Japan than in the other parts of the country.

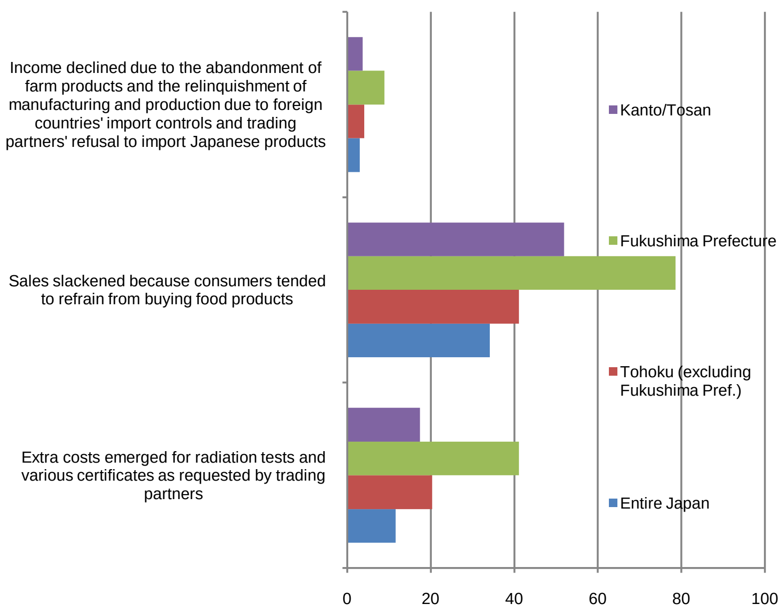


Figure 54. *Effects of nuclear accident on farmers in 2012 (percent)**
Note: *multiple answers
Source: Ministry of Agriculture, Forestry and Fisheries

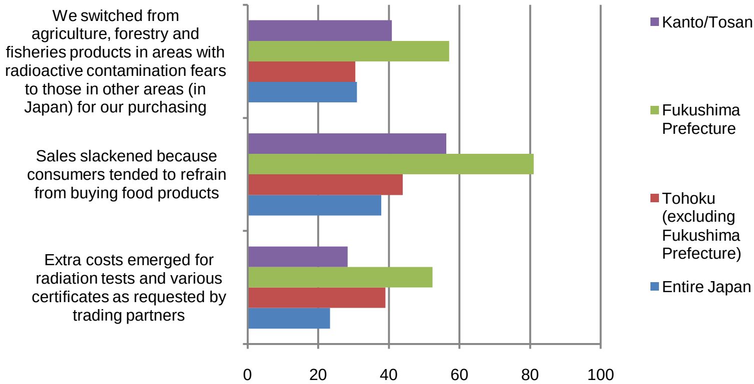


Figure 55. *Effects of nuclear accident on food industry, 2012 (percent)*
Note: *multiple answers
Source: Ministry of Agriculture, Forestry and Fisheries

In the months after the earthquake, the item most emphasized by the consumers at the time of purchase of fresh food was "production location" and for processed food the "origin of raw materials" (Figure 57). However, for the majority of consumers there was not change of the place to buy fresh (88.5%) and processed (89.1%) food comparing to the pre-duster period (Japan Finance Corporation, 2011).

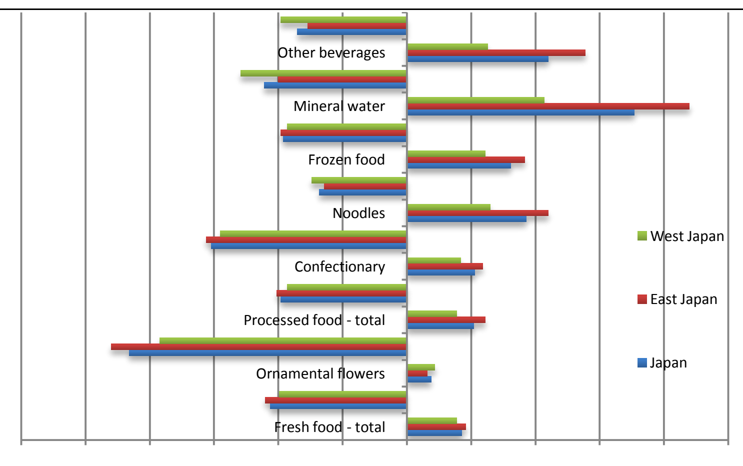


Figure 56. *Change in purchase amount of different category of food after Great East Japan Earthquake (July 2011)*
Source: Japan Finance Corporation

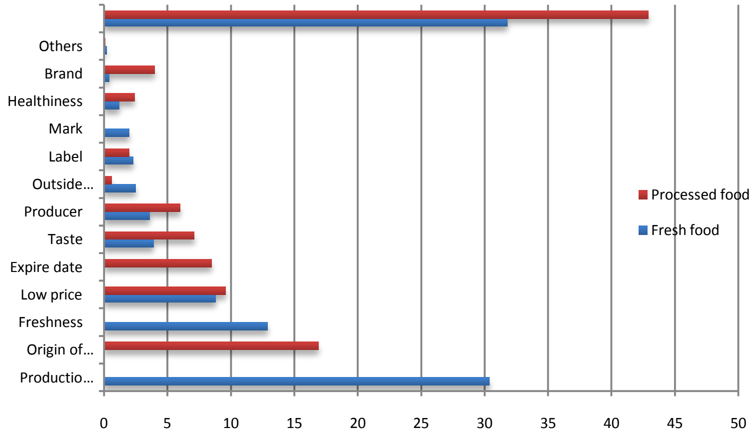


Figure 57. *After earthquake, items to be emphasized at the time of purchase of fresh and processed food in Japan (July 2011)*
Source: Japan Finance Corporation

The consumer attitude to purchase food products from the affected by the nuclear disaster regions has evolved in post disaster years (Figure 58). 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.

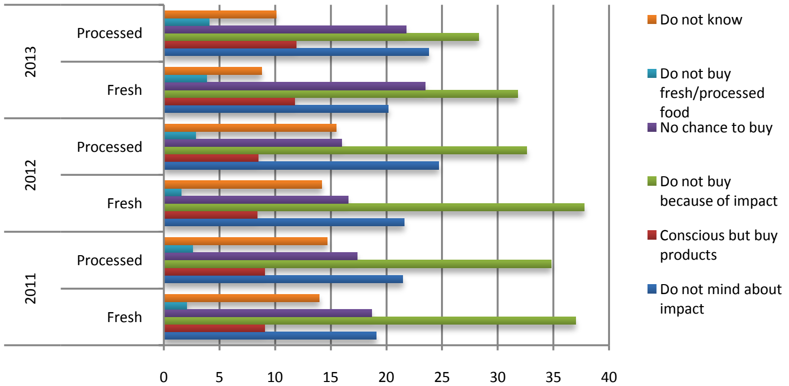


Figure 58. *Awareness when purchase fresh and processed food from region after nuclear accident (July 2011, January 2012, January 2013)*
Source: Japan Finance Corporation

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 59). 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 60).

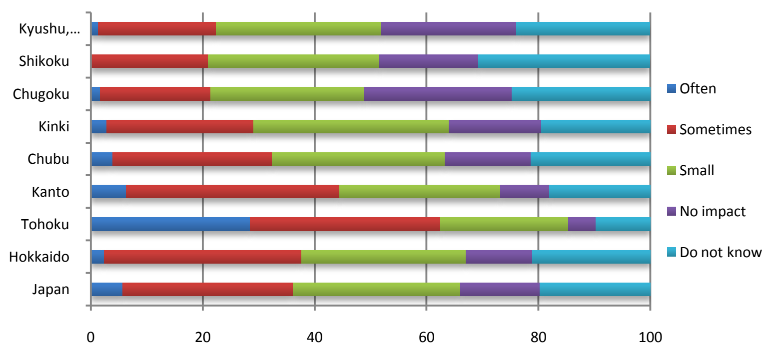


Figure 59. *Purchase of foodstuffs produced* in areas affected by Great East Japan Earthquake (including eating out) (January 2014)*
Note: *processed goods and agricultural products;
Source: Japan Finance Corporation

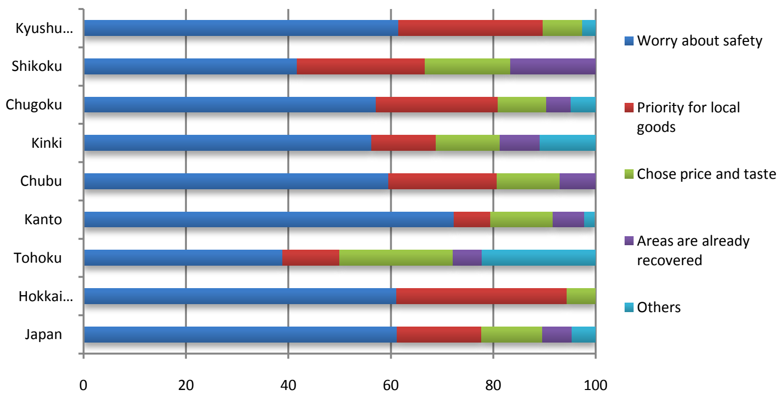


Figure 60. *Reason do not want to purchase even there is a promotion (January 2014)*
Source: Japan Finance Corporation

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. In 2011 the price of peaches from Fukushima dropped 100 to 200 Yen, and asparagus around 300 Yen compared to the same products from other regions (Murayama, 2012). Wholesale market shipment prices of vegetables in summer-fall 2012 were 20-30% lower in absolute terms than for 2011 (Watanabe, 2013). At the same time, new rice in 2011 was 10-20% more expensive than 2010 crop due to the efforts of wholesalers to purchase rice with no radioactivity (MAFF, 2012).

There was sharp decline in the demand and prices for the agricultural products mostly affected by the accidents such as vegetables, fruits, beef, etc. (Figure 61). In Fukushima prefecture the extent of price reductions and the pace of price recoveries have been much slower than the nation ones.

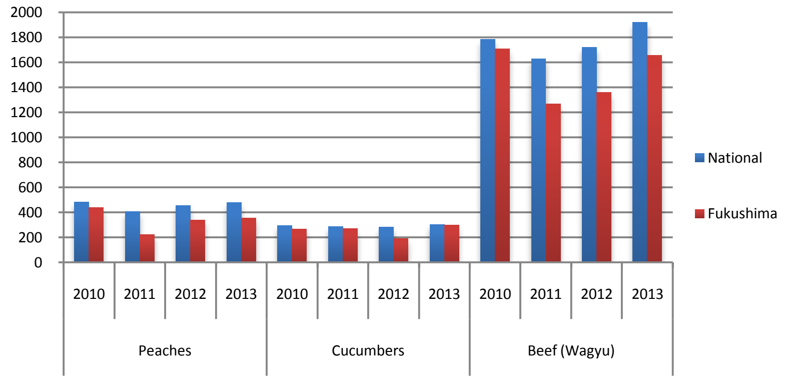


Figure 61. *Dynamics of prices of major agricultural products affected by nuclear disaster*
Source: Fukushima prefectural government

The farm products prices have not recovered yet in the most affected regions. For instance, in September 2014 farmers in Soma "were shocked by the price" that a local agricultural cooperative offered to pay saying they would not be able to make a living" (The Japan News, October 28, 2014). The cooperative offered ¥6,900 per 60 kg for Koshihikari brand rice harvest ranked as the highest grade which was about 40% lower than last year[286].

The effect of the nuclear disaster on prices can be demonstrated by comparing the dynamics of wholesale prices of major farm products from Fukushima prefecture and other regions. There was a considerable decline in the wholesale prices of beef cattle in Fukushima prefecture and in Japan after the accident (Figure 62). The prices in the country have been recovered and there has been gradual recovery of beef prices in Fukushima prefecture. Nevertheless, beef prices for different categories are still 12-13% lower in Fukushima prefecture comparing to the national prices.

[286] Prices are generally low nationwide due to abundant harvests and falling consumption in 2014. In Ibaraki prefecture ¥9,000 was offered for 60 kg - about 20% lower than in 2013.

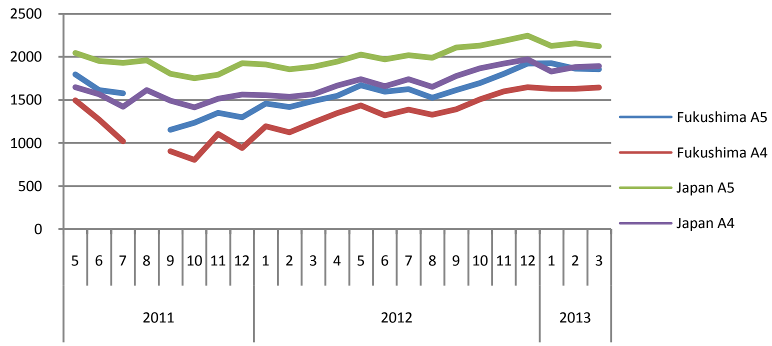


Figure 62. *Evolution of wholesale prices for beef cattle in Fukushima prefecture and other parts of Japan (yen per kg)*
Source: Central JA Union for Fukushima Prefecture

Similarly, on Tokyo Metropolitan Central Wholesale for the period July-December 2011 the average prices for wagyu (Japanese beef cattle) bullock carcasses for all producing regions were 19% lower than for the same period the year before (with a dramatic year-on-year drop of 25% in October) (Watanabe, 2013). The price of wagyu bullock carcasses from Fukushima prefecture declined by 50% in October 2011 compared to the same month of the previous year, and stayed more than 30% lower than the average price for all producing regions. Since the beginning of 2012 prices for all producing regions gradually recovered and by the end of the year returned to the level of three years ago (although under 2,000 yen/kg). The price of Fukushima bullock carcasses has been recovering but it remained more than 10% lower than the average for all producing regions.

At the first 2014 auction in Fukushima prefecture 873 calves put up for sale fetched an average of Y551,893 per head, 23% up from a year earlier, higher than the prefecture's average price (Y446,914) before the disaster, and close to the nationwide levels (Kachi, 2014). Likely wise, the price for a Japanese Black Cattle calf stood at Y548,776 per head on average in the nation's cattle market (113 locations) in December 2013[287] - 24% up compared with December a year earlier, and the highest since 1994 when the Agriculture and Livestock Industries Corporation organization started keeping records (Agriculture and Livestock Industries Corporation, 2014).

[287]December is typically when the prices are the highest.

According to the experts falling supply rather than growing demand drives beef cattle prices up nationwide and Fukushima prefecture alike (Kachi, 2014). Aging population and a lack of successors has cut the number of domestic cattle growers while high prices for cattle feed have pushed others out of the market. Fukushima farmers were strongly hurt by the March 2011 disaster (calf prices falling to Y308,628 per head in August 2011), which derived out cattle breeders and lead to the closure of two out of the three prefectural cattle markets.

There has been the same tendency at the Sendai central wholesale meat market in Miyagi prefecture. There has been significant decline in the number of transacted pigs and Japanese beef cattle in 2011 (Figure 63). Pig wholesale prices were increasing with the same nationwide tendency, but beef cattle prices decrease considerably more than the overall price reduction across the country.

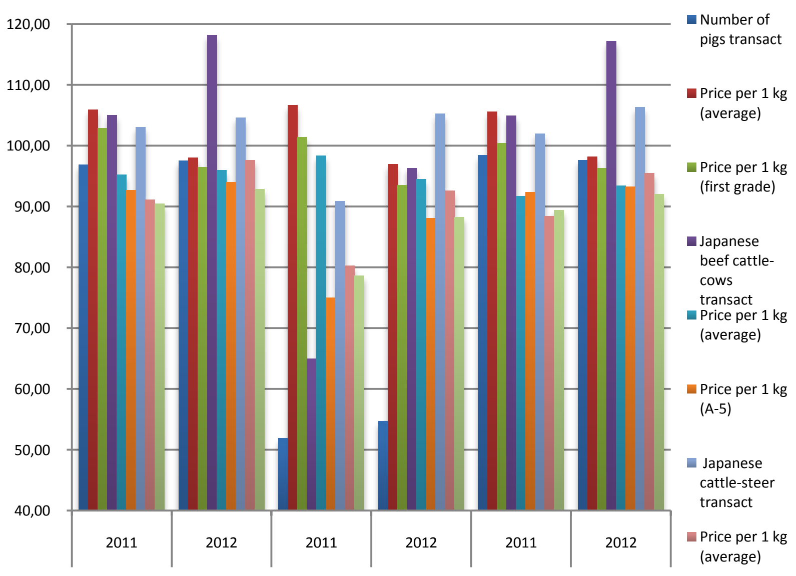


Figure 63. *Dynamics of number of transacted animals and wholesale prices at the central meat wholesale markets (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2012 there was a nationwide recovery above 2010 numbers for Japanese beef cattle transactions but wholesale prices were still below the pre-disaster level. In Sendai, recovery in the numbers and prices of traded animals was slower than in the rest of the country.

Fukushima prefecture is the forth-biggest rice-growing prefectures of Japan and rice accounts for about 40% of the prefecture's agricultural output[288]. After the nuclear accident the price of Fukushima rice fell in both absolute and relative terms (Watanabe, 2013). In 2012 rice prices in Fukushima prefecture bounced back in absolute terms, with a pace of recovery varying between 3 major regions. However, prices of the Fukushima rice continues to stay relatively lower comparing to the rice grown elsewhere. Before the nuclear accident (2005 - February 2011) Koshihikari brand grown in Nakadori region was traded between Tokyo dealers for more (on average 3.3% higher) than that in Kanto region. For the 2011 crop it was priced on average over 5% lower (falling down over 8% in February 2012) while for the 2012 crop remaining almost 3% inferior.

Fukushima prefecture was also a leading producer of summer-fall cucumbers and tomatoes. Before the nuclear accident, the Fukushima variety sold for about 10% more than the average for all producing regions at the Tokyo Metropolitan Central Wholesale Market (Figure 64). Price of Fukushima cucumbers fell more than 2% below the average in 2011 and almost 10% in 2012. Likewise, tomatoes priced were less than 8% below the average prices in 2011 and over 11% below in 2012.

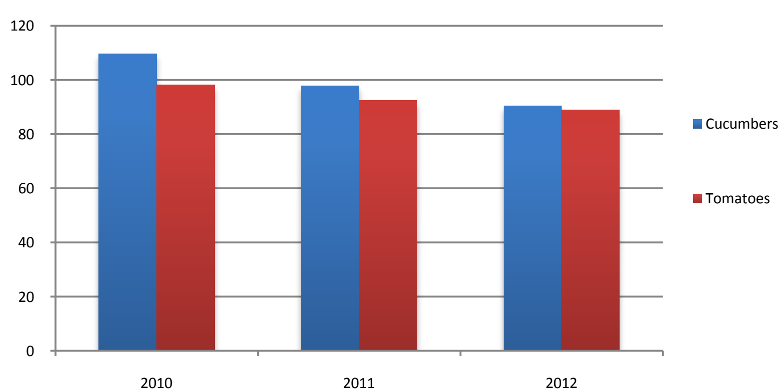


Figure 64. *Relative prices of Fukushima vegetables (average wholesale price = 100)*
Source: Ministry of Agriculture, Forestry and Fisheries, TMCWM

[288] Fukushima is divided into three regions (Hamadori, Nakadori, and Aizu) with extensive rice farming and local rice brands.

According to experts the prices of fruits in Fukushima prefecture (mostly bought for gifts) largely recovered since the consumers choice is not determined by the price but the "origin of product" (2013 interview with Prof.Komatsu).

In 2011 there was registered a decrease in the overall prices of agricultural commodities in the country (Figure 65). Prices of rice and vegetables declined more than the overall reduction (with 2.4% and 4.7% accordingly) while prices of fruits and pulses prices diminished a little (only 0.1% and 0.2% accordingly). On the other hand, potatoes and livestock prices slightly increased (2.5% and 1.2% accordingly) while that of industrial crop grown significantly (11.7%).

Diminution of the prices of Wheat and burley, Miscellaneous cereals and Leaf and stem vegetables was the highest, while that of Leguminous vegetables, and Hen eggs, and Young livestock increased the most.

There was a significant dynamics in traded quantities and wholesale prices of individual agricultural products. For instance, in 2011 there was a slight increase (0.36%) of wholesale traded domestically produces vegetables (MAFF, 2012). At the same time there was a considerable decline in the traded value (7.52%) and wholesale prices (7.93%).

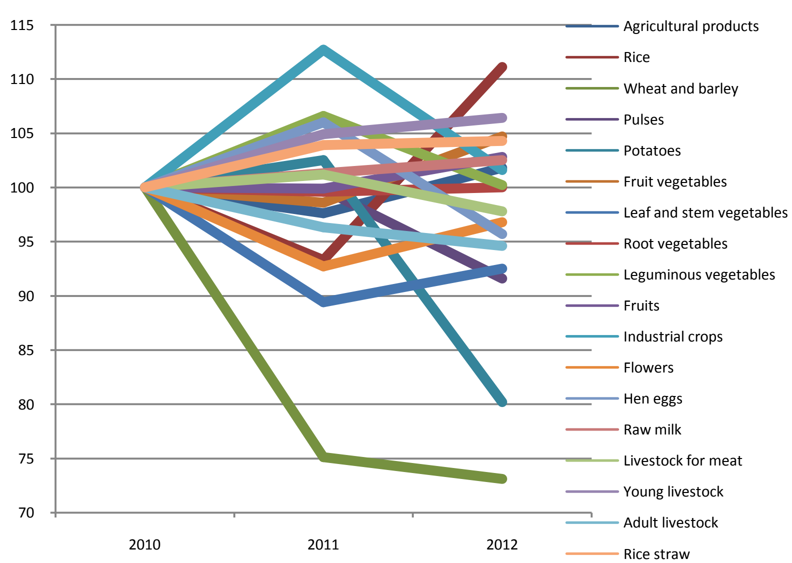


Figure 65. *Price index of agricultural commodities in Japan (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

Figure 66 shows the individual vegetables with the highest change (decrease or increase) in the wholesale quantities or prices. The most adversely affected in terms of traded quantities were Bamboo choots and in terms of price Parsley while the highest augmentation of amount was achieved by Yams and prices by Edible burdocks.

In 2012 there was a rebound of the agricultural products prices above the pre-disaster levels. The rice price demonstrated the highest growth, followed by the Young livestock and Fruit vegetables.

A significant dynamics in the wholesale quantities and prices of individual agricultural products persisted. For example, there was a small decrease (0.85%) in the wholesale traded domestically produces vegetables (MAFF, 2013). Simultaneously, significantly lower that the pre-disaster year levels of traded values (7.37%) and wholesale prices (7.84%) sustained. The greatest reduction in traded volume continued for Bamboo choots (20.68%) while potatoes showed the biggest decline in 2010 prices (43.67%). Cherry tomatoes registered the greatest augmentation in traded quantities (11.54%) and “Shungiku” in traded prices (21.69%).

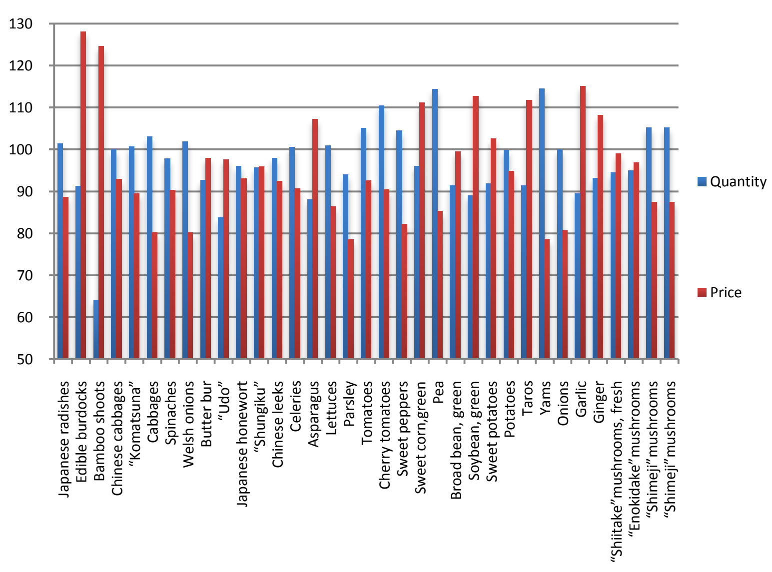


Figure 66. *Dynamics of wholesale quantities and prices of domestic vegetables with more than 5% change in traded volumes or prices in major cities in 2011 (2010=100)*

Source: Ministry of Agriculture, Forestry and Fisheries

Since March 2011 many consumers in the affected regions and throughout Japan have seen their direct procurement (e.g. prices) and transaction (information, search, assurance etc.) costs for supply of needed safe agri-food relatively from alternative regions, countries or guaranteed sources increased (Bachev & Ito, 2013). However, there are no detailed studies on these effects of the nuclear disaster yet.

Some research proves that a major way to minimize the transaction costs for supply of radiation safe product from a big number of costumers is to use "origin of product" selective governance (Uijie, 2012). A segment of consumers went even further to purchase only from the "guaranteed sources" like some Tokyo residents using direct sales contract to buy rice from Kyushu farms (Kakuchi, 2013). Some Fukushima farmers see growing new crops (like cucumbers) and direct sales to customers (rather than supermarkets) as a way to recover operations.

Experts argue that both producers and consumers are victims of the "reputation damage" (Koyama 2013). According to 2013 survey 26.1% of the consumers do not even know that inspections of radioactive contamination are being conducted (Consumer Affair Agency, 2013).

In order to facilitate communication with consumers, promote and recover Fukushima agricultural products numerous initiatives have been undertaken by farmers, agricultural organizations, NGOs, authorities, businesses, retailers, etc. such as: direct sells by farmers, on spot radiation tests, recovery markets, Farmers Café events, government "Eating for support" initiative, joint ventures with shops, promotion complains with participation of top officials, celebrities, journalists, and farmers in big cities, international fairs, etc. (Fukushima Minpo News, January 27, 2014; Inoue, 2014; The Japan News, March 8, 2014; Koyama, 2013; NHK World, May 17, September 21, 2014; MAFF, 2014).

For instance, the fast-food chain Yoshinoya has set up a joint venture to produce and market food from the Fukushima prefecture to help recovery (Thompson and Matsutani, 2013). The company provides funds (investment of Y10m or $102,000) through a joint venture (Yoshinoya Farm Fukushima Co) held with local farmers who will grow rice, onions and cabbages (35 tones), which then will go to the 1,175 restaurants the chain operates. Farmers in Fukushima had already been exploring the possibility of a similar link-up, but that project was put off following the nuclear accident.

The fight against "harmful rumors" has been also a high priority for local and national authorities. For instance, Fukushima prefecture is spending about 1.7 billion yen ($16.6 million) this fiscal year to fight rumors about radiation - fourfold budget increase over the previous year (Inoue, 2014)). In 2012 it hired popular the idol group Tokyo for commercials to appeal Fukushima agricultural produce in Tokyo area. In this year's survey of before-and-after results from the commercials the ratio of respondents who said they "do not want to buy" Fukushima produce dropped by about 10 points from 27% after viewing.

The central government plans to do more to help revive industries suffering from groundless rumors. The Reconstruction Agency compiled new guidelines for helping local businesses which say that: the government will continue releasing the results of radioactivity tests on agricultural products from Fukushima prefecture; continue to urge foreign countries to ease or abolish import restrictions; work to attract tourists, including students on school trips, from inside and outside Japan; urges related agencies to lead the way to help give the industries a boost; ask member companies of the Japan Business Federation to use Fukushima farm products as gifts and offer at in-house sales events; (NHK, June 23, 2014).

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.

Consumer food prices declined slightly in the post disaster years following the trend from the past (Figure 67). The biggest retail price diminution was marked for Vegetables and Seaweeds, while for Fruits, Fish and Shellfish the prices were increasing.

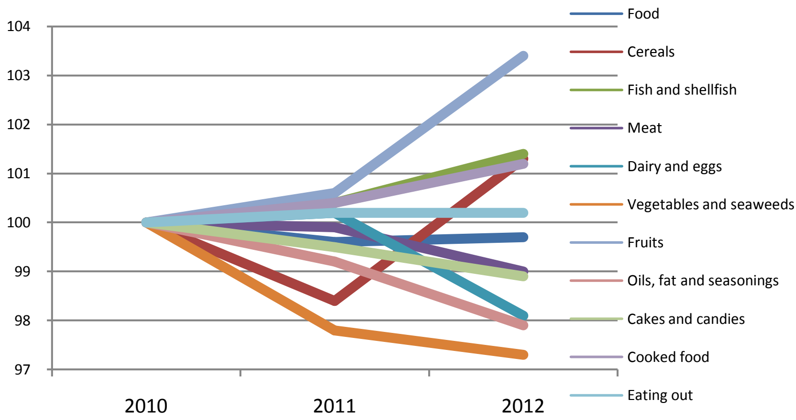


Figure 67. *Consumer food price index in Japan (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

Consequently, the annual household member food expenditures in the most of the biggest cities around the affected regions and nationwide declined in 2011 (Figure 68) following the downsizing trend in the past several years (MAFF, 2013). In 2011 it was registered a food costs rise in Aomori and Morioka as well as a higher than the national enlargement food costs in the most affected prefectures (Aomori, Morioka, Sendai, Akita, Mito) in the following year.

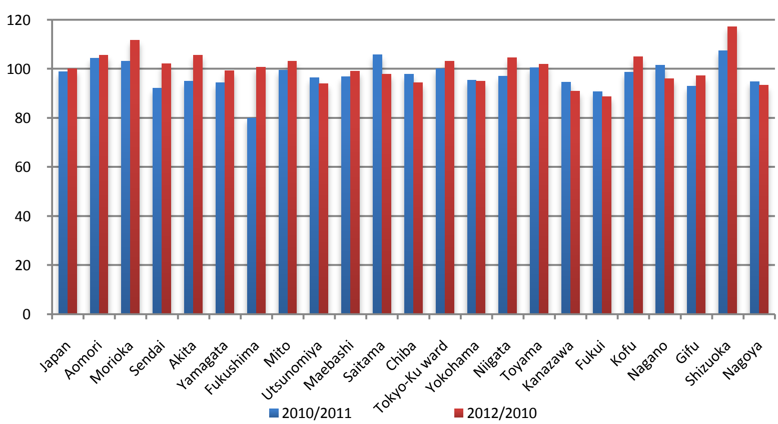


Figure 68. *Dynamic of Annual Food Expenditures per Household Member* in prefectural capitals of affected regions (2010=100)*
Source: MAFF; **Note:** * in households of 2 or more persons

All surveys show that there is increased awareness of the needs to keep foodstuff at home after the 2011 disasters (Japan Finance Corporation, 2014). Furthermore, around 29.5% of consumers report they kept food stockpiles at home event before the disaster, 21.5% are keeping such piles after the disaster (much higher percentage in worst affected Tohoku and Kanto regions), while 7.9% kept after the disaster but currently not (much higher in Tohoku region) (Figure 69).

Data show that in 2011 the daily intake per person for some of the most likely affected by the nuclear disaster food groups decreased comparing to the period before the accident (Figure 70). For instance, consumption of mushrooms dropped by 12.5%, seaweeds by 5.4%, pulses by 6.5%, etc. The later change in the national consumption pattern is probably a consequence of the newly emerged consumers risk concern, higher procurement costs or other (unspecified) reasons.

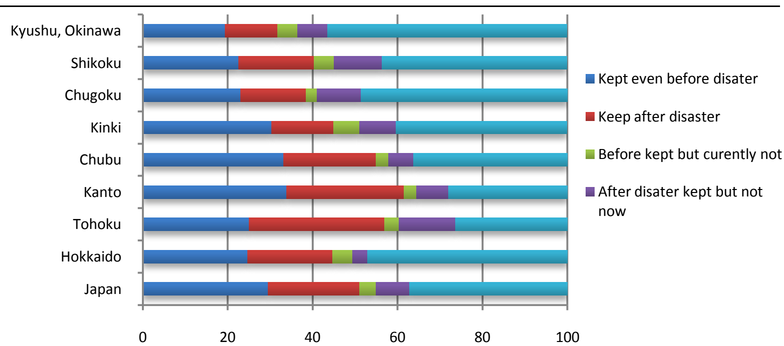


Figure 69. *Stockpiling of food (incl. drinking water) at home after Great East Japan Earthquake (January 2014)*
Source: Japan Finance Corporation

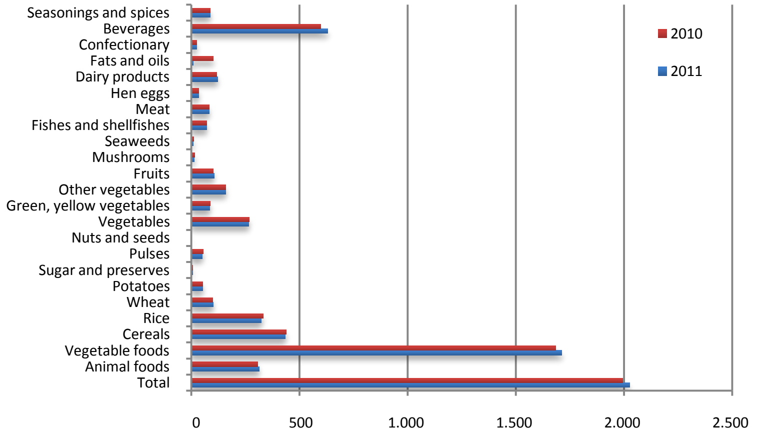


Figure 70. *Daily intake per person by food groups in Japan (grams)*
Source: Ministry of Health, Labor and Welfare

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

By March 1, 2013 as many as of 10 countries completely lifted radionuclide related restrictions on food products from Japan including Canada, New Zealand, Malaysia, Mexico, Peru, Chile, Columbia, Guinea, Myanmar, Malaysia and Serbia (Reconstruction Agency, 2014).

Various initiatives have been undertaken to promote food-safety among major importers of Japanese agri-food products (Hong Kong, Singapore, Taiwan, etc.) like fairs, information etc. Recently Chiba[289] governor has called on Taiwan to lift the ban on imports of food and agricultural products requesting Taiwanese inspectors be dispatched to Chiba to see the inspection process (NHK World, October 27, 2014).

On August 18, 2014 for the first time Fukushima rice was exported (60 bags of 5kg of "Koshihikari" variety harvested in Sukagawa) for high-end supermarket in Singapore (Fukushima Minpo News, August 19, 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 (Figure 71).

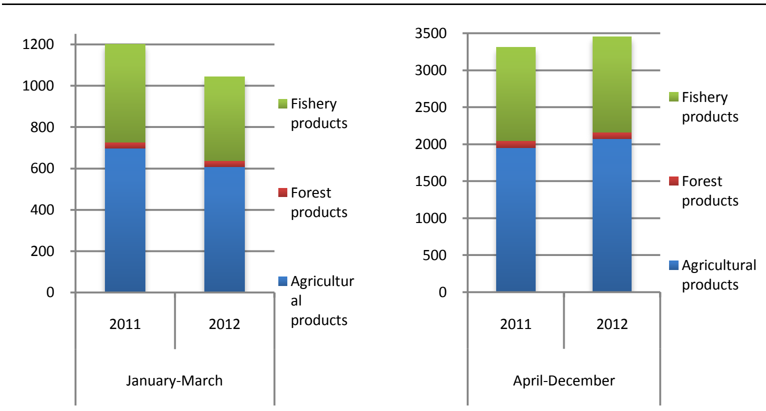


Figure 71. *Value of agricultural exports before and after March 2011 disaster (hundred millions of yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

Consequently, there was a considerable decease in the overall agricultural (including fields crops and livestock products) as well fishery products export in 2011 (Figure 72). At the same time, there was a significant increase in the import of agricultural,

[289] Among 5 prefectures with food and agricultural products blanket ban in Taiwan.

forestry and fishery products as imports of farm products jumped 16% to 5.58 trillion yen in 2011 (Figure 73).

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 was 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.

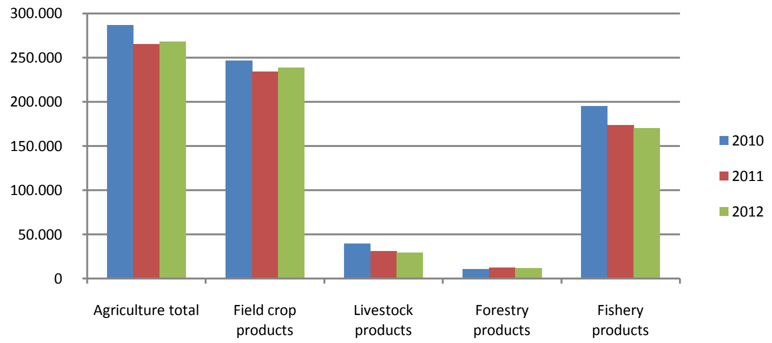


Figure 72. *Dynamics of agricultural, forestry and fishery export of Japan (million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

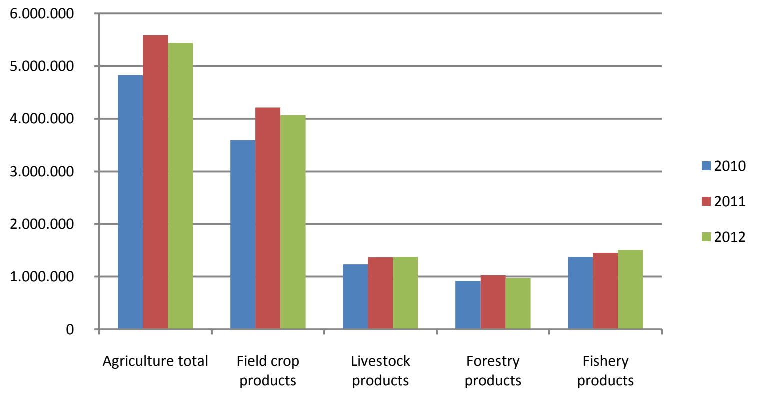


Figure 73. *Dynamics of agricultural, forestry and fishery import of Japan (million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

Japan's exports of agricultural, forestry and fishery products (like marine products, beef, processed foods and sake) hit a record in 2014 for the second consecutive year (The Japan News, December 27, 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.

Chapter 11. Effects on Food Regulation and Inspection System

Up to the Fukushima nuclear plant accident there had been no adequate system for agri-food radiation regulation and inspection to deal with such a big disaster (Ministry of Agriculture, Forestry and Fisheries, 2011). On the wake of the accident a number of measures were taken by the government to guarantee the food safety in the country.

Widespread inspections on radiation contamination were introduced and numerous shipment and consumption restrictions on agri-food products imposed.

Within a week from the nuclear accident (March 17, 2011) Ministry of Health, Labor and Welfare introduced Provisional regulatory limits for radionuclides in agri-food products[290] (Table 27).

Table 27. *Provisional regulatory limits for radionuclides in agri-food products (Bq/kg)*

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

Note: *for infants; ** values take into account the contribution of radioactive strontium.
Source: Ministry of Health, Labor and Welfare

[290] Based on intervention exemption level of 5 mSv/y and 50% contamination rate (Ministry of Health, Labor and Welfare, 2011).

On 29 March 2011, the Food Safety Commission of Japan drew up a report guaranteeing that the ongoing measures based on provisional regulation values are effective enough to ensure food safety for consumption, domestic distribution and exportation. On 4 April 2011 the Ministry of Health, Labor and Welfare decided to use the ongoing provisional regulation values for the time being and set up provisional regulation value for radioiodines in seafood (April 5).

In order to meet growing public safety concerns since April 1, 2012 new[291] official limits on radioactive cesium[292] in food items have been enforced in the country (Table 28). Four categories of Drinking water, Infant foods and Milk, and General foods are distinguished. New safety standards are more stringent than international ones – e.g. maximum allowed radioactive substances in the European Union and USA in grains are accordingly 1250 Bq/kg and 1200 Bq/kg, in vegetables 500 Bq/kg and 1200 Bq/kg, in drinking water 100 Bq/l and 1200 Bq/kg, etc.

Table 28. *New standard limits for radionuclides in food in Japan (Bq/kg)*

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

Note: * limit takes into account the contribution of radioactive strontium, plutonium etc.
Source: Ministry of Health, Labor and Welfare

For some raw materials and processed food (like rice, beef, soybean) there were transitional measures and longer periods (until December 31, 2012 or "the best before date") for complete enforcement of the novel safety standards. The reason is that producers of such commodities need more time for preparation to prevent any confusion in distribution at the time of shift to new limits for radionuclides in food (Figure 74).

[291] Annual maximum permissible dose from radioactive cesium in foods reduced from 5mSv to 1mSv - the same as Codex GLs (Ministry of Health, Labor and Welfare, 2012).
[292] Standard limits are not established for radioactive Iodine, which has been no longer detected (short half-life), and Uranium, which level is almost the same in the nuclear power plant site as in the nature environment (Ministry of Health, Labor and Welfare, 2012).

Figure 74. *Transitional measures for enforcement of new standards for radionuclides in food in Japan*
Source: Ministry of Health, Labor and Welfare

In addition, the Ministry of Agriculture, Forestry and Fisheries undertook a number of measures to improve food safety: provided advice on creation of food inspection plans and supporting inspection equipment installations in affected prefectures; commissioned laboratories to analyze agri-food contamination; implemented technical guidance regarding feeding and management of livestock (March 19, 2011); set up provisional tolerable levels for forage for producing milk and beef below the provisional regulation value for food (April 14, 2011); set up provisional tolerable levels for fertilizers and feed for preventing radioactive contamination of farmland soil from expanding and for producing agricultural and animal products below the provisional regulation value for food (August 1, 2011); released a farmland soil radiation level map (August 30, 2011) and updated it covering a wider scope and more details (March 23, 2012); supported emergency radiation inspections for rice in Fukushima prefecture and conducted analysis of factors for radioactive contamination over the regulation level (November 2011); implemented restrictions on rice planting (April 22, 2011; February 28, 2012; March 25, 2013; March 7, 2014); revised provisional tolerable levels for producing animal and fishery products below the standards limits for radionuclides in foods (February 3 and March 23, 2012); published farmland decontamination technical book (August 2012), publish list of registered administrative and private laboratories for radionuclide inspections (April 1, 2013), etc.

At the Fukushima Agricultural Technology Center, in Koriyama city, advance laboratories for emergency radiation monitoring of agricultural produces are equipped with 10 germanium semiconductor detectors and 16 of stuff trained to conduct precision analysis. They work 6 days a week from 8 am to 21 pm analyzing 200 items per day. As many as 461 items have been regularly monitored in the prefecture. The results of analysis are released on the next day through website of the center, published in the regional newspapers and other media. For the period March 19, 2011-March 31, 2013 as much as 81,502 items were analyzed.

Since June 2011 regular radiation tests have been carried out on a great number of agri-food products[293] in 17 prefectures in Northeastern and Eastern Japan. In addition, since 2012 all rice bags[294] produced in Fukushima prefecture have been checked in the Agricultural Cooperative inspection cites.

There have also emerged many private and collective inspections systems introduced by farmers and rural associations, food processors, retailers, local authorities, consumer organizations, independent agents etc.

For instance, in Nihonmatsu-shi, Towa town, there was a sharp decline in well-developed before the nuclear accident tourism and agricultural sells. The local Rural Development Association introduced radiation measurement of farm products in June 2011. It is done in own laboratory (equipment supplied by a private company) and costs 500 yen per test for farmers. Due to the timely introduction of safety inspection and the proper product safety reporting (labeling) the number of costumers visiting that farmer market recovered almost fully as well as 80% of the sells on not restricted items (interview with the Chairman of the Association Mr.Muto, July 6, 2013). The municipality has also introduced 60 points for the inspection of food for self-consumption (done free for producers).

Similarly, a group Rebuilding Beautiful Country from Radiation launched an inspection service soon after the nuclear accident through a non-governmental fund (Kakuschi, 2013). It supports more than 90,000 farming households who pay a nominal fee to have produce inspected for contamination and declared safe for consumers.

The Agricultural Cooperatives in Fukushima prefecture conduct own testing using analytical equipment (such as NaI scintillation spectrometer) either purchased or borrowed from a government agency (Watanabe 2013). Member farmers bring crop samples to testing sites before shipping, where measurement is done (about 30

[293] In late March 2014 the number of items was reduced from 98 to 65 because of low detection rate (Fukushima Minpo News, May 21, 2014).
[294] One baggage is 30 kg.

minutes) for free. Many agricultural cooperatives in the prefecture have in place systematic testing regimes covering every farm and item, and all members are required to have produce tested before shipping.

The Fukushima Consumer Cooperatives Union has also 30 machines around prefecture for food inspection and training of members. In addition, it introduced 35 machines for radiation body check providing free mobile service including in neighboring prefectures.

Many farmers groups and organizations from heavily contaminated areas have been organizing own tests on soils (detailed maps), inputs (water, livestock feeds) and output to secure safety. For instance, a large scale tests to collect data[295] and find a solution on fighting rice contamination has been carried by a group in Nihonmatsu which is no comparable with other experiments done by national or local governments (NHK World, March 10, 2014). Another producer group from Nihonmatsu developed a way to put all information about products (contamination, beta-carotene and sugar content sugar) and grower details into a QR code - a kind of bar code that people can scan with cellphones (The Japan News, March 7, 2012).

According to the Fukushima Food Industry Organization many of the member companies bought own equipment for radiation checks of ingredients, water and final produces, or use outside safety checks to avoid risks, deal with harmful humors, and secure customers. Likely wise, practically all heads of cattle are tested at meat processing plants in Tohoku and Kanto regions, and throughout Japan (Wayanabe, 2013).

Big retailers (like Aeon) have also strengthened testing with a goal of selling cesium-free food only. A mail-order company based in Tokyo (Cataloghouse Ltd.) allocated space for fresh food from Fukushima (August 2011) and sells only products cleared safety standards giving explanation on labels (Kakuchi, 2013). The store bought a testing machine (for 3.5 million yen) and checks the cesium level in food in front of customers.

Recovery, Sunday, evening, promotion etc. markets, Farmers' Document and Farmers' Café events etc. organized by farmers, authorities, NGOs, food chain partners etc. have been regularly held in Fukushima and around the country, where farmers sell directly products confirmed as safe through voluntary screening

[295] Proved that organic crops arenot contaminatrd- well-mainatined soil immobilizes Cs.

(Koyama, 2013). A numerous big processors and retailers have been also promoting products from the affected regions nationwide (The Japan Times, March 10, 2014).

Farmers, farmers' organizations, food industry, and local communities have introduced various voluntary restrictions on sale.

According to some farmers the biggest hurdle they face is the lack of a clear radiation risk standard that can be universally accepted (Kakuchi, 2013). In order to address consumer concerns on food safety some producers, processors and retailers started to use lower than the official norms for radiation. According to one of the interviewed by us experts – Mr.Nagashima, working at Agricultural Cooperative in Fukushima "Farmers in Fukushima are trying to satisfy the government's strict standard for the radioactive contamination and even to have results below 25Bq/kg ("Not Detected"), which is the limit for inspection by screening method" (June 6, 2013).

There has been a progress in efficiency of radiation testing devices for farm and food products. From April 2014 the Fukushima prefecture introduces easy to use and more accurate radiation detectors at community centers and other public facilities so that residents will no longer have to cut up items into small pieces and get result faster[296] (Fukushima Minpo News, March 3, 2014).

All these measures and actions taken at production, distribution and consumption stages have let the Fukushima agri-food products to become one of "most secure in the world" (Fukushima Minpo News, January 27, 2014). Nevertheless, many concern consumers continue to disbelieve in the existing inspection system and employ other ways to procure safe food - direct sales contracts, origins, imports, etc. (Kakuchi, 2013; Ujiie, 2012).

There have been a number of challenges with the present system of safety inspection. Due to the lack of personnel, expertise, and high-precision equipment, the water, food and soil tests have not always been accurate, consistent and comprehensive. For instance, quite expensive high-precision instruments are not available everywhere to measure lower radiation levels set up by the new regulation (e.g. for drinking water capable of detecting a single-digit level of becquerels).

[296] Now residents can test home-grown vegetables and wild plants at community centers but detectors require cutting 500 grams into small chunks, and 30 minutes to get results.

Food safety inspections are basically carried out at distribution stage (output for shipment or export)[297], and do not (completely) cover produces for farmers markets, direct sells, food exchanges and self-consumption. Nevertheless, the prefectural government and municipalities in Fukushima have been strengthening inspections for self-consumed agricultural products since 2013.

Capability for radiation safety control in Fukushima prefecture is significantly higher than in the other affected regions, while radiation contamination has "no administrative borders". Most food is regularly inspected in Fukushima prefecture and is much safer than other prefectures where strict tests are not carried out at all.

Many of privately and collective employed testing equipment are not with high precision, and/or samples are properly prepared for analysis (by inexperienced farmers). Consequently, some of the sold and consumed products are labeled as "Not detected" despite existing contamination. Some tested agricultural products are further cooked or dried reaching higher levels of radiation at consumption stage. Uptake of radioactive materials with food by local residents increases especially during summer season when mostly fresh vegetables and fruits are consumed.

There are also untested wild plants or produced food, which are widely consumed by local populations – e.g. radioactive contamination in forestry trees leaves is found far away in Nagano prefecture[298].

There are considerable discrepancies in measurements of radiation levels in air and food done in a specific location – e.g. in Nihontatsu-shi the NGO and Government laboratories are located across the street (50 m of each other) but often register different radiation in environment and food.

Agri-food inspections, regulations and countermeasures are conducted in vertically segmented administrations with "own" policies and not (well) coordinated procedures. For instance, soil contamination surveys and inspection of agricultural produce is conducted by the Ministry of Agriculture, Forestry and Fisheries, monitoring of air radiation levels by theMinistry of Education, Culture, Sports, Science andTechnology, regulations on food safety standards and value determination by the Ministry of Health, Labor and Welfare, decontamination and waste disposal by the Ministry of the Environment, training associated with food safety by the

[297] Cropping is not restricted and inspection carried at ex-post production - shipping stage.

[298] Some sayit was there before due to natural or manmade (nuclear tests) radiation.

Consumer Affairs Agency, and restoration and decontamination programs by the Reconstruction Agency.

There are no common procedures and standards, nor effective coordination between monitoring carried out at different levels and by different organizations (national, prefectural, municipal, farmers, business, research, etc.). Neither there is a common framework for centralizing and sharing all related information and database, and making it immediately available to interested parties and public at large.

Officially applied "area based" system for shipment restrictions have been harming many farmers producing safe commodities. For instance, 2014 screenings of shiitake mushrooms grown on logs in two municipal areas of Fukushima prefecture have found that samples of four farmers do not contain radioactive substances above the upper limit[299] (Fukushima Minpo News, June 11, 2014). Therefore, instead of a municipal area wide blanket lifting and a permit mushroom shipment by selected farmers would be more appropriate.

Last but not least important, there have been on-going discussions among experts about the "safety limits" and that lack of agreement additionally confuses producers and consumers alike.

One of the interviewed by us experts – Mr.Satou, working at prefectural government agricultural department said "I regret to have easily believed the "myth of safeness of nuclear power plant" and not having prepared enough for the disaster - not having made safety standards of restriction for radioactive contamination, enough machines to inspect radiation in agricultural organization, and research about technologies for preventing radioactive contamination. Floods of information confused both producers and consumers after the accident. People did not trust government's information which was caused from the government's attitude after the accident, such as not announcing the data SPEEDILY" (June 6, 2013).

There have been attempts to improve coordination and cooperation between different agencies and organizations. For instance, analysis on contamination of agri-food products is one of the major working areas of the Fukushima Future Center for Regional Revitalization. When unsafe food item is found, the Fukushima Agricultural Technology Center is informed, and the later take decision for ceasing shipments. Similarly, the Soil

[299] Out of 65 shiitake samples from greenhouses, 52.3% were measured below lowest detectable limit and the rest far below the upper limit, with a maximum of 6.6 Bq/kg (Fukushima Minpo News, June 11, 2014).

Screening Project in Fukushima is coordinated by the Fukushima Consumer Cooperatives Union with participation of a number of regional agencies and volunteers from the country.

Experts suggest existing system to be further improved by creating uniform inspection manuals and standards, enhancing coordination and avoiding duplication between different organizations, establishing inspection framework that cross prefectural borders, and a new management system that extend random sampling tests of circulating produce (shipment level) with management/control at production "planning" stage (Science Council of Japan, 2011; Koyama, 2013).

The latter is to be based on detailed contamination maps of each agricultural field based on soil analysis and a farmland certification system[300] targeting to establish production practices (crop selection, land decontamination, inputs control) preventing agri-food products contamination. Depending on the degree of radiation dose, an effective decision could be made whether to restrict cropping (high level), decontaminate (medium level), or encourage certain type of crops combined with further reduction measures (low level).

Another challenge associated with the current inspection system is the costs. The Fukushima prefecture costs for food testing, including sample purchases, amount to about 150 million yen each year[301] (Fukushima Minpo News, May 11, 2014). When tests conducting began (June 2011) available funding for food screening was about 2 billion yen while in May 2014 only about 600 million yen. The Fund is also used for projects and is expected to deplete in several years unless central government extends support. The prefectural government plans to maintain the number of tested items but it is unclear how much support the government will give (it decreased the number of items subject to screening).

The Fukushima prefectural government will continue to check all packs of rice harvested in the prefecture for radioactive contamination after the end of fiscal 2014 (Fukushima Minpo News, July 5, 2014). The program costs about 700 million yen a year and there is central government's approval to continue it until fiscal 2017. The prefecture also announced that it will screen for radioactive contamination all logs used for "shiitake" mushroom cultivation[302] blanket log test starting with the Aizu region[303]

[300] Like certification system "Guideline to indicate specially cultivated agricultural products".

[301] From the Fund for Residents' Health Management.

[302] It will be the third time for the local government to check all products and materials prior to shipment (following rice and persimmons).

(Fukushima Minpo News, September 26, 2014). However, the Fund for radioactivity-checking program is running short and there is no idea how long to continue the program in its present form.

Producers have also expressed dissatisfaction over the Ministry of Health, Labor and Welfare's new guidelines to reduce testing underlying that the government perception is very different from the field (Fukushima Minpo News, May 11, 2014). According to official from the Fukushima Japan Agricultural Cooperatives crisis management center the "Effects of unfounded rumors are still strongly rooted. It is inconceivable to say we have a choice of not conducting the testing just because radioactive substances have not been detected. We need to carry out the testing at least until the stage in which trouble at the nuclear plant, including the contaminated water issue, does not occur at all".

Some farmers started to be nervous about the efficiency of the applied methods. In some places they discuss to cease inspections, which are associated with significant costs (time for preparation of samples, shipment, payments for tests) with no adequate compensation received or a farming recovery progressing.

An interviewed by us expert – Mr.Sunaga, retired officer from the prefectural government put it that way: "Cultivation management and inspections to secure safety is needed despite they are imposing heavy burden in short terms. However, there are worries how long we should continue these works. Farmer's willingness to continue is also declining because it is unclear when they can recover consumers' trust (June 4, 2013).

Public food safety policies have been also positively affected. March 2011 earthquake and the following nuclear disaster considerably impacted citizens' consciousness on food security in Japan. This disaster has prompted more 34.3% of the consumers to "become conscious of need of food storage" on the top of another 34.5% who "remained conscious with that need" (MAFF, 2012). A great part of the surveyed consumers have also strongly recognized the importance of different food supply arrangements (Figure 75).

There have been a number of challenges in the public support responses as well. Most important among them are: a delay in establishing the Reconstruction Agency (February 2012) for coordinating multiple recovery efforts in affected areas; a lack of clear government guidelines for the nuclear disaster recovery, a lack of detailed contamination map for all affected agricultural

[303] Equipment will be put for 2015 year's harvesting season in fall. New testing will expand in rest of prefecture to restore it as largest producer of mushroom growing logs.

lands, using extension officers in affected areas for obtaining samples for monitoring tests while suppressing their ability of consulting, introducing technology, and educating in areas of production badly needed, etc. (Koyama, 2013).

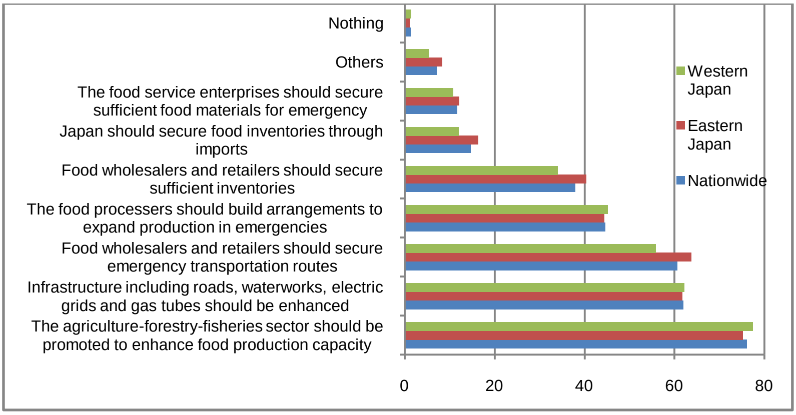


Figure 75. *Measures considered to be required for stable food supply in Japan, 2012 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

Chapter 12. Farms and Agri-Businesses Damages from Nuclear Accident

It is quite difficult to access the enormous economic damages from the Fukushima nuclear disaster on the Japanese farms and agri-businesses. The scale and directions of the negative effects have been huge. Some of the economic impacts could hardly be measured in quantitative (e.g. monetary) terms such as: lost livelihood and accumulated with many generations capital (community relations, permanent crops, livestock herds, established brands, networks, etc.), degradated natural resources (farmlands, waters, crop and livestock varieties, biodiversity, landscape), labor health implications (reduced productivity, increased healthcare costs) etc. (Bachev & Ito, 2013).

Principally the immediate and shorter-term negative effects on farms and agri-business have been in a number of directions (Figure 76):

1. Direct production damages on crops and livestock products due to the radiation contamination. A large amount of yields of crops (mostly vegetables) was lost since it was not safe to consume or process. As a result of the government sale bans farmers from a large territory had to dump millions of liters of milk, and tons of ripe vegetables and fruits. For instance, Kenzo Sasaki milking 18 cows on a farm outside Fukushima city was reported losing nearly $31,000 every month from the sales ban not including the cost of feeding the herd (Wines, 2011). Similarly Shoichi Abe, grazing 30 cows was unable to sell his 1,100 pounds of daily production (costing 70,000 yen a day or about $860) because the earthquake

damaged the local co-op milk-processing plant and the government prohibition.

2. Decreased production and income due to production and/or shipment restrictions, and low market demands for products and services. In early April 2011, government restricted planting of rice and other crops in soil with more than 5,000 Bq/kg of cesium. There was also a ban or delays of shipment of beef and other major agri-food produces. As a result of voluntary restrictions, declined consumer demands, reduction in the number of local population (evacuation and/or outmigration) and tourists, and "harmful rumors" many farmers and businesses lost significant markets and income.

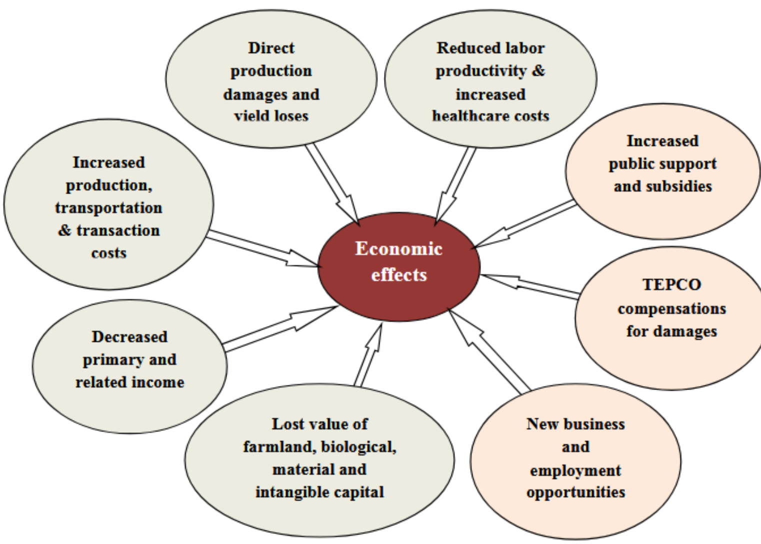


Figure 76. *Economic effects from Fukushima nuclear disaster on farms and agri-business*

For instance, considerable areas of rice paddies in Fukushima prefecture have been subject to a planting ban and other restrictions. In 2012 there were planting ban on 7,600 ha located in the exclusion zone, and around 400 ha elsewhere in the prefecture, being paddies where more than 500 Bq/kg were detected in the 2011 rice crop (Watanabe, 2013). In addition, several municipalities independently decided to call for voluntary restraints on planting of paddy rice over a total area of 5,600 ha.

The combined total area of rice paddies subject to restrictions was almost 13% of the 2010 area of paddy fields[304] in the prefecture.

Numerous shipping restrictions have been imposed on agricultural products in the prefecture. Despite the area subject to restrictions has gradually diminished most of the affected products are local specialties and important cash source. The negative impact on farm households' income has not been negligible (Wanatabe, 2013).

There has been important items subject of voluntary restraints on processing such as ampo-gaki and dried persimmons. Unusual technique for producing ampo-gaki originated in the northern part of the prefecture, and before the accident this popular local brand generated impressive revenues (Wanatabe, 2013). Since 2011 voluntary restraints on processing have been imposed in seven municipalities in the north part of prefecture.

Similarly, roughage such as grass and rice straw cannot be produced, used (fed to livestock), or distributed by livestock farms, unless they are proven to be within safety standard by monitoring inspections[305]. The use and distribution of compost are also prohibited unless monitoring inspections on each farm find radioactivity to be under the standard limit[306]. Collaborative efforts between crop and livestock farmers to recycle resources locally (e.g. livestock farmer using compost on own land or supplying it to crop farmers, or growing feed as alternative crop and sell out fodder) have lost momentum even when radioactivity has been within safety norms (Watanabe, 2013). Consequently, livestock farmers' ability to supply own roughage or source it locally has been reduced, and serious difficulties with disposing livestock manure and compost application and circulation created.

Likely wise, leaf tobacco is grown throughout the prefecture (especially the Nakadori area) but voluntary restraints were imposed on tobacco planting in 2011. Farmlands under contract to sell leaf tobacco plummeted from two thirds (from 992 ha in 2010 to 320 ha in 2012) partly because of the imposition of more stringent safety standards by Japan Tobacco Inc. (Watanabe, 2013).

Before the disaster Fukushima prefecture was known as "Tokyo's vegetable basket" and the Japan's second largest producer of peaches, the third largest producer of Japanese pears,

[304] Production targets equivalent to around 45,500 tons or 8,300 ha (547 kg, average yield per 10a in 2012) were reassigned elsewhere in prefecture (Watanabe, 2013).

[305] Provisional maximum level for fodder fed to cattle and horses is 100 Bq/kg.

[306] Provisional maximum level for radioactive cesium is 400Bq/kg.

the fourth largest producers of rice, the fifth largest producer of apples, the twelfth largest producer of grapes, etc. Orders of all these major produces plunged after the nuclear plant crisis due to fears about radiation even though radiation levels have been well below the safety limits.

According to a survey 88.5% of the farmers in Iwate, Miyagi and Fukushima prefectures suffered from the consequences of the 2011 disasters, and most of them (71.4%)[307] were still suffering in 2012 (Japan Finance Corporation, 2012). The downslide of selling price and the harmful humor were the main cause of the negative impact on farms in these regions.

After the nuclear accident, the Gross Agricultural Product in Fukushima prefecture shrunk by 47.9 billion JPY (Ministry of Agriculture, Forestry and Fisheries). There has been also agriculture-related damages amounted to 62.5 billion JPY (by May 2012). The annual loss from the nuclear accident in the prefecture is estimated to be around 100 billion JPY (Koyama, 2013). Latest data indicate that rice output in the prefecture is USD 300 million short comparing to before disaster (NHK World, November 12, 2014). And all these figures are only a calculation of damages based on flow of agricultural output (production and sells) while there has been significant unaccounted damage to farmland, rural organizations and personal relationships ("social capital") important for the Japanese agriculture.

A great majority of the surveyed food companies in Fukushima prefecture report lower income due to the decline in sales after the accident (Fukushima Food Industry Organization, February, 2013). Popular agri and rural tourism and other related businesses and services in affected areas have been also badly damaged after the disaster.

The same has been true for Ibaraki prefecture, famous with the highest production of melon, lotus roots, and blades like potherb mustard, chingen-sai (pakchoi) and mitsuba (honewort), the second highest production of rice in the country, and well developed agri-processing, etc.

On August 5, 2011, the government released interim guidelines for determining nuclear losses (Ministry of Agriculture, Forestry and Fisheries, 2011). On September 12, it established the Nuclear Damage Liability Facilitation Fund to support nuclear damages payments. In addition, Dispute Reconciliation Center for Nuclear Damage was established in order to encourage conflicts resolution. By March 2012, the agricultural damages payments associated

[307] 17.1% "had suffer but no anymore", while 11.6% "not suffer".

with the nuclear disaster totaled about 106.2 billion yen (Ministry of Agriculture, Forestry and Fisheries, 2012).

Councils were set up around the JA Group in 18 prefectures in eastern Japan to assist producers through the procedures for damage claiming. Some of the direct damages to farms' production and marketing have been specified with the compensation claims of farmers to TEPCO.

Until the end of September 2011 the compensation for damage to crop and livestock produce from the nuclear disaster demanded by 14 prefectures reached 70.9 billion USD (Table 29). The biggest claims for damage were for months after June, as Fukushima and Ibaraki prefectures accounted for the three quarters of all group agricultural claims to TEPCO. During the same period the provisional payments actually dispersed by TEPCO were 20.2 billion yen or less than 30% of the total claims (JA-ZENCHU, 2011).

Table 29. *Claims for damage to crop and livestock produce from nuclear accident as of end of September 2011 (million yen)*

Prefectures	April	May	June	July	August	September	Total
Iwate						29	29
Miyagi					222	367	590
Akita						102	102
Yamagata					63	202	265
Fukushima		478	2559	6527	8070	9905	27539
Ibaraki	1846	6619	7609	5702	2870	1633	26279
Tochigi	1108	1344	1298	1239	313	295	5595
Gunma		1607	2301	383	74	185	4550
Saitama					857	2	859
Chiba		298	1554	1495	704	204	4254
Kanagawa			142	176	53		371
Nigata					16	48	64
Shizuoka					94	11	105
Shimane						36	36
Total	2952	10346	15464	15522	13338	13018	70640

Source: JA-ZENCHU

Almost 100,000 farmers lost about 58 billion yen ($694 million) by March 1, 2012 or 25% of the production (Takada and Song, 2012).

Available information for the 2011-2012 TEPCO payments to the Groups Representing Victims indicates that the Agricultural Cooperatives received 280,400 million yen (Nomura and Hokugo, 2013). The greatest share of the groups' agricultural payments went to Fukushima (29.8%), Ibaraki (13.8%) and Shizuoka (10.4%) prefectures (Figure 77).

Food industries companies have also lost hundreds of millions from canceled orders, reduced demands and prices, and increased costs. Some of their losses have been recovered by TEPCO.

Agriculture and agri-business have been a major employer for family and non-family labor in the affected regions. After the accident a great number of workers lost temporary or permanently employment (and income) opportunities in these important sectors. The later effect of the nuclear disaster on the local agri-food economy is very difficult to quantify.

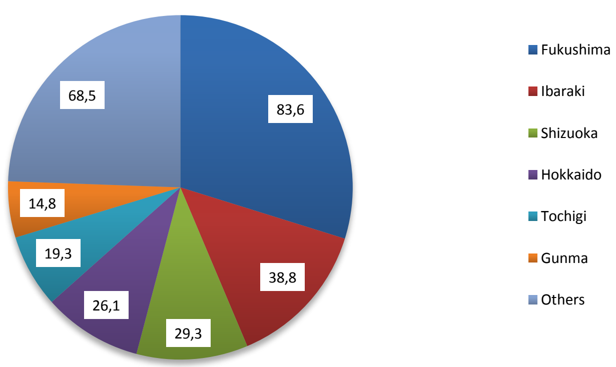


Figure 77. *TEPCO compensation payments to Agricultural Cooperatives (billion yen)*
Source: Nomura & Hokugo, 2013

4. Increased production, transportation and transaction costs in the agri-food chain. Many farmers and business have seen increased the costs associated with the post-disaster recovery, destructed and safe inputs supply, marketing (delayed, restricted and cancel shipments, safety control, certificates, and guarantees), shifting to new suppliers from other regions or countries, decontamination of crops, farmlands, material, biological assets.

A number of appropriate technologies have been tested and recommended for farmers to decontaminate the farmland and crops (Ministry of Agriculture, Forestry and Fisheries, 2013). Farmers and agricultural organization have been also trying own methods to deal with production and marketing problems associated with the nuclear accident (Nagashima, 2013). Some experts[308] argue that

[308] On June 6, 2013 we attended a lecture at Fukushima University of Prof. Hasagawa who set up organic farm and advocating it as a way for

organic farming is the way to revitalize Fukushima agriculture, but it is similarly associated with increased costs[309].

All such measures and methods have been accompanied with additional production and learning costs to farmers and their organizations.

There have been additional costs to protect labor and clean equipment used in contaminated environment, adapt new structure of products and technologies with reduced radiation absorption, partial and complete dislocate business, etc. Likely wise, there has been costs to destroy contaminated (by radiation), or unsold (due to the shipmen restrictions or lost markets) agricultural output.

Many livestock farmers had to buy forage from other locations to feed animals because own grass was contaminated occurring significant extra costs. In May 2011 about 20,000 livestock farmers in 7 prefectures were asked to refrain from grazing cattle because excessing radioactive substances found in pastures. That affected 700,000 head of cattle while forage cost additional 50 billion yen a year (Yomiuri Shimbun, May 2011).

Disrupted supply for agricultural and food produce within and from the affected regions had to be met with additional costs for food-chain businesses, public authorities, and consumers. For instance, most surveyed food companies in Fukushima prefecture report a lower income due to higher costs of alternative supply of ingredients from other prefectures[310] (Fukushima Food Industry Organization, February, 2013). The overall amount of costs for the initial emergency supply and continuing alternative food supply is hardly to be estimated.

In addition, there have been considerable transaction costs for adaptation to the new more strict official safety standards, and the voluntary restrictions imposed by the professional organizations and authorities, for multiple safety tests and certifications of inputs and output, for “additional” relations with public authorities, TEPCO, farmers organizations and other (e.g. research, international, etc.) institutions, for inputs supply, product promotion and marketing, for providing guarantees, for communications with counterparts and consumers, for alternative supply trough import from other regions and/or countries, etc.

reconstruction of Fukushima agriculture. Film on organic farmers facing nuclear crisis available on [Retrieved from].

[309] Most organic products have been (self)certified by the farmers organization while independent organic certification is still insignificant part (0.02%) of the overall production.

[310] At east one company moved its factory to another prefecture.

For instance, radiation levels in all baggage of rice and beef have been checked by the JA Fukushima since autumn 2012 and September 2011 accordingly, and huge testing programs have been going on farmlands, numerous agri-food products, etc. Some of the related costs have been covered by public authorities, others have been claimed by TEPCO, some have been invested by agricultural organizations, processing and retailing businesses, and the rest have been carried by farmers or consumers.

Similarly, there have been significant individual and collective costs associated with negotiation, application, disputing, etc. of damage claims from TEPCO. Most of the surveyed food companies in Fukushima prefecture report “additional costs and efforts” to deal with food safety risks and harmful humors such as: performing radiation checks on new acquired equipment, outside tests by other organizations, consumers and clients information, “hard working”, products safety promotions through meetings, website, labeling, etc. (Fukushima Food Industry Organization, February, 2013). Some of the surveyed companies indicate they stopped using “Fukushima made” label in order to facilitate transactions.

Last but not least important, there has been a huge increase in “public relation” costs of prefectural and local governments aimed at improving the damaged image of Fukushima products.[311] The precise scale and impact of all such private, collective and social transaction difficulties and costs are impossible to quantify.

5. As a result of the contamination, dislocation, institutional restrictions, and/or reduced markets for regional products, many farmers and agri-businesses have lost a significant portion of the value of their farmlands, livestock, orchards, material assets, and intangibles (such as established relations, reputation, brands, labels, product origins, etc.). For instance, highly popular Fukushima brand products such as Iidate beef and Anpo gaki (persimmon) has been immensely destructed. However, the total amount of such long-term damages is quite hardly to clarify.

6. There has been unspecified effect on the reduction of labor productivity, increased healthcare and recreation costs, etc. due to the nuclear accident. The extent of such kind of economic damages has not been fully studied yet.

Diverse negative economic implications have been quite unlike for the different agents and various regions. Farms and businesses in Fukushima and neighboring regions have experienced the

[311] E.g. the “public relation” item accounts a sizable portion of the overall budget of Fukushima prefectural government and it has been increasing.

greatest negative impacts on costs and sales. More than 41% of farmers and 52% of food industries in Fukushima prefecture report “extra costs emerged for radiation tests and various certificates as requested by trading partners” while these figures are much higher than in other regions of the country (Figure 100 and Figure 101).

Similarly, 3% of Japanese farmers indicate that “Income declined due to the abandonment of farm products and the relinquishment of manufacturing and production due to foreign countries' import controls and trading partners' refusal to import Japanese products” as a result of TEPCO accident (Figure 100). The later share for farmers in Fukushima prefecture is almost three times higher.

On the other hand, some farmers and agri-businesses from non-contaminated regions have got positive effects on businesses due to the increased prices, redirected demands, and better production and sales opportunities on the wake of Fukushima disaster.

“JA Group Tokyo Electric Co., Ltd. Nuclear Accident Agriculture and Livestock Damage Compensation Countermeasures Convention of Fukushima Prefecture” was established in May 2012 to deal with the compensation problems. It comprises all agricultural cooperatives in Fukushima prefecture and 35 other organizations including All-island Prefectural Headquarters, Prefectural Dairy Association, Livestock Recovery Association, Prefectural farm managers organization Liaison Assembly, and Prefectural Mushroom Promotion Assembly. General meetings have been held monthly to decide on the amount of demands for compensation and submitting it to TEPCO.

Until the mid-April 2013 demanded compensation though the Fukushima Taskforce was 109,3 billion yen, while the received compensation were 97,2 billion yen or 89% of the demand (Figure 78). Most of the claims have been for lost work due to evacuation orders and for crops damages.

Until May 2012 the amount of compensation demands reached 62.5 billion yen with a greatest portion of claims being for the untilled land (compensation for suspension of work) horticulture and livestock damages (Table 30). For the same period the amount of money received as compensation accounted for 73% of the claimed damages.

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

According to experts compensation payments to farmers in neighboring prefectures has been at lower rate - e.g. 50% in Miyagi prefecture.

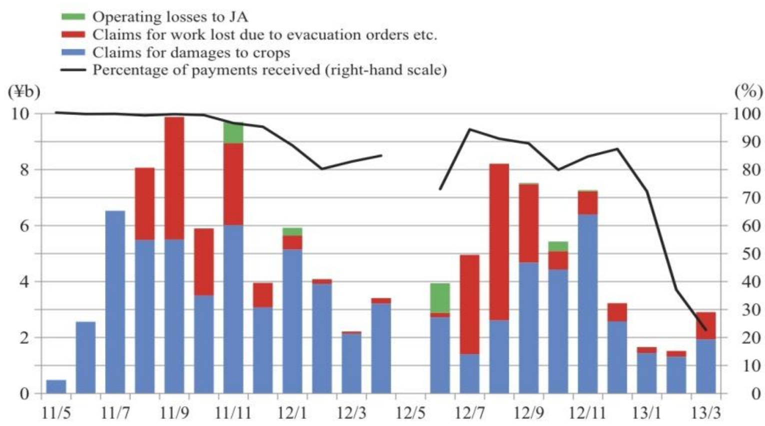


Figure 78. *Claims for damages to TEPCO by the Fukushima Prefecture JA Group*
Source: Fukushima Prefectural Union of Agricultural Cooperatives

Table 30. *Breakdown of Fukushima Prefecture Union Compensation Claims (100 million yen)*

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

Source: Central JA Union for Fukushima Prefecture

TEPCO is supposed to advance a half the amount of each claim the next month after it was filed, but it takes considerable time (almost a year) to pay the full amount (Watanabe, 2013). Meanwhile, farmers have been facing cash-flow difficulties struggling to pay production and household expenses. In January 2013 TEPCO established a new organization within the company (Fukushima Revitalization Headquarters, headed by a vice president) in order to improve compensation procedures and payments. Nevertheless, there has been no amelioration in the payments of compensation due to the lack of funding and multiple disputes.

In order to alleviate cash-flow difficulties certain agricultural cooperatives in Fukushima Prefecture started offering interest-free loans by subsidizing the interest while others established own substitute payment programs (Watanabe, 2013).

TEPCO continues to receive claims for damages of farmers and agri-food business from around the country. The total amount of claims received by and paid to different affected agents is not easy to find.

There have been many problems related to the compensation of damages from TEPCO. For farmers and agriculture cooperatives in Fukushima prefecture the major issues are: three month to almost a year delays in payments; not paying the full amount claimed; disputing nuclear accident origin of damages; denying claims when people restrain production and distribution voluntarily; claims related to farmland and farming property damage; compensation for discontinuation of business; "the closing date issue" (how long compensation will last) not decided yet; insufficient amount of compensation to restart farming; additional (inspection, administrative, radiation map preparation, etc.) costs and damages of organizations such as agricultural cooperatives not compensated yet; support for damages not clearly specified in the Dispute Reconciliation Committee for Nuclear Damage Compensation guidelines (Koyama, 2013; Nagashima, 2013).

Difficulties experienced by older age farmers associated with paper works in compensation procedures are also pointed out as a problem (Ishii, 2013). According to experts the efforts of farmers who did not market products through cooperatives are particularly big (interview with Prof.Komatsu, June 17, 2013). We have found that some of "safety tests" costs incurring by farmers (for voluntary and self-inspections) and consumer associations (e.g. Consumer cooperatives) and due to be compensated in unclear future, are also a problem.

An important issue how certain claims will be compensated is still disputed by parties and unspecified. For instance, the JA Union, Fukushima prefecture, and the Central Federation of Societies of Commerce and Industry have established a zero interest fund (Farmers Management Stability Funds) to support farmers with immediate needs. There are also funds for compensating beef distribution restrictions to help emergency management of companies raising cattle for consumption; supporting measures for emergency rice straw provisions, measures to allow undisturbed marketing of cattle, and programs sponsoring free rice straw in Fukushima prefecture.

In areas where restrictions are placed on planting, a standard compensation “per 10 are” is guaranteed. There are issues with uniform compensation, including differences in the amount of products per 10 are, discrepancies in farming method (e.g. organic, conventional), unlike value added of produce, etc.

Compensation claims negotiations are conducted individually and it is quite difficult for an individual farmer to negotiate and dispute effectively with TEPCO. For example, the compensation for areas with new planting restrictions in 2012 was 59,000 yen per 10 are while many people were purchasing rice for consumption and falling into a deficit (Koyama, 2013). The later amount is not recognized for compensation as well as the value of left property in evacuation areas.

Food processing companies also receive compensation on lost income according to the Government guidance. According to expert the procedures are quite costly and associated with great paper works, hiring layers, lengthily negotiation, etc.

The negative consequences of the nuclear accident on agriculture could be summarized by the statement of one of the interviewed by us experts – Mr.Nagashima, Agricultural Cooperative in Fukushima: “There are still harmful rumors for Fukushima products, the decontamination of farmlands is slow, and insufficient compensation is paid by TEPCO. People are starting to forget the disaster. Under these conditions, farmer’s willingness to work is decreasing, decline in new farmers is accelerating and abandoned farmlands increasing. De-industrialization of agriculture in Fukushima is a major concern” (June 6, 2013).

Part 3.
Overall Impact on Agri-Food Production, Distribution and Consumption

Chapter 13. Impact on Farms Number, Farmland use, and Agricultural Employment

The triple 2011 disaster affected significantly the Japanese agri-food sector. The most adversely impacted by the earthquake and tsunami has been farmers from the six coastal prefectures of Tohoku and Kanto regions - Aomori, Iwate, Miyagi, Fukushima, Ibaraki and Chiba. The negative effect of subsequent nuclear accident mostly damaged Fukushima farmers but also has spread to other producers in Tohoku, Kanto and Chubu regions. This part of the book analyzes the aggregate impact of the 2011 disasters on farming sector in the three most affected regions and the country as a whole.

In 2010 Tohoku, Kanto and Chubu regions accounted for 55.18% of the Agricultural Management Entities in the country, including 46.83% of the Juridical Entities and 55.29% of the Non-juridical Persons in agriculture (Table 31). What is more, 55.32% of the Management entities with sales of the country were located in these three regions, including 18.88% in Tohoku, 16.22% in Kanto, and 20.21% in Chubu region (MAFF, 2011).

In the three regions 55.3% of the county's commercial farm households were operating, including 44.7% of the full-time and 59.4% of the part-time commercial farm households (Ministry of Agriculture, Forestry and Fisheries, 2011). Thus, the 2011 disasters affected directly or indirectly a significant number of agricultural farms and organizations in Japan.

Table 31. *Number of Agricultural Management Entities in Tohoku, Kanto and Chūbu regions in 2010*

Prefectures	Juridical persons	Non-juridical persons	Local authorities	Total number	% in Japan
Tohoku region	2,731	310,587	97	313,415	18.67
Aomori	422	44,219	26	44,667	2.66
Iwate	620	56,356	25	57,001	3.39
Miyagi	347	50,390	4	50,741	3.02
Akita	394	48,106	21	48,521	2.89
Yamagata	363	40,459	9	40,831	2.43
Fukushima	585	71,057	12	71,654	4.27
Kanto region	2,761	273,393	39	276,193	16.45
Ibaraki	542	70,994	6	71,542	4.26
Tochigi	359	48,101	3	48,463	2.89
Gunma	518	32,043	6	32,567	1.94
Saitama	387	44,772	8	45,167	2.69
Chiba	672	54,710	5	55,387	3.30
Tokyo	50	7,396	9	7,455	0.44
Kanagawa	233	15,377	2	15,612	0.93
Chūbu region	4,636	332,208	54	336,898	20.06
Niigata	1,003	67,228	14	68,245	4.06
Toyama	433	22,471	2	22,906	1.36
Ishikawa	328	17,341	-	17,669	1.05
Fukui	277	19,805	4	20,086	1.20
Yamanashi	232	21,075	2	21,309	1.27
Nagano	845	63,429	15	64,289	3.83
Gifu	473	36,803	11	37,287	2.22
Shizuoka	443	39,658	1	40,102	2.39
Aichi	602	44,398	5	45,005	2.68

Source: Ministry of Agriculture, Forestry and Fisheries

After the 2011 disasters the number of commercial farm households in the most damaged prefectures declined substantially (Figure 79). For instance, by 2012 the total number of Tohoku farmers decreased by 11.8% and the full time farmers by 15.93%, which was much bigger than the national average reduction of 7.8% and 6.4%. The strongest post disaster decline of commercial farms in Japan was registered in Fukushima prefecture (almost 15%) and of the full-time farmers in Miyagi prefecture (more than 30%). Consequently, Tohoku share's in the total market farmers in Japan dropped from 18.7% to 17.9%.

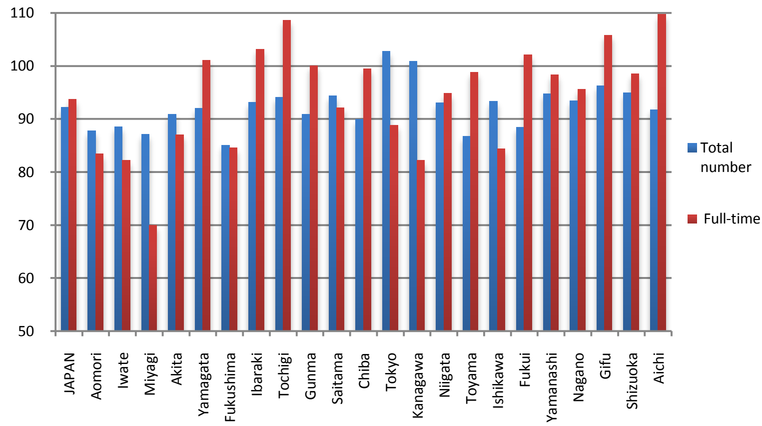


Figure 79. *Dynamics of commercial farm households in 2012 comparing to 2010 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

In other two regions there was above (but close to) the national average reduction of the commercial farm households. In some prefectures (Yamagata, Ibaraki, Fukui, Gifu and Aichi) there was even increase in the number of full time farmers during that period. The later probably was because of the (absolutely or relatively) increased business opportunities (higher demand for agricultural products to compensate reduction in most damaged areas; lack of alternative income sources) and/or increased number of new comers (young farmers, start ups by evacuees from disaster areas).

In 2013 the decrease in the amount of commercial farm household continued with a slower than national annual rate in Tohoku region (97.4%), higher in Kanto region (95.3%), and the same in Chubu regions (96.7%).

Before the 2011 disasters Tohoku, Kanto and Chubu regions cultivated 46.75% of the agricultural lands in Japan, including 57.46% of the paddy fields, 41.57% of the uplands, 48% of the permanent crops, and 12.62% of the short time meadows (Ministry of Agriculture, Forestry and Fisheries, 2011). Tohoku region was with the largest cultivated lands comprising 18.96% of the national, including 24.94% of all paddies [312], 16.11% of all permanent crops, 11.55% of uplands, and 10.25% ofmeadows (Figure 80).

[312] All rice being paddy rice.

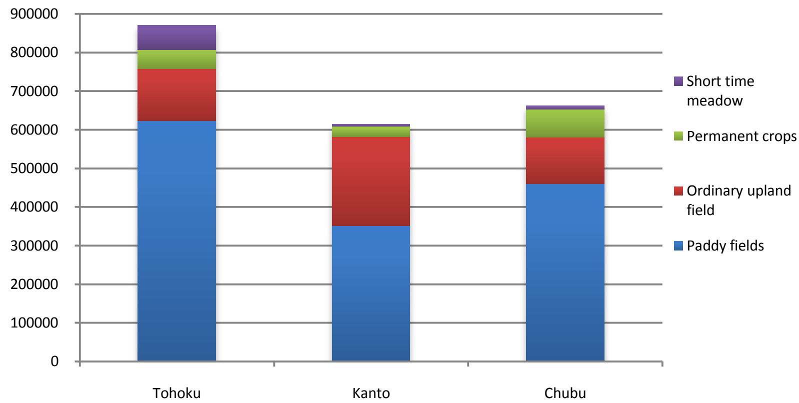


Figure 80. *Cultivated agricultural lands in affected regions in 2010 (ha)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2011 Tohoku region saw the higher that the national reduction in cultivated farmlands (including paddy and upland fields) due to the impacts of earthquake, tsunami and nuclear disaster (Figure 81). Subsequently, its share in the national cultivated land slightly contracted (from 18.96% to 18.70%). The greatest decrease in the cultivated farmland was registered in the paddies and uplands in Miyagi and Fukushima prefectures, the permanent crops in Iwate prefecture, and the short-term meadows in Ibaraki and Chiba prefectures.

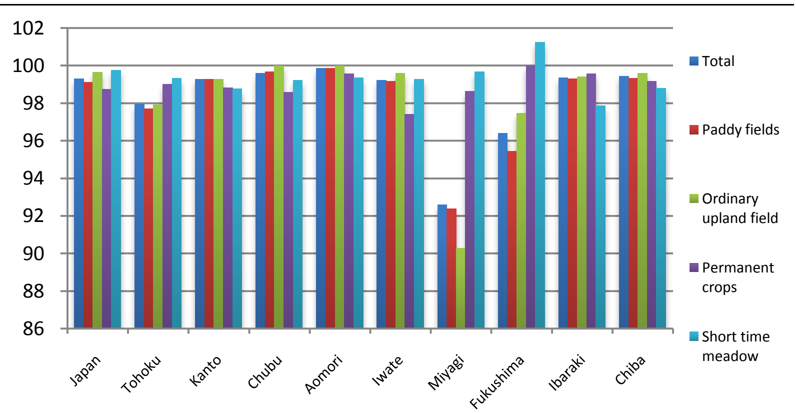


Figure 81. *Dynamics of cultivated agricultural lands in affected regions in 2011 comparing to 2010 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2012 the Tohoku region slightly increased its paddy (0.28%) and uplands (0.15%) fields on the background of an overall trend for agricultural lands reduction in the country. That was a result of resuming farming in restored previously damaged paddies in Miyagi (1.77% increase) and Fukushima (0.2%) prefectures. Consequently, the region recovered a part of the lost portion in the national cultivate land reaching 18.79% of the total.

At the same time, the total cultivated farmlands in other two regions contracted slower than the national average of 0.26%. Nevertheless, there was a higher annual rate of reduction in the short-term meadows in Kanto region due to the decreasing size in Saitama (12.66%), Chiba (3.42%) and Ibaraki (2.18%) prefectures.

Farming has been an important employment, income and food source for a great number of household members in the most affected regions. Just before the 2011 disasters Kanto-Tosan (including Ibaraki, Tochigi, Gunma, Saitama, Chiba, Kanagawa, Yamanashi, and Nagano prefectures and Tokyo Metropolis) had a bigger share of family members engaged in farming than the national average (Table 32). What is more, Kanto-Tosan and Tohoku regions had bigger absolute numbers of family members engaged in farming than the country's average.

Table 32. *Working members and working hours in farms of households in affected regions, beginning of 2011*

Regions	Total family members	Mon-ths member engaged in farm	Members engaged		Types of employment of members*				Work-ing hours in own far-ming
			in own far-ming	regular farm workers	own far-ming	own farm-ing & side busi-ness	regular office or physic-cal work	tem-pora-ry hired	
Tohoku	3.71	2.12	1.08	0.42	1.51	0.05	0.73	0.18	1,693
Kanto-Tosan	3.47	2.04	1.11	0.6	1.31	0.12	0.7	0.08	1,949
Hokuriku	4.18	2.02	0.51	0.13	0.51	0.03	1.14	0.35	955
Tokai	3.83	2.1	0.96	0.49	1.22	0.14	0.99	0.13	1,819
Japan	3.54	2.08	1.05	0.52	1.34	0.06	0.72	0.17	1,834

Note: * who always lived in the house and engaged in agriculture more than 60 days in a year

Source: Ministry of Agriculture, Forestry and Fisheries

Furthermore, in Tohoku and Tokai (including Gifu, Shizuoka, Aichi, and Mie prefectures) regions the average family member worked more months in farming than the national average. In Tohoku region the number of family members working in own farm was much higher than the national level. On the other hand, in Hokuriku region (including Niigata, Toyama, Ishikawa, and Fukui prefectures) much smaller number of family members works in own farming and spend less time in farm operations.

There is no statistical data on how the farm households members working status and loads have changed in the post disaster years. Nevertheless, we can suppose that the 2011 disasters have impacted directly the livelihood of a great number of farm households and their members in the affected regions.

Chapter 14. Impact on Agricultural Productions

All affected by the 2011 disasters regions have been large producers of major farm produces such as rice, fruits, vegetables, sweet potatoes, soybean, buckwheat, tobacco leafs, tea leafs, meats, milk, eggs etc. (Table 33 and Table 34).

Most strongly hit by the earthquake and tsunami Tohoku and Kanto regions have been large producers of vegetables, fruits, nuts and flowers in glass houses, vinyl houses, and tunnels (Figure 82). Before the disasters both regions were responsible for 47.68% of the planted vegetables in tunnels, 41.08% in the vinyl houses, and 28.2% in the glass houses; 37.42% of the planted flowers in tunnels, 25.5% in the vinyl houses, and 21.03% in glass houses; and for 20.07% of fruits and nuts in vinyl houses (MAFF, 2014).

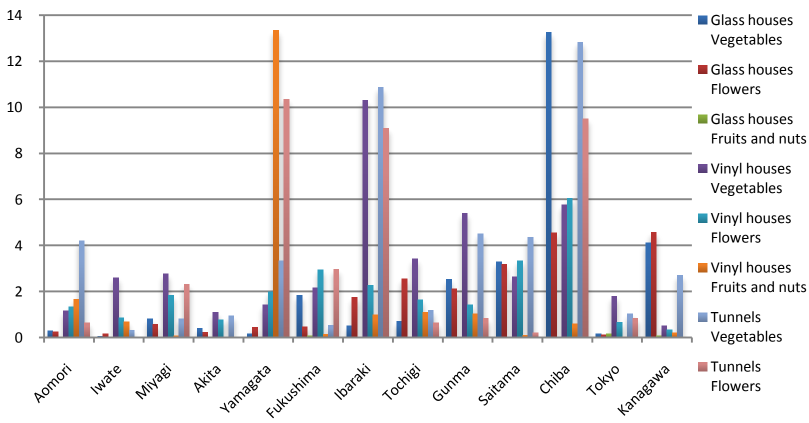


Figure 82. *Tohoku and Kanto prefectures share of planted area of crops in glass houses, vinyl houses, and tunnels in 2009 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

The 2011 disasters have been severe blow for the Tohoku rice sector. Subsequent of the tsunami destructions and the production restrictions the rice planted areas declined by 7.25% and the production by 5.96% comparing to 2010 (Figure 83).

Table 33. *Share of Tohoku, Kanto and Chūbu regions in major crop products of Japan in 2010 (percent)*

Prefectures	Rice	Apples	Jap. pears	Soy-bean	Buck-wheat	Jap. radish	Car-rots	Tob-acco
Tohoku region	27.57	93.08	12.00	21.63	19.53	15.64	6.87	30.27
Aomori	3.37	69.05	0.00	2.76	1.83	8.42	5.62	9.82
Iwate	3.68	7.46	0.00	2.04	2.43	1.89	0.36	9.65
Miyagi	4.72	0.58	1.31	8.04	0.75	1.10	0.27	0.54
Akita	5.76	4.50	1.12	3.86	1.76	0.97	0.16	3.24
Yamagata	4.79	6.67	0.61	3.55	6.50	1.19	0.13	0.99
Fukushima	5.25	4.82	8.97	1.37	6.26	2.07	0.34	6.03
Kanto region	15.42	1.37	38.63	5.69	12.75	27.62	29.91	6.91
Ibaraki	4.79	0	9.70	2.09	5.52	4.34	4.70	4.04
Tochigi	4.05	0	8.50	2.71	4.71	1.25	0.67	0.71
Gunma	0.86	1.37	1.76	0.21	1.27	2.37	0.23	0.08
Saitama	1.79	0	3.65	0.23	1.12	1.68	4.13	0
Chiba	3.92	0	12.21	0.42	0.08	10.93	19.00	2.08
Tokyo	0.01	0	0.70	0.00	0.01	0.68	0.63	0
Kanagawa	0.18	0	2.10	0.02	0.03	6.38	0.54	0
Chūbu region	18.35	22.91	18.29	16.10	17.32	12.23	6.95	6.50
Niigata	7.28	0	5.14	4.38	2.56	3.34	0.97	4.22
Toyama	2.52	0.26	1.49	3.08	0.33	0.24	0.04	0
Ishikawa	1.63	0.10	1.25	0.86	0.27	0.94	0.08	0.75
Fukui	1.64	0	0.45	0.68	5.82	0.45	0.11	0
Yamanashi	0.33	0	0	0.13	0.42	0.41	0.04	0

Nagano	2.50	22.11	6.53	1.55	7.47	1.50	0.26	0.44
Gifu	1.39	0.26	0.72	2.21	0.26	1.64	0.99	0.02
Shizuoka	1.06	0	0	0.15	0.15	1.86	0.43	0.19
Aichi	1.82	0	2.70	3.05	0.03	1.84	4.03	0.88

Source: Ministry of Agriculture, Forestry and Fisheries

Table 34. *Share of Tohoku, Kanto and Chūbu regions in major livestock and livestock products of Japan in 2010 and 2009* (percent)*

Prefectures	Cows	Row milk	Beef cattle	Pigs*	Poultry**	Eggs
Tohoku region	8.32	8.36	14.27	17.29	25.21	14.42
Aomori	0.94	0.93	2.16	3.91	6.11	3.51
Iwate	3.21	2.92	3.90	4.42	16.12	2.94
Miyagi	1.64	1.74	3.32	2.43	1.71	3.19
Akita	0.41	0.41	0.73	2.80	0	1.47
Yamagata	0.94	1.04	1.45	1.70	0.42	0.47
Fukushima	1.19	1.31	2.70	2.02	0.85	2.85
Kanto region	12.75	14.71	10.06	25.48	3.57	23.61
Ibaraki	2.08	2.18	1.96	6.66	0.99	7.52
Tochigi	3.63	4.06	3.43	3.80	0.22	2.21
Gunma	2.68	3.35	2.35	6.26	1.08	3.28
Saitama	0.90	0.97	0.72	1.40	0	2.17
Chiba	2.67	3.30	1.39	6.52	1.28	7.51
Tokyo	0.14	0.15	0.04	0.04	0	0.06
Kanagawa	0.65	0.70	0.17	0.81	0	0.86
Chūbu region	6.62	7.83	6.21	10.10	3.93	15.61
Niigata	0.65	0.81	0.47	2.09	0.61	3.89
Toyama	0.18	0.21	0.16	0.41	0	0.82
Ishikawa	0.28	0.30	0.11	0.35	0	0.81
Fukui	0.10	0.11	0.12	0.05	0.07	0.35
Yamanashi	0.29	0.26	0.26	0.19	0.35	0.31
Nagano	1.33	1.51	1.02	0.88	0.53	0.41
Gifu	0.55	0.66	1.24	1.06	0.61	2.97
Shizuoka	1.07	1.29	0.89	1.30	0.86	1.82
Aichi	2.16	2.68	1.94	3.76	0.90	4.25

Note: ** shipments
Source: Ministry of Agriculture, Forestry and Fisheries

The planted areas and the production plummeted in Fukushima (more than 20%) and Miyagi (more than 9%) prefectures. In Aomori prefecture planted area declined more than 5% while production reduction was smaller. Consequently the region's share in the national rice areas and production dropped to 24.68% and 26.17% accordingly (MAFF, 2012). The later contributed to a higher than the usual decrease in the country's rice acreages by 3,2%. However, due to the higher output in other prefectures the national reduction of rice production was only 0.6%.

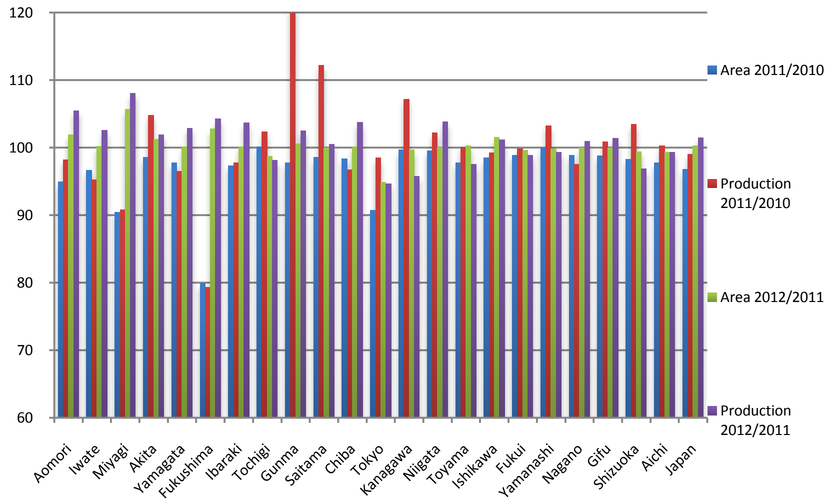


Figure 83. *Dynamics of rice planted areas and rice production in Japan (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2012 there was some recovery in the planted areas in all affected prefectures of Tohoku region and even a higher growth in the rice production. Nevertheless, rice planted areas and production in the most impacted Iwate, Miyagi and Fukushima prefectures are still below the pre-disaster levels. Consequently, region's importance in the national rice areas and rice production increased (to 25.09% and 26.84% accordingly) but it is below the 2010 figure.

The combined impact of the 2011 disasters on some other major productions has been also considerable. For instance, in 2011 there was a big decline in the production of important vegetables like Japanese radish and carrots in Fukushima (18.39% and 14%) and Miyagi (14.55% and 8.86%) prefectures due to decreased areas (Figure 84). In some other prefectures the production of Japanese radish (Aomori, Tochigi, Chubu region) and carrots (Aomori, Iwate, Nigata, Kanto region) increased.

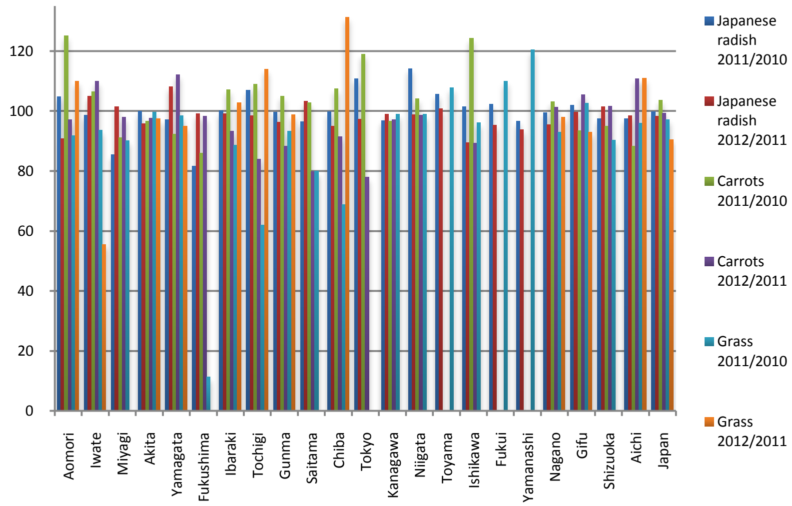


Figure 84. *Dynamics of major vegetables and grass productions in Tohoku, Kanto and Chūbu regions during 2010-2012 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

All that evolution was during a simultaneous small decrease in the national Japanese radish production and an augmentation in the carrot production. Consequently, Tohoku and Kanto region's shares in the national Japanese radish production little decreased (to 15.48% and 27.56% accordingly) while of the Chubu region increased (up to 12.69%). Contrary happened in the carrot production - Tohoku and Kanto region's importance in the national output improved (up to 7.93% and 30.82% accordingly) while that of Chubu region deteriorated (down to 6.05%).

In 2012 there was a slight rebound of the Japanese radish in Miyagi prefecture and further reduction of carrots production. In Fukushima prefecture the vegetable productions continued diminishing in 2012 due to the negative impact of the nuclear accident. Contrary, there was a good increase of the Japanese radish production in Iwate and Yamagata prefectures and Chubu region, and of the carrot production in Iwate prefecture and Chubu region. All that evolution was associated with insignificant reductions in both productions in the country as a whole. Consequently, the affected regions have lost previous positions in the national output for major vegetables with exception of Chubu region for carrots.

There has been also parallel impact of the 2011 disasters on the shipments of vegetables from different prefectures (Figure 85). For instance, in 2011 there was a huge decline in the shipments of Japanese radishes from Fukushima and Miyagi prefectures. The later was counterbalanced by the increased shipments from other prefectures (like the biggest producer Aomori), and Tohoku region even slightly increased the overall amount and its national share (13.89%). There was some decline in the shipment from a major producer Kanto region but the national lever was unaffected due to the increased shipments from other regions.

In 2012 the shipment from Aomori prefecture decreased over the national average reduction (5.15%) as well as the overall region's importance (13.31%).

The evolution of structure and level of the vegetable productions and shipments in the three regions and nationwide strongly depended on the available farmlands (extent of damaged land and pace of restoration), the level of contamination of products, the changing market demands due to harmful rumors and consumption preferences as well as the new opportunities to increase production of more profitable crops and/or compensate reduced output and shipments from other (adversely affected by the disasters) areas.

The same has been true for other important crops for the regions as well like soybean, buckwheat, sweet potatoes, tobacco, and tea leaves. For instance, Tohoku region accounted for 27.39% of the national soybean areas in 2010 (MAFF, 2012). In 2011 the areas devoted for soybean declined in all but Aomori prefectures - with 6.65% for the region, including by 27.08% in Fukushima prefecture and 12.43% in Miyagi prefecture. The soybean output decreased in the major producer Miyagi prefecture by 10.16% as well Yamagata (13.54%) and Fukushima (3.61%) prefectures (Figure 86). Nevertheless, due to the increased yields in all but Aomori and Yamagata prefectures, and the additional areas in Aomori prefecture, the annual reduction of region's soybean production was just 0.94% and lower than the national (1.76%). Subsequently the region even slightly improved its share (up to 21.79%) in the country's soybean production.

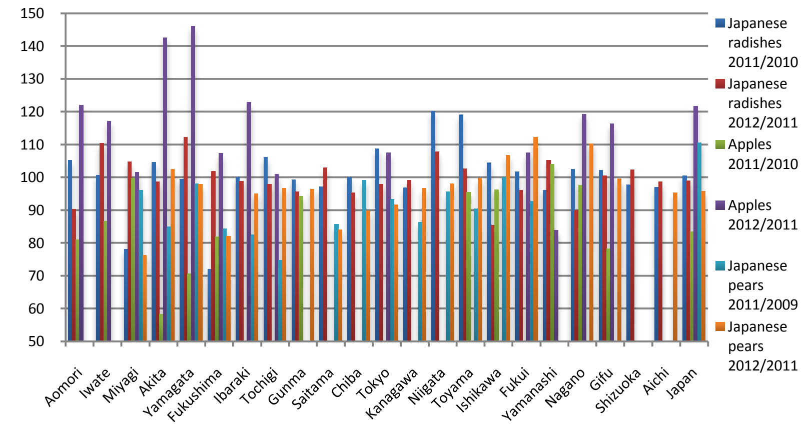


Figure 85. *Dynamics of shipments of Japanese radishes, apples and Japanese pears in Tohoku, Kanto and Chūbu regions 2009-2012 (%)*
Source: Ministry of Agriculture, Forestry and Fisheries

Similarly, in 2011 there was a decrease in the profitable buckwheat production in the tsunami-hit Aomori, Iwate and Miyagi prefectures. However, there was a general (and a higher than the national) expansion of buckwheat planted areas and production in Tohoku and Kanto regions which improved their importance (up to 23.45% and 15.16%) in the country's overall production (MAFF, 2013).

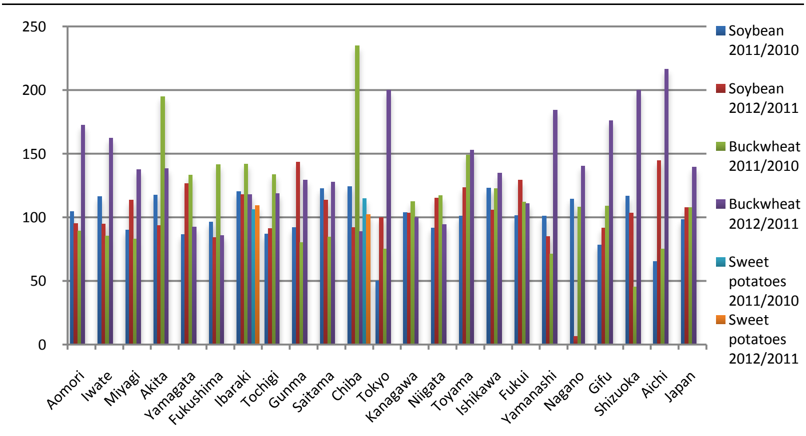


Figure 86. *Dynamics of soybean, buckwheat and sweet potato productions in Tohoku, Kanto and Chūbu regions 2010-2012 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

Likewise, in 2011 and 2012 the two major producers of sweet potatoes in Kanto region (Ibaraki and Chiba prefectures) enlarged production leading to an increased region's share in the national output to 34.19% (Ministry of Agriculture, Forestry and Fisheries, 2013). Meanwhile, the country's output of sweet potatoes increased in 2011 and slightly contracted in 2012 staying above the pre-disaster level.

The most affected by the tsunami and the nuclear accident (Aomori, Iwate, Fukushima and Ibaraki) prefectures have been major producers of tobacco leafs as well. The 2011 disasters led to 29.51% reduction in the areas and 20.79% decrease in the production of this important for the Tohoku farmers commodity. In 2011 tobacco production was entirely suspended in Fukushima prefecture and plummeted (by 12.15%) in Ibaraki prefecture (Figure 87).

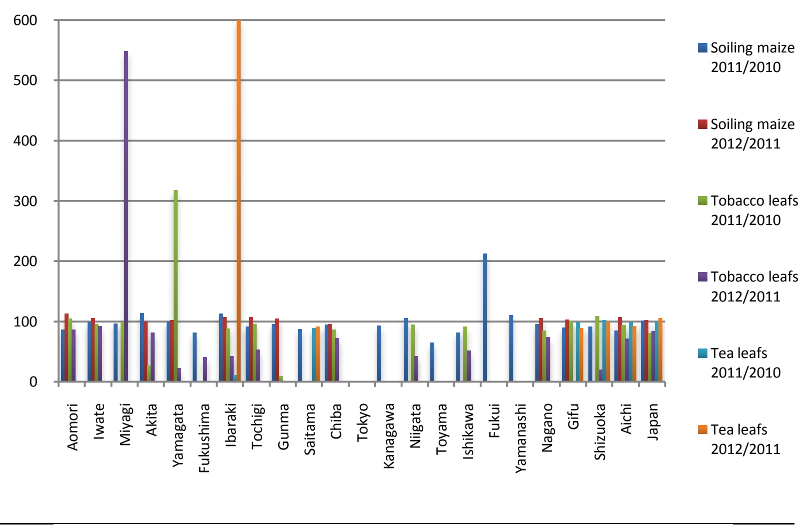


Figure 87. *Dynamics of major industrial crop and soiling maize productions in Tohoku, Kanto and Chūbu regions 2010-2012 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2012 a part of the production resumed in Fukushima prefecture and increased almost 5.5 folds in Miyagi prefecture. Contrary, both tobacco areas and production continued to decline in other prefectures. Nevertheless, due to a faster reduction in the country as a whole Tohoku prefecture enhanced its key position with 36% of the national production (MAFF, 2013).

Similarly, due to the radiation there was a huge decline in the tea leafs production in Ibaraki (89,13%) and Saitama (11.21%) prefectures in 2011. The later has been largely compensated by an increased production in the main producer Shizuoka prefecture, and the country's production dropped by merely 0.65% (MAFF, 2013). The prefecture's share in the national output increased from 38.7% to 39.59%. In 2012 tea leaf production further declined in Saitama prefecture and partly recovered in Ibaraki prefecture on the background of 5% increase in country's tea output.

Chiba and Ibaraki prefectures comprised 75.92% and 14.13% of the Japanese peanut production in 2010 (MAFF, 2011). In order to compensate fall downs in other productions due to the tsunami, radiation and rumor damages, Ibaraki and Chiba farmers enlarged profitable peanut production by 63.42% and 27.64% in 2011 (MAFF, 2012). In 2012 due to the further reduction in planted areas the peanut production dropped by 19.77% in Ibaraki and 13.38% in Chiba prefecture (MAFF, 2013). Subsequently, the national production augmented by 25.31% in 2011 and then contacted by 14.78% in 2012 maintaining above pre-disaster level.

Feed and fodder crops productions have been also badly affected by the radiation contamination, tsunami damages, and decreased livestock numbers in the region. Before the 2011 disasters the Tohoku region accounted for 12.57% country's grass areas and 11.36% of the national grass production. In 2011 there was a small decrease in the grass areas in Tohoku and Kanto regions (1.99% and 1.42% accordingly) mostly due to a bigger reductions in Fukushima (10.2%) and Ibaraki (3.33%) prefectures (MAFF, 2012). Nevertheless, the grass production in the two regions declined substantially (17.51% and 24.78% accordingly) with the plummeted by 88.73% output in Fukushima prefecture. Consequently, Tohoku share in the national grass production declined to 9.65%.

In 2012 the reduction of grass areas in almost all prefectures of the affected three regions continued with a registered further production drop in most of them and no output in Miyagi, Fukushima, Saitama, Tokyo, Kanagawa, Nigata, Toyama, Ishikawa, Fukui, Yamanashi and Shizuoka prefectures (MAFF, 2013). Consequently, the Tohoku share in the national grass production contracted to 6.91%.

Nationwide, there was a slight decrease in grass areas in 2011 (0.53%) and 2012 (0.57%) but a considerable reduction in grass production during the period (2.89% in 2011 and 9.48% in 2012).

Similarly, in 2011 the soiling maize planted areas decreased by 3.68% in Tohoku region and soiling maize production contracted by 6.58% due to reduction in the regional second and fourth biggest producers - Fukushima (8.7%) and Miyagi (3.53%) prefectures. Consequently the region diminished its share in the national production from 11.52% in 2010 to 10.6% in 2011.

In 2012 there was a further slight reduction in the soiling maize areas in the region (1.58%) and a huge contraction in the output (24.98%). There was reported increased production in Iwate, Aomori and Yamagata prefectures but no output for Fukushima and Miyagi prefectures (MAFF, 2013). Consequently, the region's importance in the national soiling maize production dropped to 7.77%.

In 2012 no soiling maize output was registered in Saitama, Tokyo, Kanagawa, Nigata, Toyama, Ishikawa, Fukui, Yamanashi and Shizuoka prefectures (MAFF, 2013). Despite the (partial or full) recovery (Tochigi, Gunma, etc.) and increase (Ibaraki and Nagano) in production in other major producers, Kanto and Chubu soiling maize output is still below the pre-disaster level while their shares in the national diminished (correspondingly from 13.69% and 4.04% in 2011 to 12.8% and 3.1% in 2012). At nationwide scale there is an increasing production of soiling maize throughout the period.

Fruits production in Tohoku region has particularly suffered by the 2011 disasters. For instance, in 2011 there was a little reduction of apple areas in the region (0.87%) due to the decline in orchards areas in all but Aomori prefectures (MAFF, 2012). Nevertheless, there was a sizable decline in the apple production in all prefectures (Figure 88), and an overall downfall by 20.20% in the region as a whole.

Chubu (a major producer) and Kanto regions also experienced some decrease in the apple production but due to the higher output in the rest of the country the national apple production sustain at previous level (MAFF, 2012). Consequently, Tohoku's bulk in the national apple output shrinked to 74.28% while Chubu's one only deteriorated slightly (22.09%).

Furthermore, major apple shipments from Tohoku region plummeted by 25.42% and together with a reduced shipment from Chubu region led to significant diminution of the national amount.

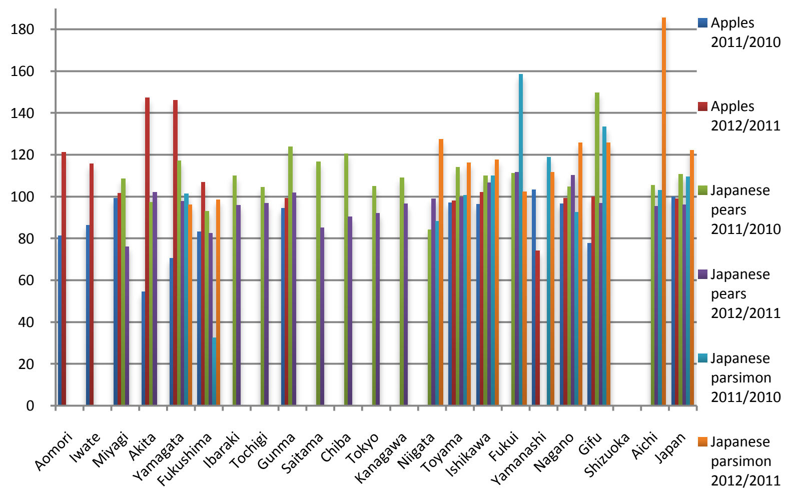


Figure 88. *Dynamics of major fruits productions in Tohoku, Kanto and Chūbu regions during 2010-2012 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2012 there was a partial recovery of the apple production in Tohoku region and a great progression in Chubu region (18.06%) and country as a whole. Tohoku region improved modestly its position in the national output (up to 75.01%) while relative share of Chubu region fell to 21.53%.

The apple shipments from Tohoku region rebounded considerably but below the pre-disaster level. However, an enormous progression of the shipment from Chubu and other regions let to effective augmentation of shipments over the pre-disaster level.

The Japanese pears production experienced another development. In 2011 there was some downsizing in the areas and a bigger one in production in the main Tohoku producer Fukushima prefecture, which led to a fall in the region's portion in the national output to 10.46%. Nevertheless, there was an expansion in the Japanese pears production in major producers from Kanto, Chubu and other regions, and the overall augmentation of the national output.

Japanese pear shipment from Tohoku and Kanto region plummeted by 17.44 % and 7.33%, and regions share in the national diminished from 13.78% to 10.29% and 48.22% to 40.42% accordingly. However, increased shipments from Kanto and another regions led to a good overall increase in the nationwide amount.

In 2012 Fukushima prefecture and Tohoku experienced a further sizable reduction in the areas and the production of Japanese pears (by 19.4% and 15.57% accordingly) downsizing the region's share in the national output to 9.18% (MAFF, 2013). That was accompanied by a lesser decrease in the areas and productions in other regions, and the in country's level.

Tohoku and Kanto Japanese pears shipments continued plummeting (15.95% and 7.35% accordingly) and the regions shares in the national further decreased (to 9.03% and 39.11% accordingly). There was some increase in the shipments from Chubu region augmenting its share in the national to 17.88%. Nevertheless, the overall amount of the national shipments further declined.

Japanese persimmon has been important for the farmers in Fukushima and Yamagata prefectures, and Chubu region. The 2011 disasters and consequent production restrictions have led to a huge reduction of Japanese persimmon production in Fukushima prefecture. Subsequently, prefecture's share in the national output dropped from 7.39% to 2.19%. At the same time, there was some increase in the Japanese persimmon production in Yamagata prefecture, a higher in Chubu region, and even more elevated nationwide.

In 2012 there was registered diminished areas and production Japanese persimmon in Tohoku region but a considerable growth in Chubu region and the country as a whole. Chubu producers enhanced their portion in the national output from 24.59% (20country 26.66% while Tohoku farmers segment plummeted down from 12.27% to 5.31% (MAFF, 2013).

Flower productions and shipments have been important for many farmers in the affected by the 2011 disasters regions. In 2010 the analyzed regions were responsible for the shipments of 58.87% of the country's roses (including 31.36% Chubu and 18.57% Kanto region), 47.04% of the chrysanthemums (including Chubu 34.45% and Kanto 6.48%), and 21.07% of the gypsophilas (including Chubu 9.39% and Tohoku 9.63%) (MAFF, 2011).

In 2011 there was a significant (much higher than the national) reduction in flower shipments from the three regions (Figure 89), as a result of which their segments in the national productions diminished. The biggest declined was registered in Tohoku region – 28.15% for chrysanthemums, 24.93% for roses, and 12.92% for gypsophilas. What is more, the sizable chrysanthemums shipments from Aomori, Miyagi, Yamagata, Chiba, Saitama and Kanagawa prefectures completely stopped. At the same time, Fukushima prefecture decreased only slightly chrysanthemums and gypsophilas shipments and ceased that for roses. Besides, Ibaraki prefecture expended its chrysanthemums shipment.

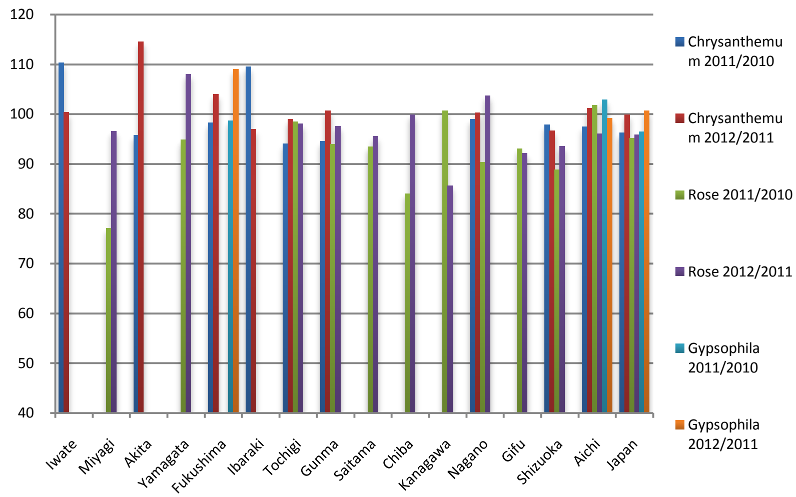


Figure 89. *Dynamics of shipments of flowers in Tohoku, Kanto and Chūbu regions during 2010-2012 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2012 Tohoku region rebounded partially its flower shipments due to an above the pre-disaster level recovery in Fukushima, Akita and Yamagata prefectures, and ceased chrysanthemums shipments from Miyagi and Aomori prefectures. Kanto regions flower shipments continue to decline faster than the national average (MAFF, 2013). All three regions have lost their portions in the national shipments of flowers.

The 2011 disasters have been a severe blow for the beef industry in the most affected regions and beyond. The number of Tohoku beef cattle declined by 9.48% during 2011-2012 with a rate of livestock reduction in all but Yamagata prefectures much higher than the national average (Figure 90). In 2011 the contraction was highest in the tsunami and nuclear accident affected Aomori, Iwate, Miyagi and Fukushima prefectures. Unlike other prefectures, were 2012 decline was lower than the national, the Fukushima beef cattle continued to contract sharply by 25.60%

during 2-year period. Consequently, the region's share in the beef cattle of the country fell to 13.72% (MAFF, 2013).

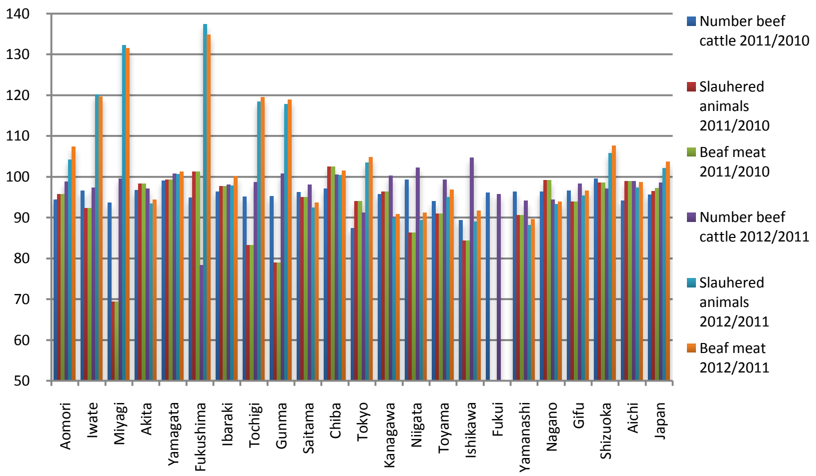


Figure 90. *Dynamics of number of beef cattle, slathered animals, and beef meat production in Tohoku, Kanto, Chūbu regions 2010-2012 (%)*
Source: Ministry of Agriculture, Forestry and Fisheries

The cutback of beef cattle and the adverse impact of nuclear accident led to a decline in the number of slathered beef animals and the produced beef meat in Tohoku region by 11.89% and 10.60% in 2011. Miyagi and Iwate prefectures experienced the biggest contraction in the slathered animals and meat production.

Kanto and Chubu regions' beef cattle have also declined but at a slower rate than the national shrinkage. On the other hand, the fall in the numbers of slathered beef cattle and the produced beef meat were higher than the national diminution.

Likely wise, in 2011 there was a greater than the national reduction in the number of cows in the three affected regions and a significant downsizing of the row milk production (in 2011, 2012). Tohoku milk production declined by 11.09% and the region's share in the national milk output dropped to 7.68%. Due to the reduced number of cows and shipment restrictions many prefectures experienced reduction of milk production. Fukushima prefecture registered the greatest contraction in milk production (more than a quarter) followed by Miyagi, Ibaraki, Nigata, and Iwate prefectures (Figure 91).

In 2012 there was a further reduction in the cows in Tohoku region mostly due to the considerable downsizing in Fukushima prefecture. The later saw 15.91% of its dairy livestock reduced in two years. Milk production rebounded in all Tohoku prefectures (which partially regain its share in the national output) and in the country as a whole but far below the pre-disaster level (MAFF, 2013). The three affected regions have seen their portions in the country's cows and milk production wakened after the disaster.

There was a significant reduction in number of pigs in Miyagi prefecture in 2011 comparing to 2009 (Figure 92). That was compensated by an increased number of animals in other prefectures, which resulted in a rise of overall number of pigs in Tohoku region (MAFF, 2012). At the same time, there was a decrease of pigs in other two regions and in the country. Consequently, the Tohoku share in the overall pig number of the country augmented to 17.81%.

In 2011 the number of slathered animals and the produced pork meat in Tohoku region declined a good deal compering to the previous year with a faster rate than the national one. The later was due to the considerable reduction in meat production in Miyagi and Fukushima. The reduction in meat production in other two regions was slower than the national (MAFF, 2012).

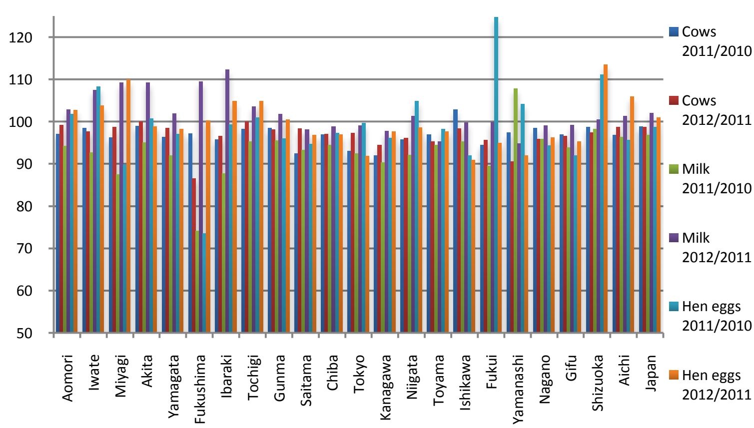


Figure 91. *Dynamics of number of cows, milk production, and eggs shipments in Tohoku, Kanto and Chūbu regions 2010-2012 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

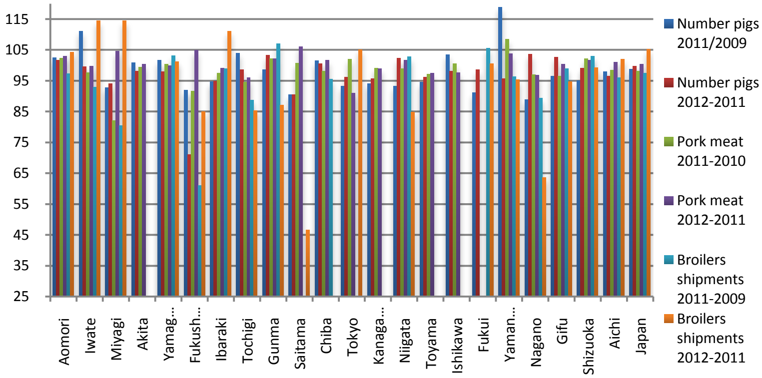


Figure 92. *Dynamics of number of pigs, pork meat production, and broilers shipments in Tohoku, Kanto, Chūbu regions 2009-2012 (%)*
Source: Ministry of Agriculture, Forestry and Fisheries

In 2012 the number of pigs in Tohoku regions decreased due to the further reductions in Fukushima and Miyagi prefectures, and some regression in all but Aomori prefectures. Comparing to 2009 the Fukushima pig farms diminished animals by 44.78%. There was a further reduction in other two regions with a slower rate in Kanto region than national one (MAFF, 2013).

What is more, in 2012 there was a significant recovery in Tohoku pork production and sustainable levels in other regions and in the country (MAFF, 2013). Consequently, the three regions reduced a little bit the pre-disaster shares in the slathered animals and the produced pork meat in the diminishing national amounts (MAFF, 2013).

Tohoku broilers and hen eggs productions have been also considerably affected by the 2011 disasters. Comparing to 2009 there was a 7.73% reduction in shipped broilers due to the contraction in all affected by the tsunami prefectures. Similarly, there was a 5.46% decrease in the hen eggs production due to the considerable contraction in Fukushima and Miyagi prefectures. Consequently, the region's portion in the national broilers shipment and eggs production declined to 23.89% and 13.83% accordingly (MAFF, 2012). In Kanto region there was lesser then the national reduction in broilers shipment and bigger for the egg production while the vise verse is true for Chubo region.

In 2012 the broiler shipment recovered rapidly in all but Fukushima prefectures of Tohoku region razing above the pre-disaster level. The eggs production also rebounded in Miyagi and continued growing in Aomori and Iwate prefectures.

The shipment of broilers was not significant in Kanto and Chubu regions and further declined in 2012 on the background on increasing shipment nationwide (MAFF, 2013). At the same time, the major eggs production slightly grew around the national average level.

Chapter 15. Impact on Agricultural Output and Income

Before the 2011 disasters Tohoku, Kanto and Chubu regions produced above the half of the agricultural output and agricultural income in the country (Table 35). The three regions were responsible for the sizable share of the Japanese rice (63.30%), vegetables (56.06%), flowers (58%), fruits and nuts (54.13%), pigs (54.53%), and hen eggs (54.77%) outputs. The biggest contributor to the national agricultural output and income was Kanto region, followed by Chubu region for the agricultural output and Tohoku regions for the agricultural income. The most severely hit by the tsunami and nuclear accident prefectures (Ibaraki, Chiba, Fukushima, Aomori, Iwate and Miyagi) were among the greatest producers of agricultural output and income in that region.

The crops value dominates in all but Iwate prefecture where livestock (chicken and pigs) production is the most important Table 36). Rice is the major segment in the most Tohoku and a good part of the Chubu prefectures while vegetables are the key sector in Kanto region and a good portion of Chubu prefectures.

The 2011 disasters have influenced considerably the farm economy in the most affected regions. In times of the overall growth of the national agricultural output, that value declined significantly in the most severely hit prefectures as biggest annual decrease was registered in Fukushima, Ibaraki and Miyagi prefectures (Figure 93).

Generated value of all agricultural products in Fukushima prefecture contracted enormously comparing to the pre-disaster period ranging from over 5% in rice up to more than 96% for the industrial crops (Figure 94, Figure 95).

Table 35. *Share of Tohoku, Kanto and Chubu regions in national agricultural output and agricultural income in 2010 (percent)*

Prefectures	Agricultural output	Crops	Livestock	Processed agricultural products	Agricultural income
Tohoku	15.17	15.39	14.97	3.02	16.56
Aomori	3.33	3.48	3.09	0.18	3.41
Iwate	2.77	1.73	5.00	0.00	2.81
Miyagi	2.03	1.87	2.42	0.53	2.36
Akita	1.81	2.14	1.15	0.18	1.80
Yamagata	2.41	2.97	1.27	0.89	2.58
Fukushima	2.82	3.21	2.04	1.25	3.61
Kanto	19.61	21.06	16.68	14.06	19.69
Ibaraki	5.22	5.63	4.25	10.32	5.91
Tochigi	3.09	3.04	3.22	1.78	3.46
Gunma	2.70	2.34	3.49	0.36	2.23
Saitama	2.43	3.07	1.12	0.36	2.64
Chiba	4.90	5.42	3.91	0.89	4.33
Tokyo	0.33	0.46	0.08	0.00	0.26
Kanagawa	0.94	1.11	0.60	0.36	0.85
Chubu	16.15	18.95	9.92	33.81	16.25
Niigata	3.10	3.76	1.79	0.18	3.78
Toyama	0.74	0.93	0.34	1.42	0.90
Ishikawa	0.62	0.74	0.36	0.36	0.75
Fukui	0.50	0.67	0.16	0.18	0.64
Yamanashi	0.96	1.28	0.27	1.25	1.06
Nagano	2.72	3.47	1.09	5.34	2.27
Gifu	1.35	1.27	1.54	0.36	1.24
Shizuoka	2.57	2.91	1.42	24.02	2.49
Aichi	3.59	3.92	2.95	0.71	3.13

Source: Ministry of Agriculture, Forestry and Fisheries

Table 36. *Share of different productions in agricultural output value in 2010 (percent)*

Prefec-tures	Crops				Livestock				
	Total	Rice	Vege-tables	Fruits & nuts	Total	Beef cattle	Dairy cattle	Pigs	Chick-en, egg
Tohoku	68.22	30.38	18.61	13.85	31.64	6.49	5.34	7.80	11.77
Aomori	70.23	14.90	23.37	27.12	29.73	4.36	2.62	9.38	12.98
Iwate	42.06	19.94	11.37	4.55	57.94	9.09	9.97	10.41	28.03
Miyagi	61.70	39.73	15.96	1.31	38.12	11.49	8.16	6.37	11.97
Akita	79.52	52.54	16.67	5.42	20.41	2.81	2.21	10.44	4.82
Yamagata	82.88	35.10	18.13	24.67	16.87	4.78	4.48	5.89	1.61
Fukushima	76.48	33.95	23.65	12.53	23.22	6.65	4.72	4.33	7.38
Kanto	72.24	16.44	41.64	4.12	27.27	3.24	7.53	8.46	7.78
Ibaraki	72.53	19.62	40.48	3.23	26.13	3.23	4.16	9.20	9.48
Tochigi	66.18	25.20	30.92	3.84	33.42	6.66	12.93	8.82	4.94
Gunma	58.45	5.71	40.61	4.04	41.46	5.66	12.35	13.70	8.98
Saitama	85.08	16.62	52.74	3.59	14.82	1.80	3.99	3.34	5.44
Chiba	74.28	16.65	41.40	3.58	25.59	1.09	6.77	8.18	9.24
Tokyo	92.36	0.36	56.36	10.18	7.64	0.36	4.73	0.73	1.09
Kanagawa	79.15	5.02	53.67	12.23	20.59	1.16	8.75	5.53	5.15
Chubu	78.91	26.13	26.55	12.43	19.69	3.03	4.83	4.30	7.02
Niigata	81.47	55.48	16.00	3.86	18.49	1.05	2.85	4.68	9.91

Toyama	83.90	66.99	7.97	3.90	14.80	2.44	2.76	3.58	6.18
Ishikawa	80.91	51.57	17.91	4.53	18.70	1.38	5.51	3.74	8.07
Fukui	89.83	63.20	16.22	2.18	10.17	1.69	2.42	0.73	5.33
Yamanashi	90.13	7.85	12.28	63.16	9.11	1.14	2.91	1.39	3.42
Nagano	85.82	19.08	35.00	21.62	12.84	3.21	5.22	2.14	1.96
Gifu	63.29	19.03	30.52	4.13	36.62	8.98	5.12	6.19	15.98
Shizuoka	75.98	8.24	27.60	13.85	17.66	3.58	4.90	2.83	5.28
Aichi	73.53	8.44	37.61	6.01	26.33	3.07	7.26	7.46	7.43
JAPAN	67.25	19.04	27.24	9.08	32.07	6.15	9.37	6.48	9.44

Source: Ministry of Agriculture, Forestry and Fisheries

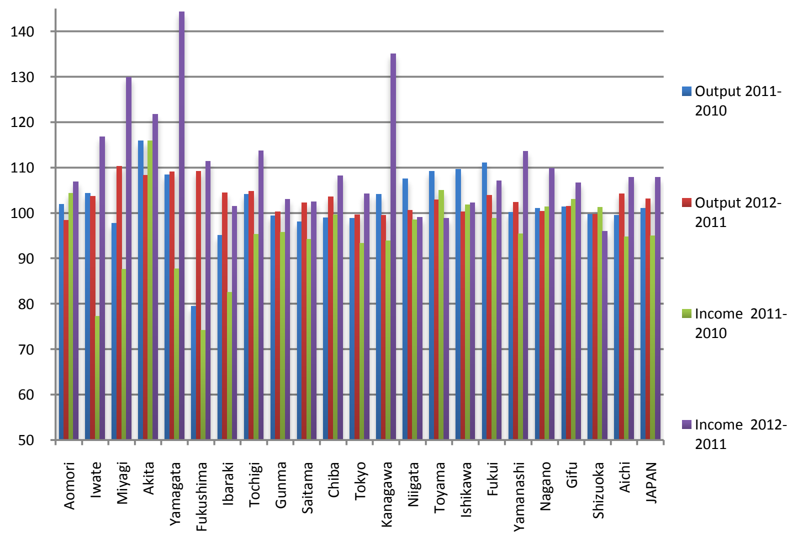


Figure 93. *Dynamics of agricultural output and income during 2010-2012 (percent)*

Source: Ministry of Agriculture, Forestry and Fisheries

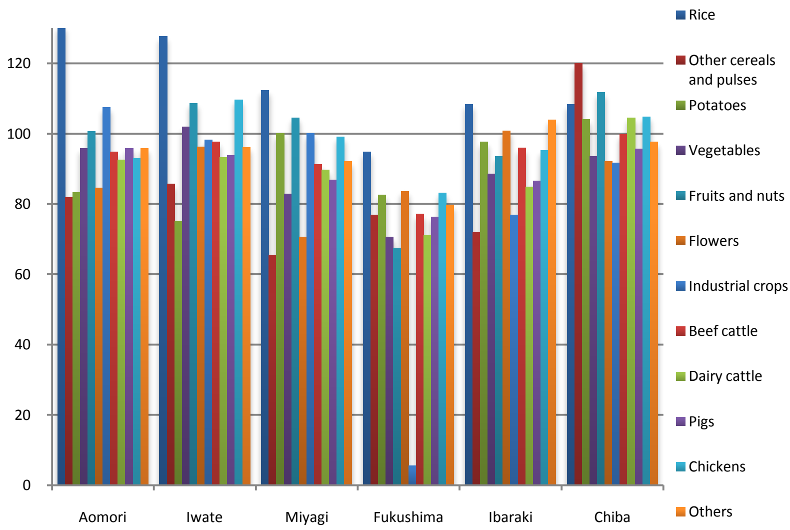


Figure 94. *Dynamics of value of agricultural products in most affected prefectures in 2011 comparing to 2010 (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

Similarly, there was a huge decline in the output of pigs, other cereals and pulses in all prefectures, beef and dairy cattle in all but Chiba prefectures, vegetables in all but Iwate prefectures, potatoes of all but Miyagi prefectures, flowers of all but Ibaraki prefectures, industrial crops in all but Aomori and Miyagi prefectures, fruits and nuts in Ibaraki prefecture, etc.

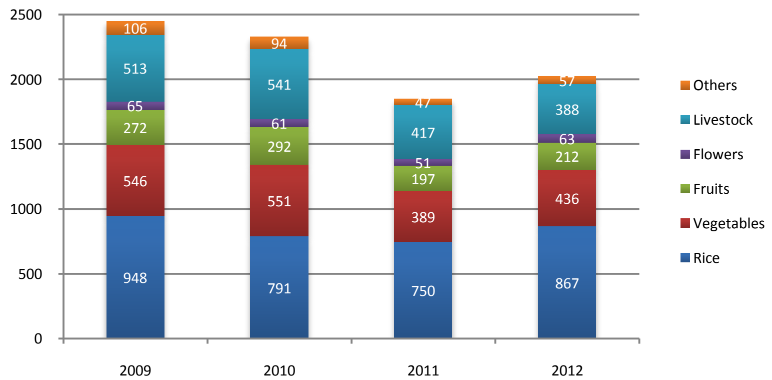


Figure 95. *Dynamics of agricultural production value in Fukushima prefecture*
Source: Ministry of Agriculture, Forestry and Fisheries

At the same time, there was a good increase in the rice value in all but Fukushima prefectures, fruits and nuts in Chiba, Iwate and Miyagi prefectures, hen eggs in Iwate prefecture, other cereals and pulses in Chiba prefecture, industrial crops in Aomori prefecture, etc. Consequently, in some of the most affected prefectures like Aomori and Iwate, there was even an increase in the total value of agricultural output. Furthermore, a strong augmentation of produced farm output was achieved in neighboring Akita and Yamagata prefectures. Subsequently, there was a slight increase in the overall agricultural output of the Tohoku region as a whole (Figure 96). In Kanto regions all but Tochigi and Kanagawa prefectures registered a drop in agricultural output. The most adversely affected were beef cattle in all but Chiba and Tokyo prefectures, fruits and nuts in Tochigi, Gunma and Saitama prefectures, etc. The sustainable levels or the insignificant augmentation in other productions did not compensate the later, and the overall agricultural output of the region slightly declined by 0.74%.

On the other hand, in Chubu region only Shizuoka and Aichi prefectures registered a little reduction in agricultural output. The later was compensated by an increased output from other prefectures, and the region demonstrated a higher than the national progression in the overall agricultural output (2.78%). The strongest augmentation of the produced farm output was achieved in Toyama, Ishikawa and Nigata prefectures.

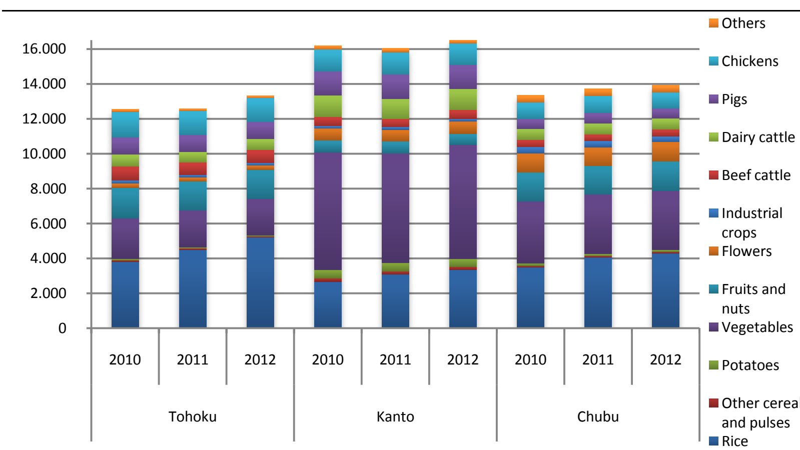


Figure 96. *Dynamics of agricultural output in Tohoku, Kanto and Chubu regions (100 million yens)*
Source: Ministry of Agriculture, Forestry and Fisheries

There was a decline in the outputs from potatoes, wheat and burley productions, miscellaneous cereals and pulses in all but Shizuoka and Ishikawa prefectures, fruits and nuts in all but Fukui, Gifu and Shizuoka prefectures, vegetables in all but Nigata, Toyama, Ishikawa and Yamanashi prefectures, beef cattle in all but Ishikawa, Fukui and Yamanashi prefectures, dairy section in all but Fukui, Yamanashi and Aichi prefectures, industrial crops in all but Nigata, Ishikawa, Nagano and Gifu prefectures, pigs in Yamashi prefectures, etc.

At nationwide scale, there was an annual reduction of the value of wheat and burley production (21.03%), miscellaneous cereals and pulses (8.77%), industrial crops (7.42%), vegetables (5.08%), flowers (4.03%), dairy cattle (2.46%), potatoes (1.76%), beef cattle (0.91%), and processed agricultural products (0.18%) (MAFF, 2012). Simultaneously, there was a slight progression in the outputs of pigs and chickens, and a good increase in the rice output (17.91%) leading to an overall growth in the country's agricultural output.

All that development has been associated with a changing structure of the agricultural output in the most affected regions and nationwide. There was a considerable enlargement of rice share in the overall value of agricultural output in the three regions and nationwide (to 22.21%). At the same time, there was a reduction in the importance of all other productions but fruits and nuts, pigs and chickens in Kanto region, and pigs in Chubu region.

In 2012 there was a good progression in the agricultural output value in all affected prefectures but Aomori, Tokyo, Kanagawa, and Shizuoka. The augmentation in most impacted prefectures and Tohoku region was higher than the national average, while in Kanto region the same as national, and in Chubu region below the national.

Nevertheless, there was a further deterioration of the output of beef cattle (24.55%), other cereals and pulses (20%), and chickens and eggs (8.03%) in Fukushima prefecture (MAFF, 2013).

Consequently, there was a recovery of the pre-disaster levels and the effective growth during the period in all but Fukushima, Ibaraki, Gunma, Tokyo, and Shizuoka prefectures (MAFF, 2013).

Ibaraki prefecture almost achieved the agricultural output level from the pre-disaster period (99.42%), producing more (0.86%) crops value and lagging behind (4.44%) for livestock.

The situation was still quite bad in Fukushima prefecture producing 15.26% less, including 8.42% in crops and 28.28% in livestock value. The recovery was particularly slower for the important beef cattle farming producing 46.45% of the pre-disaster level as well as other cereals and pulses (28.46%), potatoes (7.39%), vegetables 20,87%), industrial crops (55,66%), row milk (17.35%), pigs (8.81%), chickens and eggs (26.73%), and processed agricultural products (85.61%). During that period there was only effective progression in rice (9.61%) and flowers (3.28%) output value.

In a national scale there was three times higher than the overall expansion of the rice output and much higher growth for other cereals and pulses (Ministry of Agriculture, Forestry and Fisheries, 2014). On the other hand, there was a modest increase in the value of milk, processed agricultural products, beef cattle, vegetables, fruits and nuts, flowers, and pigs, and contractions for all others. Subsequently, besides for rice output (where there was 29.45% enlargement during post-disaster period) and miscelenouse cereals and pulses, beef and dairy cattle, pigs and processed agricultural products, for all other production there was an effecting reduction in the agricultural output value.

All that evolution was associated with a further modification of the agricultural output structure in the three regions and nationwide. Rice share continued to enlarge reaching 39.1% in Tohoku, 30.86% in Chubu, 20.24% in Kanto, and 23.64% countrywide. There was a small (but below the 2010 levels) expansion of fractions of "other cereals and pulses" (along with the same nationwide trend), fruits and nuts, flowers and beef cattle in Chubu region, and diminished importance of all other groups.

The 2011 disasters have affected considerably the farm income as well. In 2011 there was 10.52% decline in the produced agricultural income in Tohoku region due to a significant drop in all but Aomori and Akita prefectures (Figure 97). What is more, the decrease in income in Fukushima and Miyagi prefectures was superior then the reduction of agricultural output. Furthermore, a good agricultural output enlargement in Yamagata and Iwate prefectures was associated with a negative development in produced income.

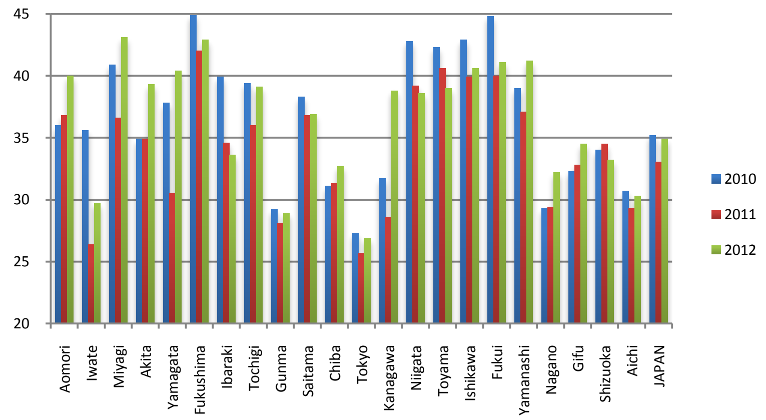


Figure 97. *Share of agricultural income in agricultural output (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

On the other hand, Akita and Aomori prefecture registered a good growth in generated income, which in the latter case was higher than the output augmentation.

Consequently, the share of agricultural income in agricultural output deteriorated in all but Aomori prefectures, as particularly strongly were affected Iwate and Yamagata prefectures. That led to a decrease in the region's ration from 38.4% to 34.23% in line with deterioration of the national figure. During the pre-disaster period farming profitability in Tohoku region and in all but Akita prefectures was higher than the national level. In the disaster year, all prefectures but Iwate and Yamagata maintained or improved (like Aomori) superiority over the country's performance in terms of income share.

As a result of all that development most prefectures, with exception of Aomori and Akita, decreased their shares in the national agricultural income as the portion of Tohoku region diminished to 15.59% (MAFF, 2012).

The agricultural income of Kanto region plummeted by 7.71% in 2011. Ibaraki prefecture was the worst hit while most prefectures had higher than the national decline in produced income with exception of Tochigi, Gunma and Chiba prefectures with a lesser reduction. Tochigi and Kanagawa prefectures, having outputs grown, saw their income contracted while other prefectures registered a higher income reduction that in the output. Only Chiba prefecture had a lesser annual reduction in the income than the output.

All but Chiba prefectures saw the ration of generated income in the output diminished in 2011 leading to a decline of the region's from 35.32% (higher than the national average) to 32.92% (below the national). Nevertheless, Ibaraki, Tochigi and Saitama prefectures continued to maintain a higher income generating efficiency than the national one.

Tochigi, Gunma and Chiba prefectures decreased their portions in the national agricultural income, as regional share slightly declined from 19.69% to 19.12% (MAFF, 2012).

All prefectures in Chubu region but Aichi had a better performance in terms of income than the national one. There was an augmentation of produced agricultural income in Toyama, Gifu, Ishikawa, Nagano and Shizuoka prefectures while in the rest the decline was less that the national average leading to a small annual drop (0.7%).

During 2011 all prefectures but Nagano and Gifu saw their income segment in the agricultural output diminished, which led to a decrease of the regional from 35.39% to 34.19%. Nevertheless, the number of prefectures with efficiency rations lower than the national decreased by 1 and only Nagano, Gifu and Shizuoka were performing worse than country's average. Aichi prefecture maintained and all others improved their share in the generated national income, increasing the regional portion to 16.98%.

In 2012 there was registered a considerable increase in the produced agricultural income in all prefectures of Tohoku region leading to an annual growth of 20.22% in the region as a whole. Moreover, in all but Aomori prefectures the annual rate of income augmentation was higher than the national increase.

Generated income in Fukushima and Iwate prefectures was still far below the pre-disaster level – 17.39% and 9.69% accordingly. Simultaneously, other prefectures achieved much higher income growth than the national one being superior in Akita prefecture (41.19%), followed by Yamagata (26.67%), Miyagi (13.85%) and Aomori (11.53%) prefectures (MAFF, 2013). During the post disaster period the Tohoku efficiency in terms of progression in agricultural income (7.57%) was much higher than in the other regions and the country's levels.

All prefectures in the region improved the income-output rations. However, in Iwate prefecture it was much lower than the national level and the pre-disaster level. Furthermore, Fukushima prefecture achieved lower than 2010 but much higher than the national efficiency ratio. Consequently, the region's profitability in terms of income generation recovered slightly above the pre-disaster level (38.91%).

Contribution of all prefectures to the national agricultural income increased during 2012 (being still below the pre-disaster level in Fukushima and Iwate prefectures) leading to an enlarged regional share of 17.38%.

All Kanto prefectures generated a growth in agricultural income being higher than the national in Chiba and Kanagawa prefecture. Nevertheless, the later was not enough to compensate the post-disaster decline and the produced agricultural income in Gunma, Saitama, and Tokyo prefectures was below 2010 levels while in Ibaraki prefecture far below under it (16.14%). On the other hand, Kanagawa and Tochigi prefecture achieved a superior that the national income augmentation.

All prefecture but Ibaraki improved their income-output ration leading to an average regional of 34.21%. Furthermore, Ibaraki, Gunma and Saitama prefectures diminished further their share in the national agricultural income, and the region's overall contribution dropped to 19%.

Generated agricultural income in Chubu region increased slower (3.74%) than in the rest of the country. Only Yamagata and Nagano prefectures had a higher than the national income growth while in Shizuoka, Nigata and Ishokawa prefectures there was a contraction. Comparing to the post-disaster period most prefectures and the region as a whole achieved a higher income growth rate than the national one. In Aichi prefecture the expansion of the income was slightly below the national while in Nigata and Shizuoka prefectures still below 2010 level.

During 2012 there was a progression of the income-output ratio for all but Nigata, Toyama and Shizuoka prefectures, and the regions figure rose to 34.9%. Nevertheless, performance for all but Nagano, Shizuoka and Aichi prefectures, and region as a whole was still below the pre-disaster level.

As a result of that development the contribution to the national agricultural income of most prefectures and the entire region diminished (16.33%) but it was higher than in the pre-disaster period.

Chapter 16. Impact on Farm Economy

The integral impact of the 2011 disasters on farm households' agricultural and overall incomes and expenditures has been quite divers in different parts of the affected regions and the country.

In 2011 there was an increase in the total Agricultural Expenditures of farming households in all affected regions and nationwide (Figure 98). In Kanto-Tosan region the rate of augmentation of the Agricultural Expenditures was much higher than country's average, while in other affected regions lower that the national one.

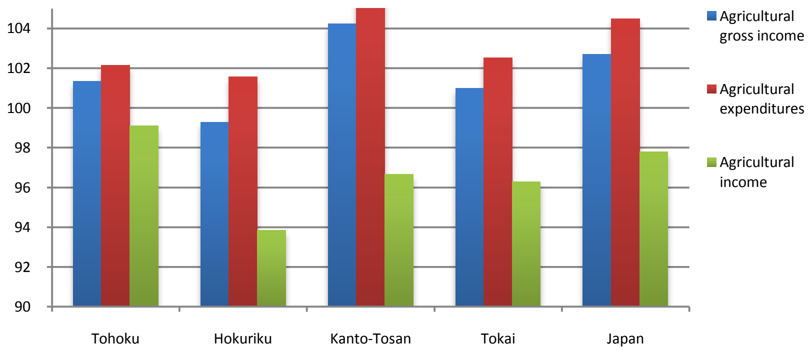


Figure 98. *Dynamics of farm households Agricultural Gross Income, Agricultural Expenditures, and Agricultural Income in Japan (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

National average Agricultural Cash Expenditures of farm households rose a little bit more (4.5%) than the Total Agricultural Expenditures while that of the Depreciation costs slower (4.12%). Similarly, in Tokai region the Agricultural Cash Expenditures expended faster (3.74%) that the overall agricultural costs, while the Depreciation rise was much lower (1.26%).

On the other hand, in Tohoku and Hokuriko regions the annual rise of the Agricultural Cash Expenditures of farm households was lower (1.78% and 1.5% accordingly) then the growth of the total amount while that of the Depreciation higher (4.27% and 2.42%). In Kanto-Tosan region the Agricultural Cash Expenditures increased (7.31%) almost as much as the Total Agricultural Expenditures, while Depreciation hike was slower (6.55%).

The highest augmentation was registered in the costs “Paid for agricultural employees” in all regions but Tohoku (Figure 99). Similar to the national trend, in all affected regions there was a higher than the overall augmentation of the expenditures for “Fuel, light, heat and power”, “Agricultural implements”, and “Rental change” (except of Tokai).

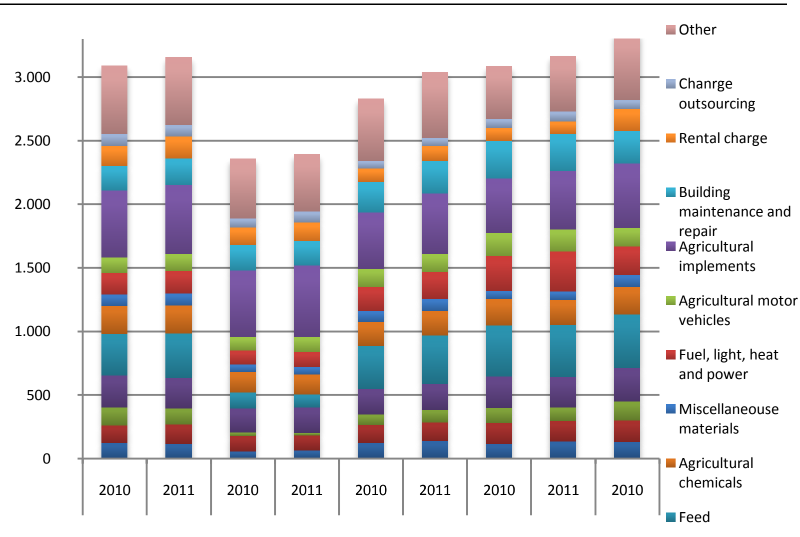


Figure 99. *Dynamics of farm households Agricultural Expenditures in affected regions (Thousands yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

Like country’s average, there was a considerable rise in “Feed” costs in Tohoku and Kanto-Tosan regions and “Animal and insemination charges" in Kanto-Tosan region. There was also registered a significant growth in the costs for "Maintenance and repair of farm building" in Tohoku and Kanto-Tosan regions, "Agricultural motor vehicles" expenditures in Tohoku and Hokuriko regions, "Seed and seeding" costs in Tohoku region, and "Fertilizer" costs in Hokuriko region.

In addition, the "Mutual relief premiums and other contributions" portion in the "Other" expenditures increased a lot in Kanto-Tusan (17.24%) and Tokai (6.9%) regions on the background of a declined figure in other two regions and unchanged national average (MAFF, 2013). The later does not comprise a big share in the overall expenditures of farms households and its dynamic affected little the variations in total amount.

The Agricultural implements, Others, and Feed costs retained their dominant shares in the overall agricultural costs of farm households in the affected regions (with exception for Feed costs in Hokuriko region) and nationwide. What is more, in 2011 the relative fractions of "Agricultural implements" slightly enlarged while that of "Others" tiny dropped. Similarly, there was a further expansion of the portion of "Feed costs" in Tohoku and Kanto-Tosan regions, and "Rental charges" in Tohoku, Hokuriko and Kanto-Tosan regions, along with the same trends nationwide.

Unlike countrywide development, in most affected (but Tokai) regions there was an increased share of the costs for "Maintenance and repair of farm building", "Agricultural motor vehicles costs" in Tohoku and Hokuriko regions, and "Seed and seeding costs" in Tohoku region. At the same time, the relative importance of all other items of Agricultural Expenditures declined.

Rice production costs data indicate a downsizing trend in the pre-disaster period (MAFF, 2013). In 2011 production year there was a further decrease in the production costs in the most affected regions along with the same nationwide evolution (Figure 100). Nevertheless, some of the most affected by the disasters prefectures (like Iwate) registered a considerable annual growth in the production costs.

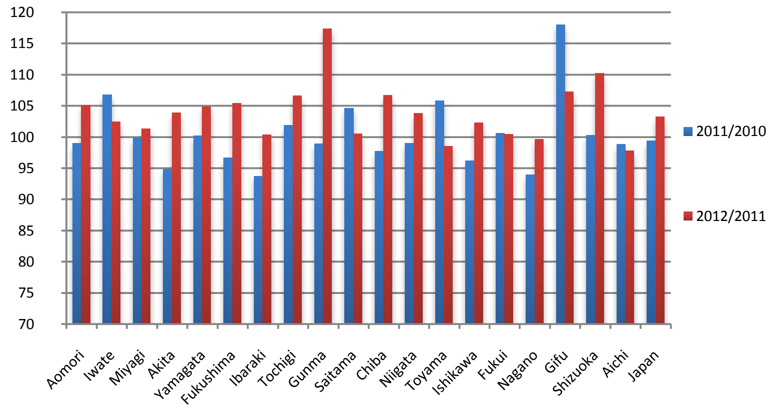


Figure 100. *Dynamics of production cost for 10 are* paddy field rice in most affected prefectures*
Note: *1 a = 100 m^2
Source: Ministry of Agriculture, Forestry and Fisheries

There was also a significant augmentation of certain costs items in the most affected prefectures. For instance, there was a much higher than the national rise in "Building repairing costs" in Aomori (31.46%) and Miyagi (65.84%) prefectures; a substantial increase in "Machinery repairing costs" in Iwate (30.03%) and Yamagata (16.37%) prefectures unlike the diminution trend nationwide, etc. The latter is likely a consequence of the higher costs associated with post disaster recovery and reconstruction in respected regions.

In 2012 production year there was a reverse dynamics in the production costs level in the majority of prefectures and countrywide. The production costs expansion in some of the most affected prefectures (like Aomori, Fukushima, Yamagata, Chiba etc.) was higher than the national average.

In most affected by the disasters prefectures there was a significantly faster than the national augmentation of costs for "Building repairing" (Fukushima – 143.27%, Chiba 111.85%, Yamagata 107.32%, Aomori - 40.12%, etc.) and "Machinery repairing" (Iwate 39.72%, Miyagi, 23.15%, etc.) (MAFF, 2013).

Summarized nationwide production costs data [313] for major annual upland crops demonstrate continuing downsizing trends for

[313] No data available for evolution of production costs in individual prefectures and regions.

wheat, barley, rape seeds, and buckwheat, a 2011 increase and followed reduction for soybean and sugar cane, and a 2012 augmentation for potatoes and sweet potato use (MAFF, 2013). All that means that the 2011 disasters had no significant impact on the production costs dynamics for most upland crops in Japan. However, there are no indications that the same trends have been applicable in the most affected regions as well.

Likewise, the national production costs data for livestock for the last several years suggest continuing upwards trends for Japanese veal calf, Raising dairy male and hybridize type cattle, and row milk, and a 2011 augmentation (from the lowest for the period 2010 level) for Fattening castrated young, dairy male and hybridize type cattle (MAFF, 2013). The increasing "Feeds costs" has been mostly responsible for that tendency. We can only guess on what extend the later development has been affected by the 2011 disasters, and what the regional specificities are.

A survey on effects of the nuclear plant accident found out that more than 41% of the farmers and 52% of the food industries in Fukushima prefecture report "extra costs emerged for radiation tests and various certificates as requested by trading partners" while the figures are much higher than in other regions of the country (MAFF, 2012).

The 2011 disasters have had a considerable effect on the farm households' finance in most affected regions. For instance, there was a bigger than the national (2.33%) rise in the Deposits and Accounts Receivable of the farm households in Tohoku (2.57%) and Tokai (17.14%) regions (Ministry of Agriculture, Forestry and Fisheries, 2013). On the other hand, there was a considerable reduction of that amount in Kanto-Tosan (5.84%) and Hokuriko (3.96%) regions.

In the pre-disaster year the Deposits and Accounts Receivable of the farm households in Tohoku and Hokuriko regions were much smaller than the national average (with 45.14% and 8.92% accordingly) while in Kanto-Tosan and Tokai regions much above that level (28.45% and 21.37%). Therefore, 2011 events positively affected that part of farmers finance in Tokai and Tohoku regions, and relatively deteriorated it in the other two regions.

In the pre-disaster period there was a tendency for decreasing of the overall amount of borrowed and owned money by farm households in Japan (MAFF, 2013). In 2011 there was a further reduction in the average volume of debt of farm households nationwide (Figure 101).

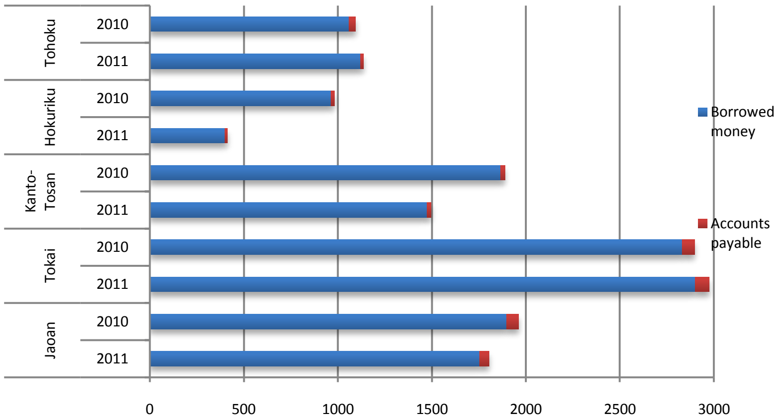


Figure 101. *Dynamics of farm households Debts in affected regions, end of the year (Thousands yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

In the most disaster affected Tohoku region there was a considerable (5.56%) increase in Borrowed Money by farming households. Simultaneously, the amount of money owned to suppliers (Accounts Payable), which usually is a small portion of the overall debt of Japanese farmers, declined by a half. Consequently, there was a good progression in the total debt of farm households. The later dynamic of borrowed and owned money was a likely consequence of the adverse impact of disasters on farm households' finance.

Similarly, in Tokai region there was some augmentation of Borrowed Money and a sizable increase in Accounts Payable of farm households, while in other affected regions a higher than the national diminution of farms' debt was registered.

In the pre-disaster year the amounts of farm households' debt in Tohoku and Hokuriko regions were only a fraction of the national average (smaller with 44.22% and 49.97% accordingly) while in Tokai region it was among the country's highest (MAFF, 2011).

Interest rates have been traditional low in Japan but an increasing amount of borrowed and owned money in 2011 put an additional burden for many farm households in times of hardship.

Japanese farmers finance their activities and investment through a variety of public, cooperative and private sources. The Japan Finance Corporation is a major policy-based financing institution[314], which supports the reconstruction after the Earthquake. In 2011 it approved 11,076 cases of agricultural loans worth of 214,533 million yen (MAFF, 2013). There are no data for the relative importance to farmers of this

[314] Utilizing a variety of financing programs and schemes to meet social needs while complementing the activities of private financial organizations.

funding and public support source. Nevertheless, data gives some idea about the significance of different type of loans through that specific financing institution.

In the pre-disaster period there was a trend for decreasing the overall cases of agricultural loans provided by the Japan Finance Corporation while approved 2010 value was the lowest for the past several years (MAFF, 2012).

In 2011 there was a big increase in the approved cases and the values of agricultural loans nationwide (Figure 102). In Tohoku region there was much higher than the national rate of multiplication of loan cases and approved loans (78.1% and 97.3% accordingly). In badly hit Miyagi prefectures the loans' cases and volumes tripled comparing to the previous year. Similarly there was a significant growth in loan cases and volume in Fukushima and Yamagata prefectures, and loans value in Aomori prefecture.

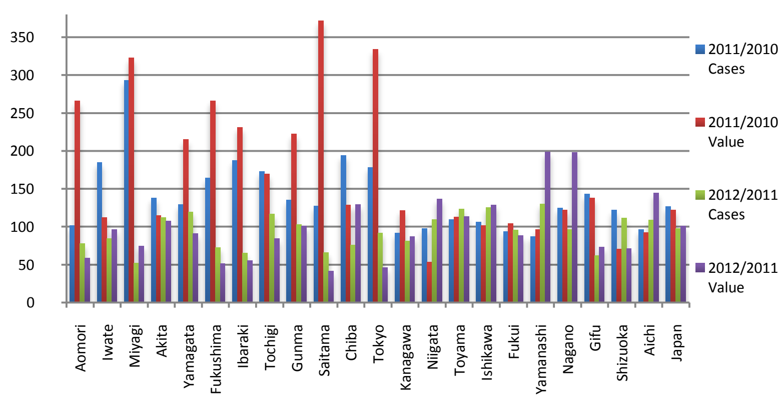


Figure 102. *Dynamics of cases and values of loans to agriculture business units approved by Japan Finance Corporation (percent)*
Source: Ministry of Agriculture, Forestry and Fisheries

Consequently, the Tohoku prefecture expended significantly its share in the country's loan cases (from 14.30% in 2010 to 20.12% in 2011) and values (from 10.48% to 16.94%) (MAFF, 2012).

Likewise, there was a great augmentation of loan cases and values in Kanto region (69.41% and 95.19% accordingly) and its most badly affected prefectures (Ibaraki, Tochigi, etc.). Subsequently, region's portion in the national loan cases and values considerably augmented - from 11.55% to 15.45%, and from 14.77% to 23.62% accordingly (MAFF, 2012).

In less affected by the earthquake Chubu region a lower than the national dynamics of loan cases and value was registered - 7.01% increase and 7.44% reduction accordingly. As a result, the region's fraction in the overall loan cases dropped from 16.46% to 13.91% and in the loan values from 17.64% to 13.38% (MAFF, 2012).

There was also a substantial change in the structure of approved agricultural loans comparing to the pre-disaster year. In 2011 the "Agricultural management reinforcement" loans retained, but diminished considerably, their major share in the overall amount nationwide – the portion of loans numbers declined from 54.94 % to 42.26 %, and that of loans value from 61.70 % to 45.85% (MAFF, 2012). At the same time, the "Agriculture safety nets" stake expended enormously – from 9.51% to 19.28% in terms of loan cases, and from 5.3% to 18.02% in terms of loans value. All other type of agricultural loans diminished their importance in terms of cases and values.

In Tohoku and Kanto regions, and in the most affected by the disasters prefectures (but Aomori) the "Agriculture safety nets" loans become dominant in terms of cases and value (Figure 103). Simultaneously, in Aomori prefecture a tiny share of the loan cases for Agriculture, Forestry and Fisheries Equipment (0.83%) become the major loans value users (45.18%). In Chubu region the later type of relatively small number of loans retained its bulk share in terms of value.

In 2012 there was a slight reduction in cases and a small augmentation of the values of agricultural loans nationwide. Nevertheless, the numbers and amounts of loans in Tohoku and Kanto regions considerably declined – accordingly by 24.66% and 18.45% in terms of cases, and by 21.54% and 23.76% in terms of value (MAFF, 2013). Consequently, the relative share of two regions in the national loan numbers diminished to 15.74% and 12.91% accordingly, and in loans values to 13.12% and 17.8%.

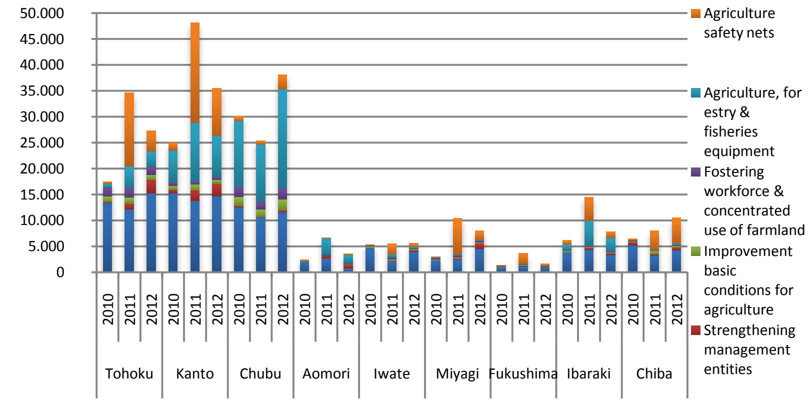


Figure 103. *Values of loans to agriculture business units approved by Japan Finance Corporation, 2010-2012 in affected regions (million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

At the same time, the loans cases and amounts increased a lot in Chubu region (by 7.2% and 44.76%) as the region enlarged its portion in the national one to 15.27% and 19.12% accordingly (MAFF, 2013).

In 2011 there was some annual growth in the Gross Agricultural Income of farm households in all affected regions but Hokuriku (Figure 96). In Tohoku and Tokai regions the expansion was slower than the country's average, and much higher in Kanto-Tosan region.

The Gross Agricultural Income of farm households from "Crops" augmented more than the overall in Tohoku and Tokai regions, and nationwide, while in Kanto-Tusan region the growth of "Livestock" contribution was higher that the composite one (Figure 104). Consequently, the crop shares in the Gross Agricultural Income increased further everywhere. At the same time, there was a slight rise in the fraction of "Livestock and livestock products" in Kanto-Tosan region and countrywide at the expense of "Others".

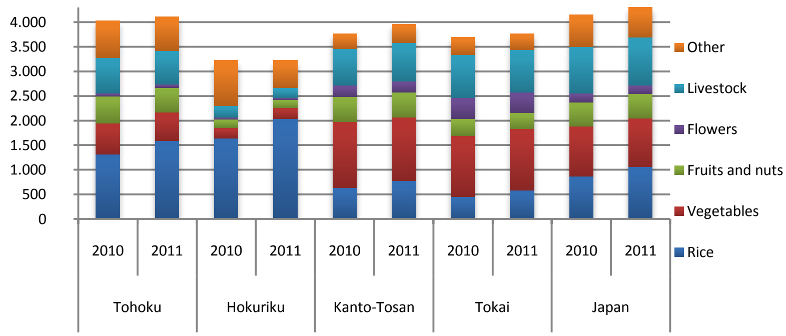


Figure 104. *Dynamics of farm households Agricultural Gross Income in affected regions (Thousands yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

In all regions there was a huge increase in the "Rice" Gross Agricultural Income of farm households (20.87% in Tohoku, 22.68% in Kanto-Tosan, 23.9% in Hokuriko, and 30.22 in Tokai) being a lower than the national one (22.52%) in Tohoku region.

Simultaneously, there was a considerable (and a higher than the national 3.33%) decline in the "Vegetables" Gross Agricultural Income of farm households in Tohoku (8.52%) and Kanto-Tusan (4.39%) regions with a good growth registered in Hokuriko (3.23%) region. Similarly, there was a great reduction in the "Fruits and nuts" Gross Agricultural Income of farm households in Tohoku (8.03%) and Tokai (6.09%) regions with a positive growth nationwide (1.14%) and lesser one in other regions.

Furthermore, there was a huge fall in the contribution of "Livestock and its products" to the Gross Agricultural Income of farm households in Hokuriko (14.83%), Tohoku (6.12%) and lesser one in Tokai (1.15%) regions, on the background of a good growth in Kanto-Tosan region (5.55%) and country's average (2.87%).

Tohoku region also registered a high growth in the "Flowers" Gross Agricultural Income of farm households (10.17%) at the time of the overall decline in that contribution in other regions and country as a whole.

Farm households in all regions but Kanto-Tosan reported downsizing of "Others" Gross Agricultural Income of farm households, including the "Mutual relief indemnity". Nevertheless, in 2011 the later still composed a good segment in the Gross Agricultural Income of all regions being higher than the (10.65%)

national in Tohoku (12.69%) and Hokuiko (11.41%) regions, and lower in Kanto-Tosan (7.69%) and Tokai (6.01%) regions.

In the pre-disaster period there was a decrease in national figures for the farm households indemnified for paddy field rice, damaged acreages and yields, and the mutual relief, insurance and reinsurance indemnities paid (MAFF, 2012). The later followed the tendencies for reduction of insured farm households[315] and the mutual relief, insurance and reinsurance premiums, and a "stable" amount of covered acreages and yields.

In 2011 it was registered a good progression of the number of farm households indemnified in the country as they reached 63,750 or 3.86% of all insured farm households (Figure 105). At the same time, further reductions in damaged acreages and yields, and mutual relief, insurance and reinsurance indemnities were reported as they dropped to 25,637ha (or 1.74% of the insured paddy fields), 21,745t (0.4% of the insured crops), 4,045.85 million yen (16.72% of the mutual relief premiums), and 1,285.129 million yen (7.21% of the insurance premiums), and 93.112 million yen (0.62% of the reinsurance premiums) (MAFF, 2013).

In Tohoku region there was a huge increase as the number of indemnified for rice farm households increase by 74.33%, the amount of damaged areas and yields by 58.41% and 93.86%, and the mutual relief and insurance indemnity by 99.28% and 154.29% (Ministry of Agriculture, Forestry and Fisheries, 2013). The biggest rise in all these figures was reported in the most affected Fukushima, Yamagata, Iwate and Miyagi prefectures.

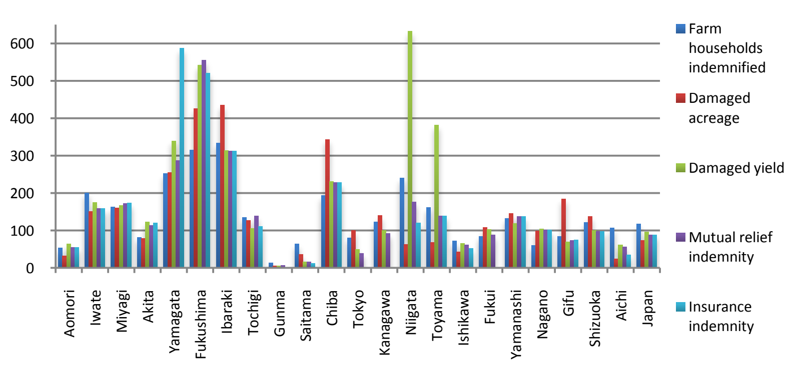


Figure 105. *Dynamics of mutual relief and insurance of farm households for paddy field rice in affected regions in 2011 (2010=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

[315] In Japan practically all market-oriented farms are insured for paddy filed rice.

Consequently, Tohoku's share in the country's indemnified farms augmented from 6.02% to 8.94%, in damaged acreages from 11.3% to 24.38%, in damaged yields from 6.07% to 12.19%, in mutual relief indemnity from 6.85% to 15.39%, insurance indemnity from 4.91% to 14.01%, and reinsurance indemnity[316] from 0.24% to 40.79% (MAFF, 2013).

In Kanto region there was an overall reduction of farms households indemnified (by 36.87%), damaged areas (by 67.42%) and yields (by 60.36%), and mutual relief indemnity (by 59.03%), and a small increase in the insurance indemnity (1.02%). However, in most severely hit by the disasters Ibaraki, Tochigi and Chiba prefectures a considerable rise in all these figures was registered.

Consequently, region's portion in the country's overall number shrinked enormously – from 15.81% to 8.63% for indemnified farms, from 18.17% to 8.06% for damaged rice paddies, from 16.94% to 6.95% for damaged rice yields, from 14.14% to 6.53% for mutual relief indemnity, from 3.99% to 4.53% for insurance indemnity, and 53.27% to 0.37% for reinsurance indemnity (MAFF, 2013).

In Chubu region there was a good increase in the number of indemnified farms (38.24%), damaged yields (179.76%), and paid mutual relief (44.05%) and insurance (14.25%) indemnities. The biggest rise was registered in Nigata, Toyama, Yamashi, and Shizuoka prefectures.

Subsequently, region's share in the country's indemnified farms further increased from 12.97% to 15.25%, in damaged yields from 10.62% to 30.76%, in mutual relief indemnity from 15.53% to 25.21%, and in insurance indemnity from 23.09% to 29.62%, while slightly decreased for damaged acreages (from 20% to 18.81%) and plummeted for reinsurance indemnity (from 43.54% to 0.01%) (MAFF, 2013).

The Japanese farms have been well supported by the government through various subsidy schemes. In FY 2011 there were 1,150,159 payments to Agricultural Management Units under the "Individual Income Support Allowance System for Farmers" amounting to 5,366 million yen (MAFF, 2013).

The average amount of support per payment was 466,544 yen (Ministry of Agriculture, Forestry and Fisheries, 2013). The highest amount per payment was for "Income support allowance subsidy for upland field crops" averaging 2,114,998 yen, followed

[316] Reinsurance indemnitiesapplied only in Akita (2010) & Yamagata (2011) prefectures.

by the “Additional subsidy” (428,878 yen), the “Income support allowance subsidy for utilizing paddy fields” (410,938 yen), and the “Income support allowance subsidy for rice (fixed amount)” (152,081 yen).

The greatest majority of recipients of public subsidies were Individuals (Table 37), and the rest Juridical Persons (0.66%) and Rural Communities (0.66%). A great portion of the commercial farms households was covered by that support system as the number of payments to Individuals accounts for 75.47% of the number of Farm households.

Table 37. *Share in total numbers and amounts of payments under Individual Income Support Allowance System for Farmers, April 30, 2012 (percent)*

Regions	In total number of payments					In total amount of subsidies			
	Indivi-duals	Subsi-dy for rice fixed amount	Subsi-dy utilizing paddy fields	Sub-sidy upland field crops	Addi-tional subsidy	Rice fixed amount	Utili-zing paddy fields	Upland field crops	Addi-tional
Tohoku	98.57	89.29	50.86	8.15	0.79	41.77	47.04	10.44	0.65
Aomori	99.07	84.29	52.61	6.78	0.52	32.50	56.88	10.00	0.63
Iwate	98.60	85.51	55.17	3.21	0.59	36.67	52.22	10.00	1.11
Miyagi	97.90	94.06	27.52	2.73	0.72	38.16	46.05	14.91	0.44
Akita	98.27	92.41	63.36	9.95	1.02	46.02	45.13	8.41	0.44
Yamagata	98.44	87.03	65.01	17.32	1.26	46.11	43.33	10.00	0.56
Fukushima	99.40	91.15	43.03	11.41	0.63	55.56	36.11	7.41	0.93
Kanto	99.15	90.28	46.74	6.49	0.74	30.41	48.16	20.82	0.20
Ibaraki	99.27	88.71	45.28	5.70	0.34	31.39	43.80	24.82	0.00
Tochigi	99.24	92.59	52.13	9.00	1.18	32.50	53.00	14.00	0.50
Gunma	98.63	85.65	44.95	6.06	0.98	17.74	45.16	35.48	0.00
Saitama	98.95	91.25	42.57	6.52	0.49	25.00	46.15	28.85	0.00
Chiba	99.08	90.81	45.49	1.27	0.67	43.24	48.65	8.11	0.00
Tokyo	100	98.84	1.16	2.31	0.00	0	0	0	0
Kanagawa	99.48	96.77	17.87	3.14	0.05	50.00	0.00	0.00	0.00
Chubu	98.50	92.67	38.84	5.79	0.84	43.57	40.08	15.55	1.07
Niigata	98.49	97.99	45.16	5.35	1.03	55.27	36.71	7.17	0.84
Toyama	96.87	97.17	45.93	5.07	0.69	42.74	41.03	15.38	0.85
Ishikawa	98.25	98.32	19.58	3.61	0.84	57.63	30.51	11.86	1.69
Fukui	97.50	97.78	29.54	7.94	0.71	41.98	37.04	19.75	1.23
Yamanashi	99.47	88.83	24.55	6.95	0.10	50.00	50.00	25.00	0.00
Nagano	99.04	84.46	41.36	11.00	0.66	35.53	36.84	26.32	1.32
Gifu	99.05	86.70	41.70	1.08	0.50	31.43	50.00	17.14	1.43
Shizuoka	98.84	86.19	34.82	3.78	1.64	42.11	52.63	10.53	0.00
Aichi	99.38	90.49	33.67	6.13	1.69	20.48	49.40	27.71	1.20
Japan	98.68	87.64	46.93	6.49	0.73	28.57	41.33	29.41	0.67

Source: Ministry of Agriculture, Forestry and Fisheries

Tohoku, Kanto, and Chubu farms got accordingly 19.82%. 9.65% and 20.34% of the overall national payments under that particular scheme (MAFF, 2013). In 2011-2012 as many as 227,920 Tohoku farms, 110,951 Kanto farms, and 233,941 Chubu farms were supported by the scheme.

The majority of supported farms in the affected regions received "Subsidy for rice (fixed amount)" and a considerable portion of them "Subsidy for utilizing paddy fields". A small part of the farms also got "Subsidy for upland field crops" and "Additional subsidy".

The biggest part of the public payments in Tohoku and Kanto regions was for "Utilizing paddy fields" followed by the "Subsidy for rice" and "Upland field crops". The later took relatively a higher share in Ibaraki region at the expense of a lower portion of the rice subsidy.

On the other hand, in Chubu region the support for rice dominated followed by the subsidies for utilizing paddy fields and for upland field crops. In all affected regions the "Additional subsidies" were a tiny fractions of the overall amount similar to the countrywide trend.

The shares of subsidies for utilizing paddy fields and for rice in the total were higher than the national for all affected regions, while for upland field crops lower than the country's average.

For Tohoku farms the level of overall public support under that scheme was a little bit higher (1.75%) than the national, being a considerably above the country average for all but Iwate and Fukushima farms (Figure 106). All farms in the region received significantly more Income support allowance subsidy for rice; and Miyagi farms more Income support allowance subsidy for utilizing paddy fields and for upland field crops; and Aomori farms more Income support allowance subsidy for utilizing paddy fields; and Aomori, Iwate and Fukushima farms more additional subsidies, than in the other parts of the country.

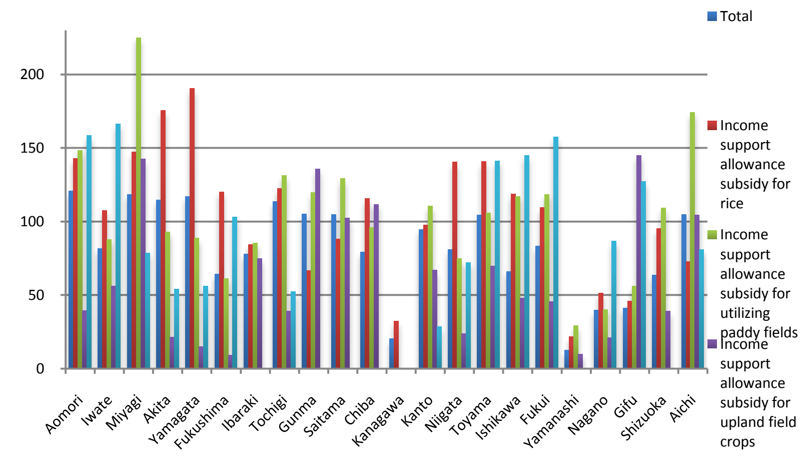


Figure 106. *Amount of support per farm of different type of payments in FY2011 (Japan=100)*
Source: Ministry of Agriculture, Forestry and Fisheries

On the other hand the overall support to Kanto and Chubu farms was much lower than the country's average. Nevertheless, the level of certain support measures in some prefectures were much higher than the national.

In FY 2012 there was a decrease in the number of payments under the Individual Income Support Allowance System for Farmers in the country (2.76%), and increase in the amount of support (4.42%) (MAFF, 2013).

In Tohoku region there was less than the national reduction in number of payments (1.22%) and a slight augmentation in the badly affected Fukushima (3.58%) and Miyagi (1.09%) prefectures. At the same time, there was a less that the country's average increase in total subsidies in the region as a whole (0.83%) and in most prefectures (Iwate and Yamagata – 2.22%, Miyagi 2.63%, Fukushima – 2.78%), with a decline in Aomori (4.37%) and Akita (0.78%) prefectures.

In Kanto and Chubu regions there was registered a reduction in the number of payments (2.5% and 4.34% accordingly) and increase in the total amount of support (3.88% and 5.76% accordingly).

In 2012 the amount of subsidies per payments increased less that the country's average of 7.38% in Tohoku and Kanto regions (1.97% and 6.54% accordingly) and faster in Chubu (10.56) region (MAFF, 2013). Consequently, the amount per a payment in all affected regions was below the country's average level – with

3.37% in Tohoku, 6.08% in Kanto, and 29.62% Chubu region (MAFF, 2013).

While the overall subsidies per payment was still higher that the national in Aomori (10.15%), Miyagi (12.01%), Akita (10.05%), and Yamagata (16.23%) prefectures, it was significantly lower in the badly hit Iwate (20.56%) and Fukushima (39.59%) prefectures. Nevertheless, the specific payments for Income support allowance subsidy for rice was considerably higher than the national average in all prefectures (with 45.1% in Tohoku region as a whole) as well as for Income support allowance subsidy for utilizing paddy fields in Aomori and Miyagi, and for Income support allowance subsidy for upland field crops in Miyagi, and for Additional subsidy in Aomori, Iwate and Akita prefectures.

There has been also a huge budget of the Ministry of Agriculture, Forestry and Fisheries for direct and indirect support of diverse aspects of agrarian and rural development (Table 38). Particularly, there has been an increasing amount of the public works expenditures for the "Improvement of agriculture and agricultural village", constant spending on the "Disaster restoration", and fluctuating "Subsidies for development of rural areas" (Figure 107).

Table 38. *Ministry of Agriculture, Forestry and Fisheries accounts for agrarian and rural development (million yen)*

Budget items	2011	2012	2013
Securing food safety and consumer trust	12,272	10,882	9,961
Strengthening cooperation between food and agriculture	134,510	82,880	61,645
Strengthening cooperation food and agriculture for domestic agricultural and livestock products, by customs duty on beef	65,966	64,247	60,035
Strengthening agricultural and food industries	3,127	2,093	24,422
Establishment of food security	8,349	12,922	11,922
Farm management	670,617	705,896	670,175
Securing and efficient use of superior farmland	17,863	22,377	20,326
Promotion of agricultural production infrastructure	2,432	28,643	17,967
Development of agricultural production infrastructure	62,479	63,754	60,710
Support for environmentally-sound agricultural production	4,024	3,403	3,119
Collaboration of primary, secondary, and tertiary industrialization of rural areas	13,236	10,962	10,193
Securing against expansion of consumption for national agriculture, forestry, fisheries	na	na	3,984
Exchange between cities and rural areas	1,749	1,449	2,546
Conservation of rural area resources and others	49,296	50,763	56,857
Countermeasure against tidal damage	2,936	2,866	2,917
Preservation of farmland	14,465	15,072	36,670
Infrastructure facilitating individual income support allowance	17,870	18,290	2,092
Maintenance of strengthening agricultural conflict	na	na	36,507
Revitalization of rural areas	29,640	13,575	15,733
Development of rural areas	25,669	8,570	91,357
Global environment agriculture, forestry and fisheries industry	95	114	129

For storm damages	90	63	57
Contract construction costs such as implementation costs	1,553	1,197	3,564
Coastal project surveys	4	4	4
Surveys on maintenance and development of agricultural production infrastructure	1,146	1,146	1,145
Damaged agricultural facilities restoration works	7,932	7,990	7,977
Works associated with disaster against agricultural facilities	228	170	183
Transfers to special accounts	253,051	219,928	210,051

Source: Ministry of Agriculture, Forestry and Fisheries

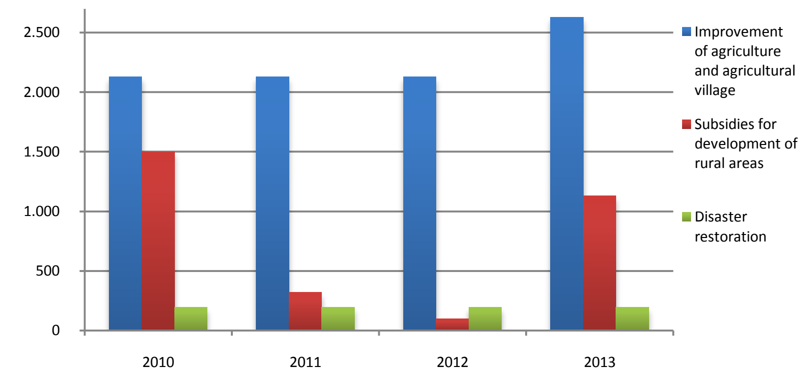


Figure 107. *Evolution of public works expenditures related to agriculture (100 million yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

As a result of all these development, there was a higher than the national (2.15%) augmentation of the Cash Income from Agriculture per farms households in Kanto-Tosan region (3.3%), lesser rise in Tohoku (1.09%) and Tokai (0.63%) regions, and a (1.19%) reduction in Hokuriko region.

Comparing to the pre-disaster period in 2011 there was a certain growth in the Gross Agricultural Income of farm households in the most affected regions. However, the later was accompanied by a higher rise in the farm households Agricultural Expenditures. Consequently, the Net Agricultural Income per farm households contracted in all affected regions and nationwide (Figure 96).

In Tohoku region the Agricultural Income of farm households contracted less (0.91%) then the national one (2.21%) while in the other affected regions the reduction was much greater (Hokuriko – 6.17%, Tokai – 3.72%, and Kanto-Tosan 3.45%).

Consequently, in 2011 the relative share of Agricultural Income in the Total Farm Households Income decreased in most regions (from 26.95% to 25.81% in Tohoku region, from 21.12% to 19.51% in Hokuriko, and from 19.08% to 18.11% in Tokai) and nationwide (from 26.24% to 25.81%) (Figure 108). On the other hand, in Kanto-Tosan region there was a slight augmentation in the relative importance of that income source - from 24.37% to 24.54%.

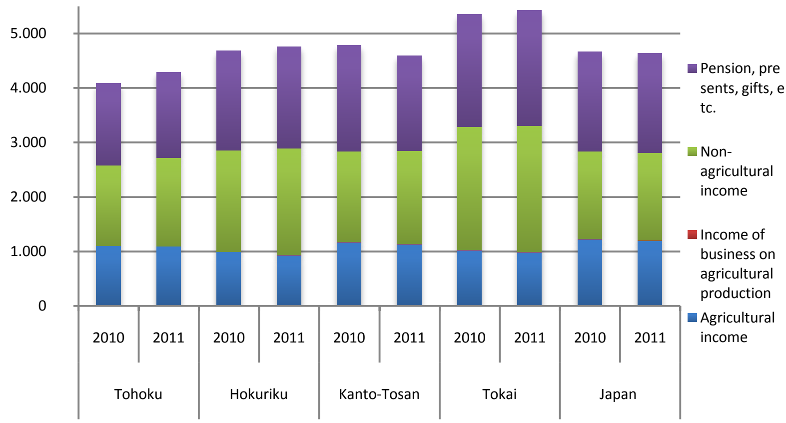


Figure 108. *Dynamics of farm households income in affected regions (Thousands yen)*
Source: Ministry of Agriculture, Forestry and Fisheries

The agricultural income has been the third biggest income source of the farm households in all affected regions and nationwide. In Tohoku and Kanto-Toscan regions that source of income comprised a bigger part of the overall households' income. Therefore, the variation of the former affected strongly the overall farm households' income.

The Income of Business on Agriculture Production was not affected in Tohoku and Hokuriko regions, and largely increased in the other parts of the country (55.56% in Kanto-Tosan, 25% in Tokai, and 14.29% nationwide). Subsequently, the relative portion of that income source increased slightly in all but Tohoku regions. Nevertheless, this income source has been an insignificant part of the overall income of farm households in the affected regions (0.07% in Tokai, 0.1% in Tohoku, 0.15% in Hokuriko, and 0, 19% in Kanto-Tosan) and nationwide (0.15%). Therefore, the variation of the later had no essential effect on the overall households' income.

A survey on effects of the nuclear plant accident found out that 3% of the Japanese farmers indicate that "Income declined due to the abandonment of farm products and the relinquishment of manufacturing and production due to foreign countries' import controls and trading partners' refusal to import Japanese products" (MAFF, 2012). The later share for the Fukushima prefecture farmers is almost three times higher.

There was an increase in the Non-agricultural Income of farm households in all affected regions. That was a result in the increased Gross Non-agricultural Income in all regions but Tokai, and an effective diminution of the Non-agricultural Expenditures everywhere.

The expansion of the Non-agricultural Income was particularly high in Tohoku region (10.06%) and good in other regions (4.94% in Hokuriko, 2.48% in Tokai, and 2.4% in Kanto-Tosan) on the background of an overall reduction in that income source at nationwide scale (0.37%). Subsequently, the comparative importance of this income source increased across the country – from 42.24% to 42.67% in Tokai region, from 39.8% to 41.12% in Hokuriko, from 36.06% to 37.75% in Tohoku, and from 34.87% to 37.21% in Kanto-Tosan, and 34.55% to 34.62% in the country as a whole (MAFF, 2013).

In Tohoku, Hokuriko and Tokai regions the Non-agricultural Income represents the biggest segment of the overall income of farm households while in Kanto-Toscan region and nationwide it is the second most important one. Therefore, its variation affected quite significantly the overall income of farm households.

Finally, there was much higher than the national (0.27%) augmentation of the Pension, Presents, Gifts etc. in all affected regions (Tohoku – 4.71%, Tokai – 2.81%, Hokuriko – 2.36%) with exception of Kanto-Toscan, where there was a sizable reduction (10.26%) in that income source. Consequently, the relative segment of that income source slightly increased in Hokuriko (from 38.93% to 39.23%) and Tokai (from 38.61% to 39.13%) regions and nationwide (from 39.06% to 39.39%), and decreased in the other two regions (from 36.89% to 36.75% in Tohoku, and from 40.58% to 37.95% in Kanto-Tosan).

In Kanto-Toscan region that source accounts for the biggest income source for the farm households while in all other regions it is the second biggest one.

As a result of all these developments, the Total Farm Household Income in Tohoku, Hokuriko and Tokai regions increased, which was a particularly high (5.12%) for the Tohoku farmers, and modest for producers in other two regions (1.58% in Hokuriko, and 1.44% in Tokai). At the same time, in Kanto-Tosan region there was a considerable (4.04%) and a higher than the national (0.58%) reduction of the farm households income.

The Taxes, Imports and Other obligations (except agricultural management) effectively decreased in all affected regions, which was less than the national (3.98%) reduction in Tohoku region (3.27%) and higher in other regions (Tokai – 7.58%, Kanto-Tosan, 6.13%, and Hokuriko 5.96%). Subsequently, the relative importance of these payments diminished everywhere – from 12% to 11.05% in Tohoku region, from 12.17% to 11.27% in Hokuriko region, from 16.38% to 16.02%, from 18.73% to 17.06% in Tokai region, and from 14.55% to 14.05% nationwide (MAFF, 2013).

Ultimately, the Disponible Income of farm households in all but Kanto-Toscan region augmented being especially high in Tohoku region (6.26%), and modest in Tokai (3.52%) and Hokuriko (2.63%) regions. On the other hand, in Kanto-Toscan region farmers saw their Disponible Income reduced (3.73%) while at a nationwide scale it was the same as in pre-disaster year.

There was an augmentation of the share of the Disponible Income in the Total Income of Farm Households in all affected regions (from 88% to 88.95% in Tohoku, from 87.83% to 88.73% in Hokuriko, from 83.62% to 83.98% in Kanto-Tosan, and from 81.27% to 82.94% in Tokai) and nationwide (from 85.45% to 85.95%).

In the pre-disaster period the farm households in Tohoku region had lower than the national Agricultural, Total and Disposable Incomes (Table 39). On the other hand, farmers in other affected regions had a lower than the national Agricultural Income but higher overall and disponible incomes.

Table 39. *Level and structure of farm households income in affected regions (Japan=100)*

Regions	Agricul-ltural income	Income agricul.b usi-ness*	Non agricul-tural income	Pension, prese-nts, gifts, etc.	Total farm house-hold income	Taxes, importso bli-gations	Dispo-sabe income
2010							
Tohoku	89.94	57.14	88.94	82.75	87.60	72.27	90.21
Hokuriku	80.87	100.00	104.35	100.16	100.49	84.07	103.29
Kanto-Tosan	95.26	128.57	111.01	106.59	102.60	115.49	100.40
Tokai	83.48	57.14	153.11	113.52	114.83	147.79	109.22
2011							
Tohoku	91.14	50.00	96.72	86.41	92.62	72.81	95.86
Hokuriku	77.59	87.50	109.91	102.25	102.68	82.33	106.00
Kanto-Tosan	94.15	175.00	114.61	95.40	99.03	112.90	96.76
Tokai	82.19	62.50	148.71	116.38	117.16	142.24	113.06

Note: * calculate labor cost and material cost
Source: Ministry of Agriculture, Forestry and Fisheries

After the 2011 disasters, the farm households in Tohoku region diminished the differences with the average nationwide level slightly for the Agricultural, and more visibly for the Total and the Disposable Incomes. At the same time, the farm households in other two regions saw their agricultural income decreased comparing to the average national level. However, while there was a further enlargement of the total households and disposable incomes in Hokuriko and Tokai regions, in Kanto region these levels deteriorated below the country's average.

Chapter 17. Expert Assessments on Impacts and Factors of March 2011 Disasters

Needs and importance of expertise

Our analysis has demonstrated that some of the impacts and factors of the March 2011 disasters are difficult to identify and assess due to the insufficient information, controversial data, continuing challenges and uncertainties, etc.

In order to expend the assessments we have carried out numerous in-depth interviews with leading experts in the areas, and representatives of governments, farmers, food industry and non-governmental organizations, and affected farmers, business and consumers.

In addition, we have organized two expert assessments in order to identify the 2011 disasters' short and longer terms impacts on agriculture, food industries and consumers as well as factors for persistence of negative impacts, and longer-term impacts on major resources, productions, organizations, efficiency, etc. in the most affected regions and the rest of Japan.

The experts' identification was based on a careful study of their positions in the affected agri-food chains, decision-making, and post-disaster evaluation and governance as well as research, publications and presentations. In addition, multiple consultations with the leading analysts in the field were made before selecting the members of the expert panels.

The experts were asked to specify the overall impacts on agriculture, food industry, and food consumption in different regions affected by the earthquake, tsunami and nuclear disaster. Since individual effects have quite different time span and the individual experts have quite different horizon we let the experts to decide on the duration of "short-term" and "longer term".

We prepared a list of factors for persistence of the negative effects on the base of an extensive study of most commonly cited factors by officials, experts, stakeholders, analysts, media, etc. A similar approach was employed in working out the list of most likely affected in the long-term aspects of agri-food sectors (resources, performances, behavior, markets, costs, governance, international trade, etc.). There was also an option left for experts to include other (new) factors and assess their importance as well as a space for free comments related to the 2011 disasters. A Japanese translation of the assessment form was provided to all experts who are not fluent in English, while a bilingual expert translated responses back into English.

The first expertise was carried out in June-July 2013 and focused on the specific impacts and factors of the Fukushima nuclear accident. The number of experts was eleven, including four researchers (two from the Fukushima University, one from the Tohoku University, and one from the Tsukuba University), two representatives of the prefectural government in Fukushima, two farmers, two representative of farmers associations from Fukushima prefecture, and one representative of a Fukushima food industry organization. One out of the twelve initially selected expert panel members[317] did not fill in the assessment form but gave us an in-depth interview on major issues.

The second expert assessment was carried out in October-November 2014 and covered the specific and combined impacts of the March 2011 earthquake, tsunami and nuclear disaster. The number of experts was thirteen – all leading researchers in the area[318] (five from the Tohoku University, one from the Tsukuba University, and seven from the Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries). The same approach like in the first expertise was used throughout that assessment.

More than three and a half years after the triple disaster, the expertise gives some tentative assessment on the diverse (specific, combined, short-term, long-term, functional) impacts of the 2011 earthquake, tsunami and nuclear accident on agriculture, food industries, and food consumption in different regions of the country.

Specific impacts of earthquake

[317] The Managing Director of the Consumer Cooperatives Union, Fukushima.
[318] All of them assessed the impacts on agriculture, eleven assessed the impact on food industry, and twelve assessed the impact on food consumption.

Short-term implications

According to the experts, the short and long-term impacts of the Great East Japan earthquake on agriculture, food industries and food consumption in different regions of the country have been quite different.

The specific short-term impact of the earthquake on agriculture in Miyagi and Fukushima prefectures is significant negative according to a greatest proportion of the experts (Figure 109). Furthermore, a good portion of them evaluates that impact as moderate negative. In Iwate prefecture the most of the experts believe that impact is moderate or insignificant negative, while in Aomori, Chiba and Ibaraki prefectures the effect is predominately assessed as insignificant negative. The specific short-term impact of the earthquake on agriculture in other parts of the country is generally evaluated either as insignificant or none.

At the same time no expert believes there is a positive specific of combined short or long-term impact on the 2011 disasters on agriculture in Japan.

The specific short-term impact of the earthquake on food industries in Miyagi and Fukushima prefectures is significant negative (Figure 110). Nevertheless, a good segment of the expert panel evaluates that impact as insignificant negative. In Iwate and Chiba prefectures the greatest portion of the experts assess that effect as moderate negative or insignificant negative. The short-term impact of the earthquake on food industries in Aomori and Ibaraki prefectures, and the rest Japan is predominately evaluated as insignificant negative. However, many experts also believe the later impact is more severe (including up to a significant one in the two Tohoku prefectures).

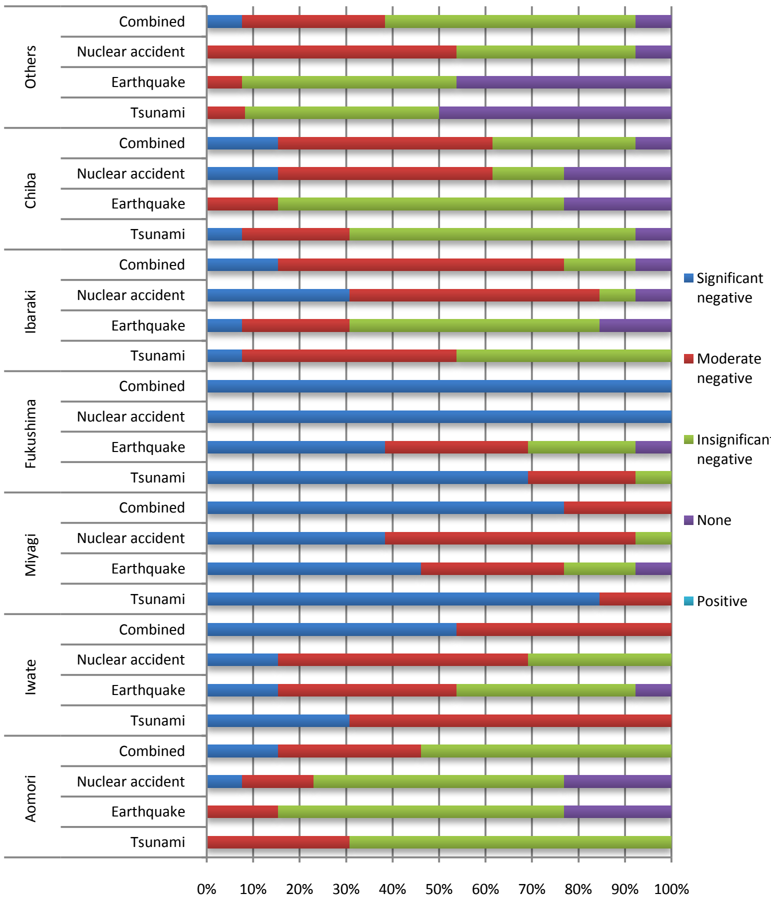


Figure 109. *Short-term impacts of March 2011 disasters on agriculture in different prefectures of Japan*
Source: assessment by panel of experts, 2014

Simultaneously, no expert indicates that there is a positive specific short or long-term impact on the 2011 earthquake on food industries in Japan.

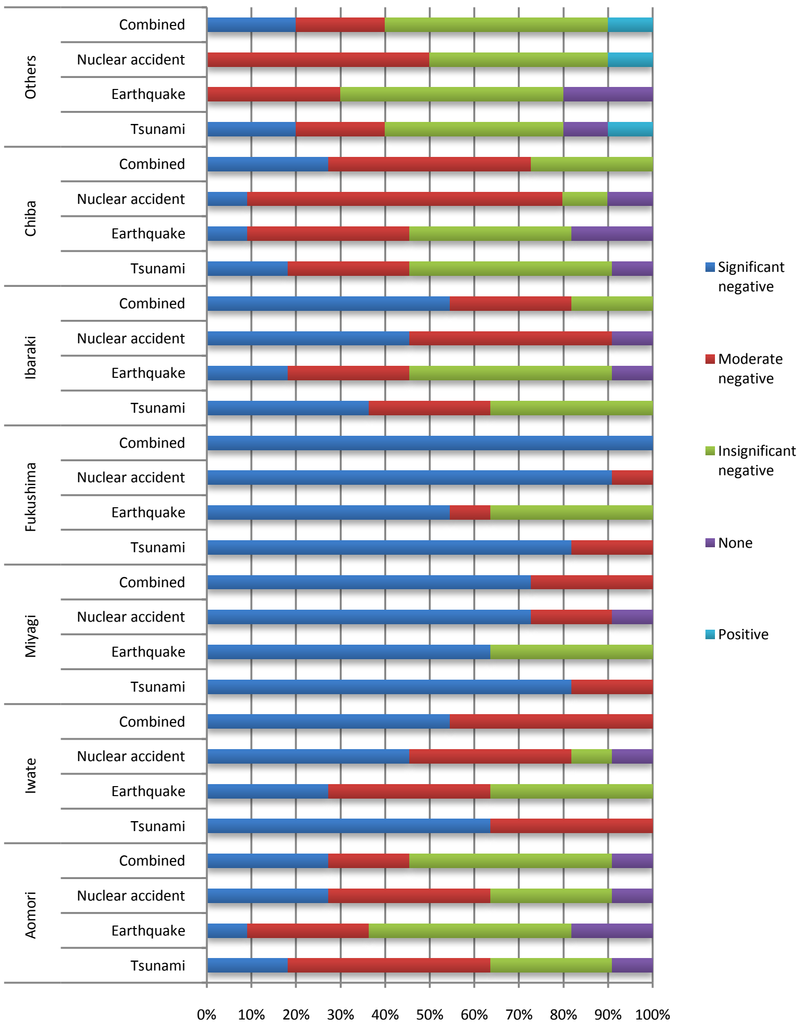


Figure 110. *Short-term impacts of March 2011 disasters on food industries in different prefectures of Japan*
Source: assessment by panel of experts, 2014

The majority of experts think that the specific short-term impact of the earthquake on food consumption in Fukushima, Miyagi and Iwate prefectures has been significant or moderate negative (Figure 111). Despite that, the number of those evaluating that impact as insignificant or none is also not small. For Aomori and Ibaraki prefectures, a half of the experts evaluate that impact as significant or moderate negative while another half as insignificant negative or none. The specific short-term impact of the earthquake on food consumption in Chiba prefecture is mostly assessed as insignificant negative or none, but a good proportion also ranks it with a higher magnitude. In the rest of the country that impact is mostly estimated as insignificant, but every third expert still believes it is more severe (predominately significant).

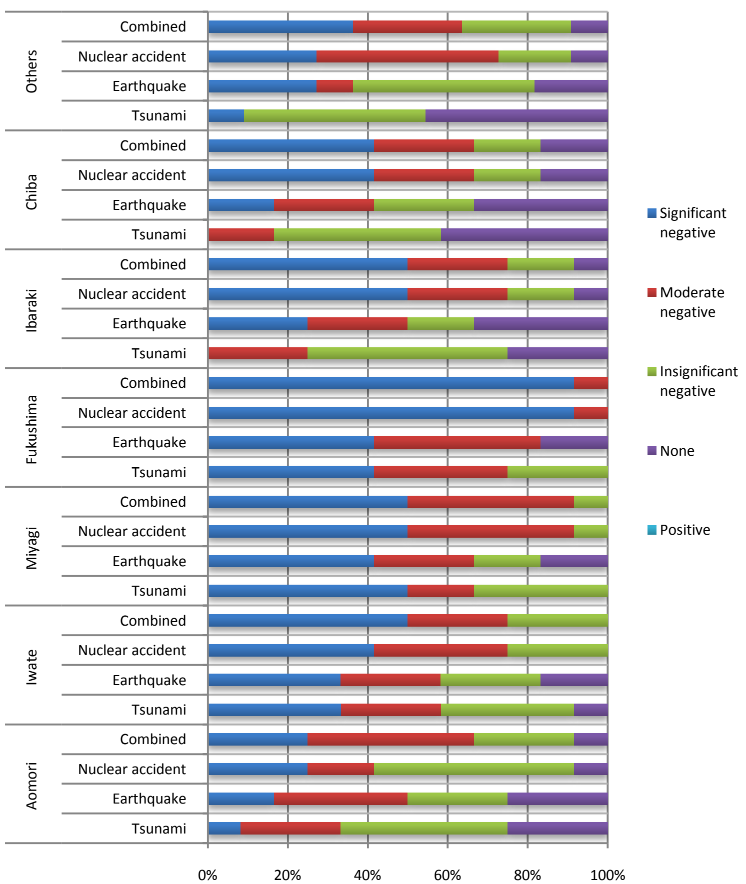


Figure 111. *Short-term impacts of March 2011 disasters on food consumption in different prefectures of Japan*
Source: assessment by panel of experts, 2014

No expert believes there is a positive specific or combined short or long-term impact of the 2011 disasters on food consumption in Japan.

Long-term implications

According to a great majority of the experts there will be no specific long-term impact of the 2011 earthquake on agriculture in Aomori, Ibaraki and Chiba prefectures, and other parts of Japan (Figure 112). Nevertheless, a good number of experts expect more severe consequences for the later three Tohoku prefectures (mostly evaluated as insignificant).

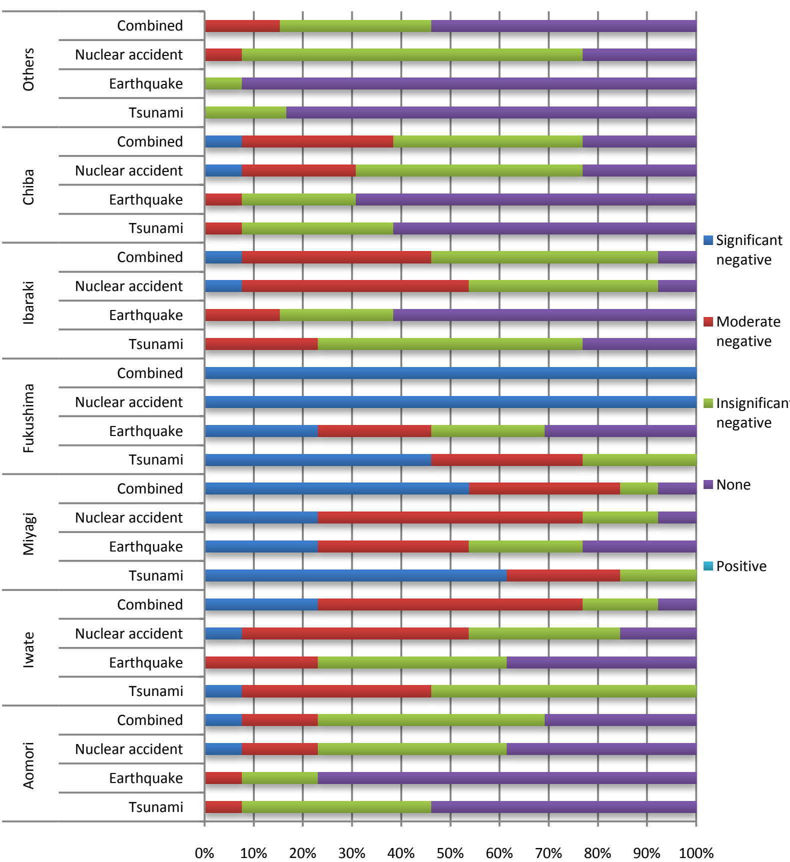


Figure 112. *Long-term impacts of March 2011 disasters on agriculture in different prefectures of Japan*
Source: assessment by panel of experts, 2014

The experts are divided in their impact estimates for Miyagi and Fukushima prefectures as around a half foresees it as significant or moderate negative, while the rest as insignificant negative or none. Long-term consequences for Iwate agriculture are predominately seeing as negative (mostly insignificant) but a significant number of the experts also expect no impact at all.

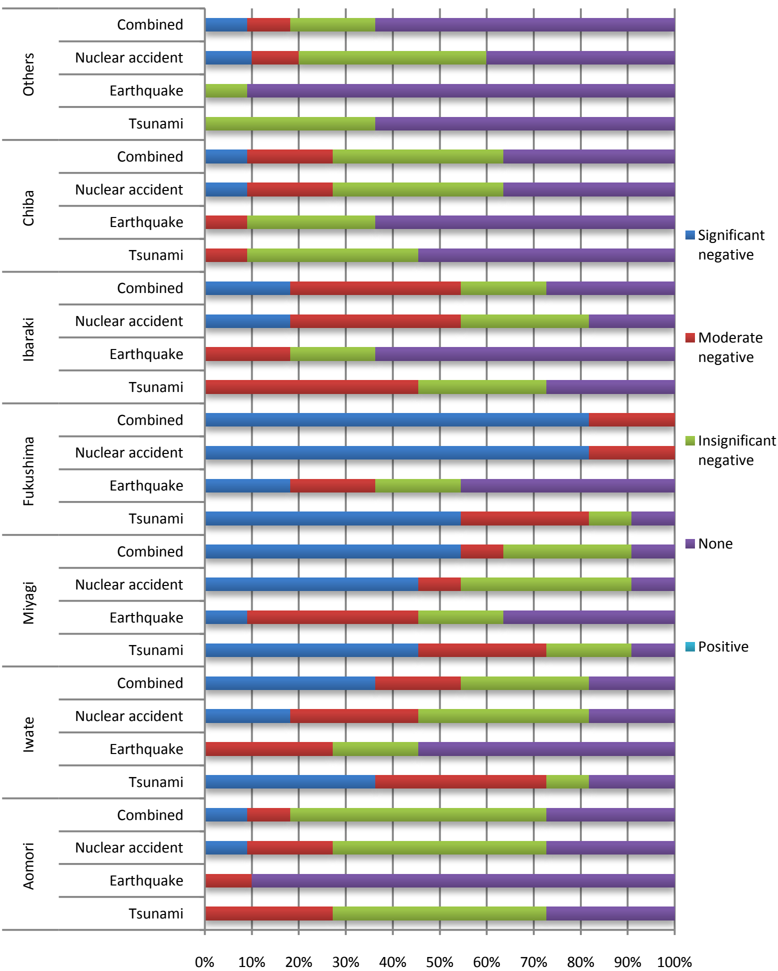


Figure 113. *Long-term impacts of March 2011 disasters on food industries in different prefectures of Japan*
Source: assessment by panel of experts, 2014

The bulk of experts estimate there will be no specific long-term impact of the earthquake on food industries in Aomori, Iwate, Ibaraki, and Chiba prefectures, and other parts of Japan (Figure 113).

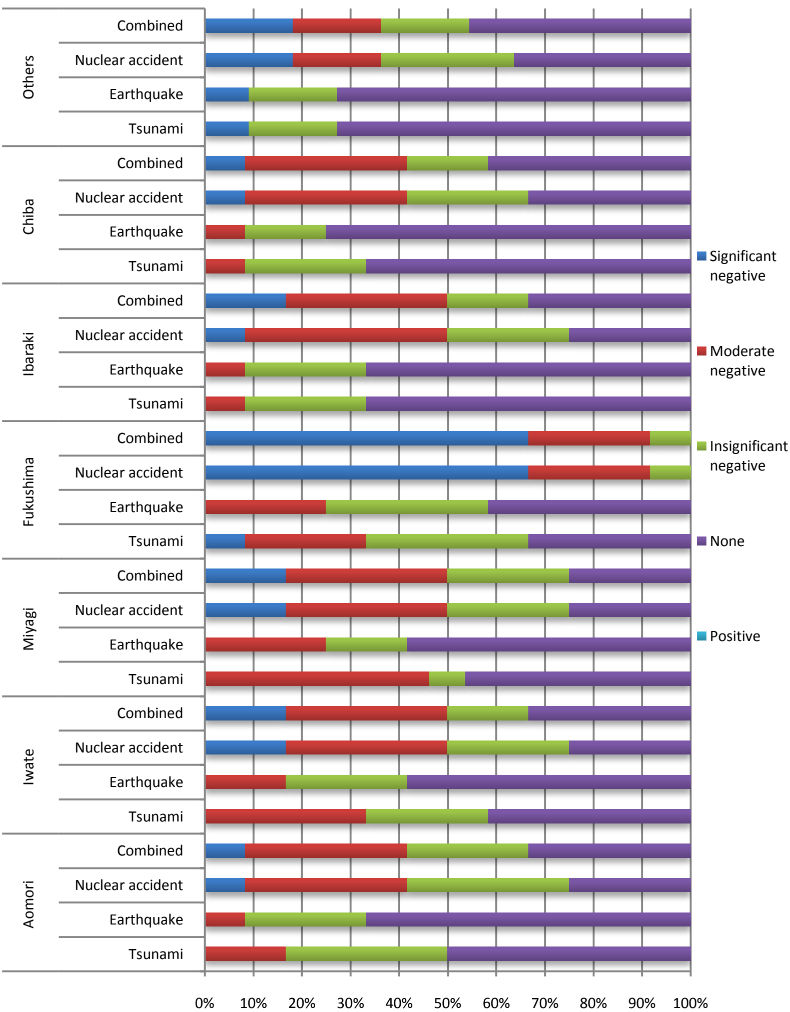


Figure 114. *Long-term impacts of March 2011 disasters on food consumption in different prefectures of Japan*
Source: assessment by panel of experts, 2014

Nevertheless, a good proportion of the panel foresee some insignificant to moderate adverse long-term consequences for Iwate and Ibaraki prefectures' food industries. In Miyagi and Fukushima prefectures most experts expect some negative long-term impact predominately evaluated as moderate and insignificant in the former one and not consensually determined for the later. However, the number of experts anticipating no impact in the latter two prefectures is also considerable.

The greatest majority of the experts predict no specific long-term impact of the earthquake on food consumption in Aomori, Iwate, Miyagi, Ibaraki and Chiba prefectures, and other parts of Japan (Figure 114). Nevertheless, a good portion of the panel foresees some negative long-term consequences - insignificant to moderate in Tohoku prefectures (mostly moderate for Miyagi prefecture and insignificant for all others), insignificant or significant in the rest of the country. For Fukushima prefectures the greatest part of the experts expect some (insignificant or moderate) negative impact from the earthquake on food consumption. At the same time, the number of experts appreciating no long-term implications in that prefecture is also quite considerable.

Specific impacts of tsunami

Short-term implications

According to the experts the short and long-term impacts of the 2011 tsunami on agriculture, food industries and food consumption in different regions of the country have been also unlike.

The greatest majority of the experts assess the short-term adverse impact of the tsunami on agriculture as significant in Miyagi and Fukushima prefectures, as moderate in Iwate prefecture, as insignificant in Aomori and Chiba prefectures, and moderate or insignificant in Ibaraki prefecture (Figure 109). As far as the impact on agriculture in the rest of the country is concerned, the experts are divided as half of them assess it as neutral while another half as negative (mostly insignificant).

The specific negative short-term impact of the tsunami on food industries in Miyagi, Fukushima and Iwate prefectures is evaluated as significant by the greatest portion of the expert panel (Figure 110). In Aomori prefecture that effects is mostly ranged to be moderate while in Chiba prefecture insignificant. For Ibaraki prefecture opinions of the majority are split between significant negative and insignificant. Similarly, the greatest part of the experts evaluates as negative the impact of tsunami on food industry in the rest of the country but there is no agreement on the extent – one part evaluate it as insignificant while another part as moderate or significant. What is more, some experts evaluate the short-term implications for food industries in the rest of Japan as none or even positive.

Most experts estimate there is a negative short-term impact of the tsunami on food consumption in all affected prefectures (Figure 111). The latter is mostly described as significant in Miyagi prefecture, significant or moderate in Fukushima prefecture, insignificant in Ibaraki prefecture, insignificant or moderate in Aomori and Chiba prefectures, insignificant or significant in Iwate prefecture. The majority of experts indicate either there is not adverse impact on food consumption in the rest of Japan or it is principally insignificant.

Long-term implications

According to the biggest part of the experts there will be a significant long-term impact of the tsunami on agriculture in Miyagi and Fukushima prefectures (Figure 112). Most of them assess that effect to be insignificant for Iwate and Ibaraki agriculture. Nevertheless, a good portion of the panel evaluates much more severely the adverse long-term implications of that disaster on agriculture of the latter two prefectures - moderate in Ibaraki prefecture and predominately moderate in Iwate prefecture. The majority of experts do not perceive any long-term impact for Aomori and Chiba prefectures, and the rest of the country. Nevertheless, a good segment of them still believe there will be some negative (mostly insignificant) long-term impact on Aomori and Chiba agriculture.

The greatest proportion of the experts evaluates that there will be a significant negative long-term impact of the tsunami on food industries in Fukushima and Miyagi prefectures, significant or moderate in Iwate prefecture, and a moderate one in Ibaraki prefecture (Figure 113). Most experts expect the negative long-term effect to be insignificant in Aomori prefecture, and none in Chiba prefecture and the rest of the country. Nevertheless, a good part of them foresee some adverse impact (mostly insignificant) in Chiba prefecture and (insignificant) in the rest of Japan.

The majority of the experts predict there will be no specific long-term impact of the tsunami on food consumption in Ibaraki and Chiba prefectures, and other parts of the country (Figure 114). For other four affected prefectures most experts expect some negative longer-term consequences for food consumption, which is mainly evaluated as moderate (for Miyagi and Iwate prefectures) or insignificant (for Aomori and Fukushima prefectures).

Specific impacts of nuclear disaster

Short-term implications

According to the experts the Fukushima nuclear accident's impacts on agriculture, food industries and food consumption in different regions of the country are quite dissimilar.

The experts are unanimous that the specific short-term impact of the nuclear accident on Fukushima agriculture is significant negative (Figure 109). Most of them also assess the short-term impacts of the disaster on Aomori agriculture as insignificant negative. The adverse impact in other badly affected prefectures (Iwate, Miyagi, Ibaraki, and Chiba) and the rest of the country is evaluated chiefly as moderate. Moreover, a good portion of the panel ranks as significant the short-term impact of the accident on Miyagi and Ibaraki agriculture. Some experts also believe there are no negative implications for the agriculture of Aomori, and Chiba prefectures.

The greatest number of experts estimates that the specific short-term impact of the nuclear accident on food industries in the most affected prefectures and the rest of Japan is negative (Figure 110). Most of them range it as significant for Fukushima, Miyagi and Iwate prefectures, and moderate for Chiba and Aomori prefectures and other parts of Japan. The experts are divided for the scale of the negative effect on Ibaraki food industries between significant and moderate. Moreover, some experts believe there is a positive short-term impact from that accident on food industries in other parts of the country.

Almost all experts estimate there is a significant negative short-term impact of the nuclear accident on food consumption in Fukushima prefecture (Figure 111). The majority of them also believe that short-term negative effects on food consumption in Miyagi, Ibaraki, Iwate and Chiba prefectures, and the rest of Japan are significant or moderate. A half of the panel evaluates as insignificant the negative impact on food consumption in Aomori prefecture but another half thinks it is much more adverse (moderate or significant).

The 2014 expertise principally reconfirmed the 2013 expert assessments on impacts of the Fukushima nuclear disaster on agriculture, food industries and food consumption in Fukushima prefecture, neighboring prefectures, and other parts of Japan (Bachev & Ito, 2013).

Most experts agree that the overall agricultural impact from the nuclear disaster in Fukushima prefecture varies considerably according to the specific location of farms since living and working environment, contamination of farmlands and assets, restrictions on entry, production, shipping of produces, etc. have been quite different in the evacuation areas and rest of the prefecture. The common view is that "in the areas of restriction to entry, stay and residence, the recovery of agriculture remains difficult while the other areas are affected by bad reputation".

The major reason for the negative consequences of the nuclear accident on food industries in Fukushima region is specified as "decreasing sales caused by the contamination and harmful rumors". The experts also believe that "in a longer term the recovery of regional food industries will be faster than in the sector agriculture".

The most badly affected by the nuclear disaster areas of agriculture in Fukushima region are described as: harmful rumors, shipping restriction, contaminated farmlands, decreased sales, unable and restricted farming, farming, lowered price of products, declined willingness to continue farming, works to prevent absorbance of radioactive matters, radiation inspections, polluted agricultural mountain products, compensation procedures, destroyed livestock in evacuation area, abolished products, destructed high brand local products, organic agriculture, agricultural management (decreased income), decreased values of farm assets, increased abandoned farmlands, moving farmers to other prefectures, declined consumption of local products by local population, secured market, external exposure to radiation, vegetables, rice, milk, beef, mushrooms, and fruits (Table 40).

Some experts are particularly concerned with the "decreased current and future number of farmers" as a result of diminished willingness to farm and moving farmers to other prefectures as well as with the "decreased consumption of local products by local people".

Table 40. *Most badly affected areas from Fukushima nuclear disaster*

In	Agriculture	Food industries	Food consumption
Fukushima region	Harmful rumors (******) Restriction of shipping (*****) Contaminated farmlands (****) Decreased sales (*****) Unable farming due to evacuation (****) Restricted farming (***) Lowered price of products (***) Declined willingness to continue farming (**) Works to prevent absorbance of radioactive matters (**) Radiation inspections (**) Polluted agricultural products (**) and mountain vegetables	Harmful rumors (******) Decreased use of local ingredients (****) Changed places for buying ingredients (***) Increased costs (***) Decreased sales (**) Closed factories because of evacuation (**) Unrecovered consumer trust	Avoiding Fukushima products (******) Worries of radioactive contamination (*****) Stopped use of local products for school lunch Increased costs for nonlocal supply Increased costs for buying water, etc.

	Procedures for compensation Destroyed livestock in evacuation area Abolished products Destructed high brand local products Organic agriculture Agricultural management (decreased income) Decreased economical values of farm assets Increased abandoned farmlands Some farmers moved to other prefectures Declined consumption of local products by local people Secured market External exposure to radiation Vegetables Rice Milk Beef Mushrooms Fruits	Safety of local raw materials Excluded from tenders local factories Decreased naming "Made in Fukushima" Management Seafood produces	Declined population Whole Fukushima area
Neighboring regions	Harmful rumors (****) Restriction of shipping (***) Decreased sales (***) Needs of inspection Anxiety about polluted farmland Gradual radioactive pollution Procedure for compensation It depends on density of radioactive substance Vegetables Rice Milk Beef	Harmful rumors (**) Decreased sales (**) Changes in buying ingredients (**) Needs of inspection Inspection fees Worries of consumers Decline in exportation More damages from earthquakes and tsunami It depends on density of radioactive substance. Seafood produce	Anxiety due to radioactive contamination (***) Avoiding East Japan products (**) Decreased consumption of local products Avoiding Fukushima products Harmful rumors Increased costs for buying water, etc.
Other parts of Japan	Worries of radioactive contamination in East Japan Polluted agricultural products and mountain vegetables and little promotion made Declined exportation Restriction of shipping abroad Decreased sales Detected radioactivity in wild plants Beef	Restriction of shipping abroad Changes in buying ingredients	Avoiding East Japan products Avoiding Fukushima products Increased costs for buying water, etc. Increased anxiety

Note: * frequency of listing; **Source:** assessment by panel of experts, 2013

The most badly affected by the nuclear disaster areas of agriculture in the neighboring regions are defined as: harmful rumors, restriction of shipping, decreased sales, needs of inspection, anxiety about polluted farmland, gradual radioactive pollution, procedure for compensation, density of radioactive substance, vegetables, rice, milk, and beef.

As far as agriculture in other parts of the country is concerned, the most badly affected areas from the nuclear disaster are specified as: worries of radioactive contamination in East Japan, polluted agricultural products and mountain vegetables, little promotion made, declined exportation, restriction of shipping abroad, decreased sales, detected radioactivity in wild plants, and beef.

The most badly affected by the nuclear disaster areas of food industries in Fukushima region are identified as: harmful rumors, decreased use of local ingredients, changed places for buying ingredients, increased costs, decreased sales, closed factories because of evacuation, unrecovered consumer trust, safety of local raw materials, excluding from tenders of local factories, decreased naming "Made in Fukushima", management, and seafood produce.

The most badly affected areas of food industries in the neighboring regions are listed as: harmful rumors, decreased sales, changes in buying ingredients, needs of inspection, inspection fees, worries of consumers, decline in exportation, density of radioactive substance, seafood produces. It is also mentioned that the food industry in these regions has been "more damaged from the earthquakes and tsunami than from the nuclear accident".

As far as food industries in other parts of the country are concerned, the most badly affected areas from the nuclear disaster are specified as: restriction of shipping abroad, and changes in buying ingredients.

The most badly affected areas of food consumption in Fukushima region are determined as: avoiding Fukushima products, worries of radioactive contamination, stopped usage of local products for school lunch, increased costs for nonlocal supply, increased costs for buying water etc., declined population, and the whole Fukushima area.

The most badly affected areas of food consumption in neighboring regions are identified as: anxiety due to radioactive contamination, avoiding East Japan products, decreased consumption of local products, avoiding Fukushima products, harmful rumors, and increased costs for buying water etc.

The most affected areas of food consumption in other parts of Japan are listed as: avoiding East Japan products, avoiding Fukushima products, increased costs for buying water etc., and increased anxiety.

Long-term implications

According to all experts there will be a significant long-term negative impact of the nuclear accident on agriculture in Fukushima prefecture (Figure 112). Most experts also predict that in a longer term the Fukushima nuclear disaster will cause a moderate negative impact on Iwate, Miyagi and Ibaraki agriculture, insignificant one on agriculture in Chiba prefecture and the rest of Japan. For long-term consequences on Aomori agriculture the majority of experts are divided between none and insignificant adverse effects. Nevertheless, a good portion of the experts foresees significant negative long-term implications on Miyagi agriculture, and more severe (moderate to significant) on Aomori and Chiba agriculture.

The greatest segment of the experts evaluate that there will be a significant negative long-term impact of the nuclear accident on food industries in Fukushima prefecture (Figure 113). For other prefectures the largest part of the experts expects some negative consequences for food industries mostly assessed as significant for Miyagi prefecture, moderate for Ibaraki prefecture, and insignificant for Aomori, Iwate and Chiba prefectures and the rest of Japan. At the same time, a good proportion of the panel does not expect any negative impacts on Aomori, Chiba and the rest of Japan food industries in a longer term.

All experts expect there will be a negative long-term impact of the Fukushima nuclear disaster on food consumption in Fukushima prefecture, mostly ranged as significant (Figure 114). The majority of experts also suggest there will be some adverse long-term impactions from the nuclear disaster on food consumption in other badly affected prefectures as well as the rest of Japan. The later are mostly estimated to be moderate in Aomori, Iwate, Miyagi, Ibaraki, and Chiba prefectures, and insignificant for the rest of the country. Nevertheless, a third of the experts do not expect any long-term negative implications from that accident for food consumption in Chiba prefecture and the rest of the country. The same is true according to a fifth of the experts as far as the food consumption in Aomori, Iwate, Miyagi and Ibaraki prefectures is concerned.

All these foresights have basically reconfirmed the 2013 experts assessments on long-term impacts of the Fukushima nuclear disaster on agriculture, food industries, and food consumption in Fukushima prefecture, neighboring prefectures and the rest of the country (Bachev & Ito, 2013).

Combined impacts of 2011 disasters

Short-term implications

Finally the experts have assessed the combined impacts of the triple 2011 disaster on agriculture, food industries and food consumption in different parts of the country.

The combined short-term impact of the 2011 disasters on agriculture in all regions is negative. According to all experts the disasters' overall short-term impact on Fukushima agriculture is significant negative (Figure 109). All experts also evaluate as significant or moderate the short-term impacts on Miyagi and Iwate agriculture (mostly scaled as significant). The adverse short-term implications on Ibaraki and Chiba agriculture are predominately ranked as moderate. The negative short-term impact on agriculture of Aomori prefecture and other parts of Japan is commonly evaluated as insignificant.

According to the great majority of all experts the combined short-term impact of the 2011 disasters on food industries in all regions is negative (Figure 110). There is a full consensus among experts on the severity of the adverse effect on Fukushima food industries, which is inclusively jugged as significant. Most experts also assess as significant the negative impact on food industries in Miyagi, Iwate and Ibaraki prefectures. The short-term impact on food industries in Chiba prefecture is predominately evaluated as moderate, and in Aomori prefecture and the rest of the country as insignificant. Nevertheless, a good number of the experts also believe in a stronger (moderate and significant) negative impact in Aomori prefecture and the rest of the country. Furthermore, some experts think the 2011 disasters had a combined positive short-term impact on food industries in other parts of the country.

The experts also estimate that the combined short-term impact of the 2011 disasters on food consumption in all regions of the country has been negative (Figure 111). The food consumption in Fukushima prefecture has been the most severely affected where the general assessment is significant negative. The biggest part of the experts estimates that the adverse short-term impact has been considerable in all other badly affected prefectures as well as the rest of the country. The latter is mostly ranked as significant throughout all regions with exception of Aomori prefecture where the common estimate is moderate.

According to the experts the most badly affected by the 2011 disasters areas of agriculture in Aomori prefecture are: paddy fields, vegetable farming, livestock, and apple production (Table 41).

Table 41. *Most badly affected areas from March 2011 disasters*

Regions	Agriculture	Food industries	Food consumption
Aomori prefecture	Paddy fields (**) Vegetable farming Livestock Apple production	Equipment Inputs supply Marine products Rice milling Milk processing Fish industry	Vegetables Apple and other fruits Rice Milk Fish
Iwate prefecture	Paddy fields (***) Paddy fields near seashore Livestock (****) Buildings Mushrooms Vegetable farming Irrigation Fisheries	Equipment Inputs supply Seafood processing Marine products Processing factories Rice milling Milk processing Dairy industry	Eligible wild plants Vegetables Fruits Rice Milk Dairy products
Miyagi prefecture	Paddy fields (*******) Buildings Hamlet infrastructure Mushrooms Community Agricultural machinery Livestock Vegetable farming Irrigation Labor availability Restoration of farmland in some areas Fisheries	Equipment Inputs supply Seafood processing Marine products Processing factories Rice milling Milk processing Labor availability Fish industry Shellfish products	Eligible wild plants Vegetables Fruits Rice Milk Fish
Fukushima prefecture	Paddy fields (******) Fields Livestock (***) Irrigation (**) All agricultural products Hamlet infrastructure Brand reputation Labor Soil and water Community Vegetable farming Peach production Fisheries Reputation	Equipment Aizu brand reputation Inputs supply Brand reputation Reputation Many brands Price Rice milling Milk processing Fish industry Shellfish products Coastal fish products	Eligible wild plants Food self-sufficiency Vegetables Fruits Rice Milk Fish Reputation
Ibaraki prefecture	Paddy fields (**) Buildings Livestock Vegetable farming Irrigation Fisheries	Rice milling Milk processing Fish industry Shellfish products	Eligible wild plants Vegetables Fruits Rice Milk Leaf vegetables
Chiba prefecture	Paddy fields (**) Buildings Vegetable farming Livestock	Rice milling Milk processing Fish industry Shellfish products	Vegetables Fruits Rice Milk

			Leaf vegetables
Other parts of Japan	Brand reputation Vegetable farming Paddy fields	Fish industry	Vegetables Apple and other fruits Rice Milk Fish

Note: * frequency of listing;
Source: assessment by panel of experts, 2014

The most severely impacted areas of food industries in the prefecture are: equipment, inputs supply, marine products, rice milling, milk processing, and fish industry. The most badly affected areas of food consumption in this prefecture are: vegetables, apple and other fruits, rice, milk, and fish.

The worst affected by the 2011 disasters areas of agriculture in Iwate prefecture are identified as: paddy fields, paddy fields near seashore, livestock, buildings, mushrooms, vegetable farming, irrigation, and fisheries. The most badly impacted areas of the prefectural food industries are: equipment, inputs supply, seafood processing, marine products, processing factories, rice milling, milk processing, and dairy industry. The most affected areas of food consumption in this prefecture are: eligible wild plants, vegetables, fruits, rice, milk, and dairy products.

The worst affected by the 2011 disasters areas of agriculture in Miyagi prefecture are specified as: paddy fields, buildings, hamlet infrastructure, mushrooms, community, agricultural machinery livestock, vegetable farming, irrigation, labor availability, restoration of farmland in some areas, and fisheries. As the most badly impacted areas of food industries in the prefectures are listed: equipment, inputs supply, seafood processing, marine products, processing factories, rice milling, milk processing, labor availability, fish industry, and shellfish products. The most severely affected areas of food consumption in this prefecture are: eligible wild plants, vegetables, fruits, rice, milk, and fish.

In Fukushima prefecture the most badly affected by the triple disaster areas of agriculture are identified as: paddy fields, fields, livestock, irrigation, hamlet infrastructure, brand reputation, labor, soil and water, community, vegetable farming, peach production, fisheries, and reputation. The worst affected areas of prefectural food industries are: equipment, Aizu and other brands reputation, inputs supply, brand reputation, reputation, price, rice milling, milk processing, fish industry, shellfish products, and coastal fish products. The most badly impacted areas of food consumption in this prefecture are: eligible wild plants, food self-sufficiency, vegetables, fruits, rice, milk, fish, and reputation.

The most badly affected by the 2011 disasters areas of agriculture in Ibaraki prefecture are specified as: paddy fields, buildings, livestock, vegetable farming, irrigation, and fisheries. The worst impacted areas of food industries in the prefecture are: rice milling, milk processing, fish industry, and shellfish products. The most severely affected areas of food consumption in this prefecture are: eligible wild plants, vegetables, fruits, rice, milk, and leaf vegetables.

In Chiba prefecture the most badly affected by the triple disaster areas of agriculture are identified as: paddy fields, buildings, vegetable farming, and livestock. The worst impacted areas of food industries in the prefecture are: rice milling, milk processing, fish industry, and shellfish products. Adverse effect on food consumption in this prefecture is in the area of: vegetables, fruits, rice, milk, and leaf vegetables.

In other parts of the country the most badly affected by the 2011 disasters areas are brand reputation, vegetable farming, and paddy fields in agriculture; fish industry; and vegetables, apple and other fruits, rice, milk, and fish consumption.

In addition, many experts have underlined that there are considerable differences in the impacts in major regions (like Tohoku, Kanto, rest of Japan) as well as among individual areas of each prefecture. Therefore, in depth studies for each area are necessary in order to better understand diverse impacts and factors of the disasters.

Furthermore, some experts have pointed out that the 2011 disasters added some complication to already existing problems like aging communities in rural areas. The lost community identity by many people, avoidance of Tohoku products, and labor scarcity in certain industries (e.g. marine), all they have been also highlighted by some experts.

One expert has commented that the March 2011 disasters hurt a lot the agri-food chain but some subsectors (like vegetable and fruit marketing) quickly restarted in Miyagi prefecture thanks to the small commercial shops (Yoyo). The later rapidly secured vegetables and fruits supply from local producers (on March 12, 2011) and proved that small size marketing business is much more resilient during a big disaster comparing to "highly efficient" large operators (supermarkets).

Long-term implications

According to all experts there will be a significant negative long-term impact of the 2011 disasters on agriculture in Fukushima prefecture (Figure 112). The majority of the experts also expect a significant impact on Miyagi agriculture and moderate one on

Iwate agriculture. For Aomori, Ibaraki and Chiba agriculture the majority foresee insignificant long-term adverse implications. However, a good share among experts also believes there will be stronger long-term negative consequences for agriculture in these three prefectures (particularly Ibaraki and Chiba). At the same time, a good portion of the panel perceives no adverse implication in a longer term for Aomori and Chiba agriculture – almost a third and a quarter of experts accordingly. While the bulk of the experts do not project any long-term implication on agriculture in other parts of Japan, a good portion of them still believe there will be some (mostly insignificant or moderate) negative impacts.

The greatest part of the experts estimate there will be a significant negative long-term impact of the 2011 disasters on food industries in Fukushima and Miyagi prefectures (Figure 113). Most of them also expect significant negative consequences on Iwate food industries, moderate one for Ibaraki prefecture, and insignificant ones in Aomori and Chiba prefectures. Nevertheless, a good portion of the panel believes there will be no long-term implications for Chiba, Ibaraki, and Iwate food industries. Most experts indicate they see no long-term consequences from the 2011 disasters for food industries in other parts of Japan as well. However, many among them believe there will be some type of negative impacts on a longer run.

Two-third of the experts predict that the combined long-term impact of the 2011 disasters on food consumption in Fukushima prefecture will be significantly negative while a quarter among them project it is tobe moderate negative (Figure 114). The greatest portion of the experts also believes there will be some negative consequences on food consumption in all other regions of the country - mostly evaluate as moderate and insignificant. Nevertheless, many experts predict there will be no long-term effects from the disasters in relation to food consumption in all these regions.

Long-term impacts on different aspects of agri-food sector development

The expert panel has also assessed the long-term effects of the 2011 disasters on different aspects of the agri-food development in most affected regions and the rest of Japan.

According to the experts, in the longer term the mostly affected by the disasters areas of agri-food sector in Fukushima prefecture are likely to be: livestock, permanent crops, seasonal and annual crops, water and land resources, production structure, relations with buyers, disaster prevention measures, demand for region's products, reputation of products and services, safety control, labor, sector's export, viability of agricultural communities, rural infrastructure, relations with buyers, willingness to enter that business, product safety, farming and business infrastructure, public support to the region, sustainability of small enterprises, willingness to leave present business, income and profit, relations with community, and public support to the sector (Figure 115). The greatest majority of the experts evaluate the level of long-term effects in all these areas as high.

In the long-term the most severely affected by the disasters area of agri-food sector of Miyagi prefecture is specified to be land resources (Figure 116). The greatest majority of the experts also expect a considerable (moderate or high) long-term effect on disaster prevention measures, viability of agricultural communities, sustainability of small enterprises, relations with community, labor, and willingness to enter agri-food business in the prefecture. Besides, a good number of the experts project significant long-term implications on willingness to leave present business, sustainability of middles size enterprises, and production structure of Miyagi agri-food sector. The long-term impacts of the disasters on all other areas of the agri-food development are ranked as less important in this prefecture.

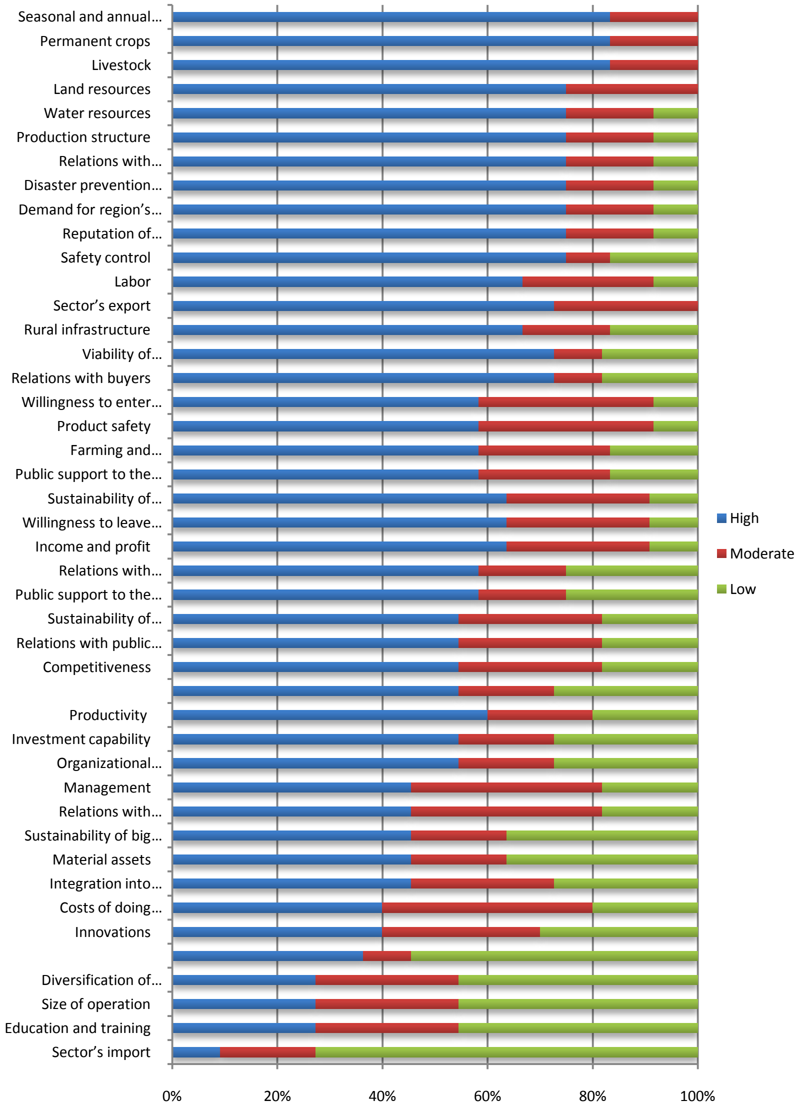


Figure 115. *Longer-term effects of March 2011 disasters on different aspects of agri-food sector in Fukushima prefecture*
Source: assessment by panel of experts, 2014

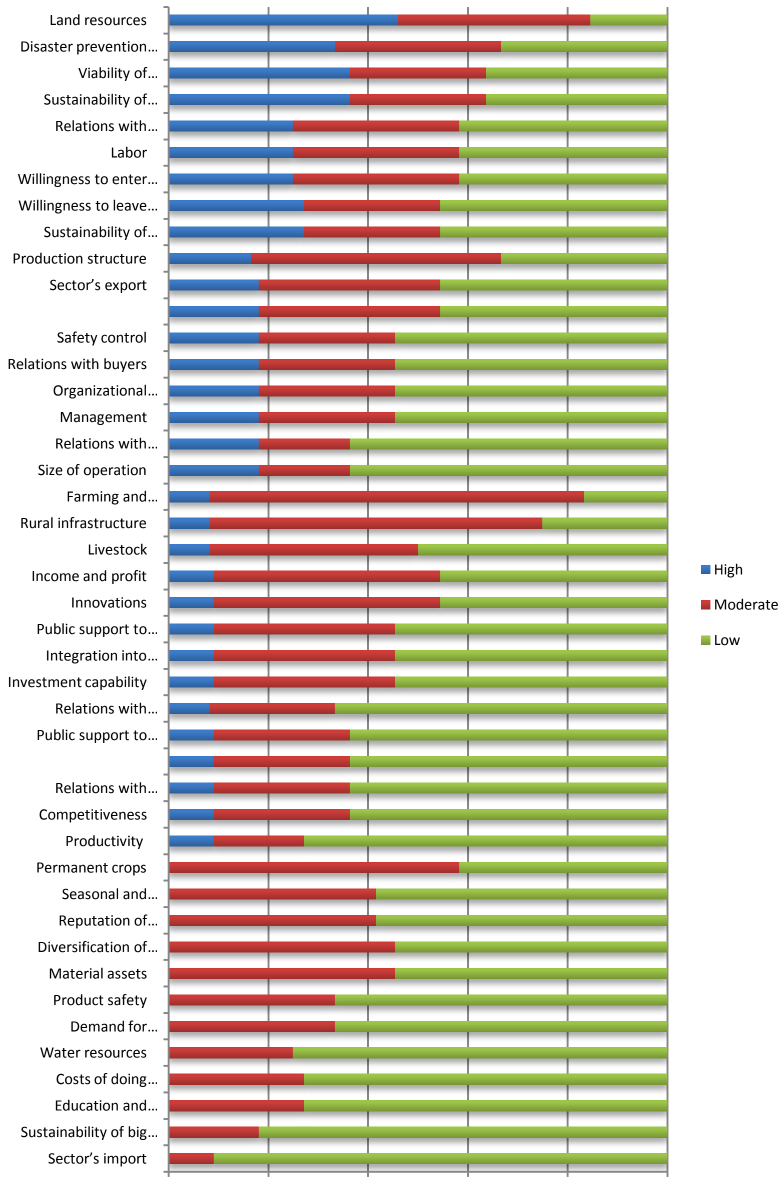


Figure 116. *Longer-term effects of March 2011 disasters on different aspects of agri-food sector in Miyagi prefecture*
Source: assessment by panel of experts, 2014

In Iwate prefecture the majority of experts expect a more substantial (moderate or high) long-term effect by the 2011 disasters on agri-food sector in following areas: disaster prevention measures, relations with community, sustainability of small enterprises, viability of agricultural communities, and land resources (Figure 117). A good number of them also project a significant impact on sustainability of middle size enterprises, farming and business infrastructure, and rural infrastructure in the prefecture. On the other hand, the majority of experts foresee no significant implications for all other areas of agri-food sector in this prefecture.

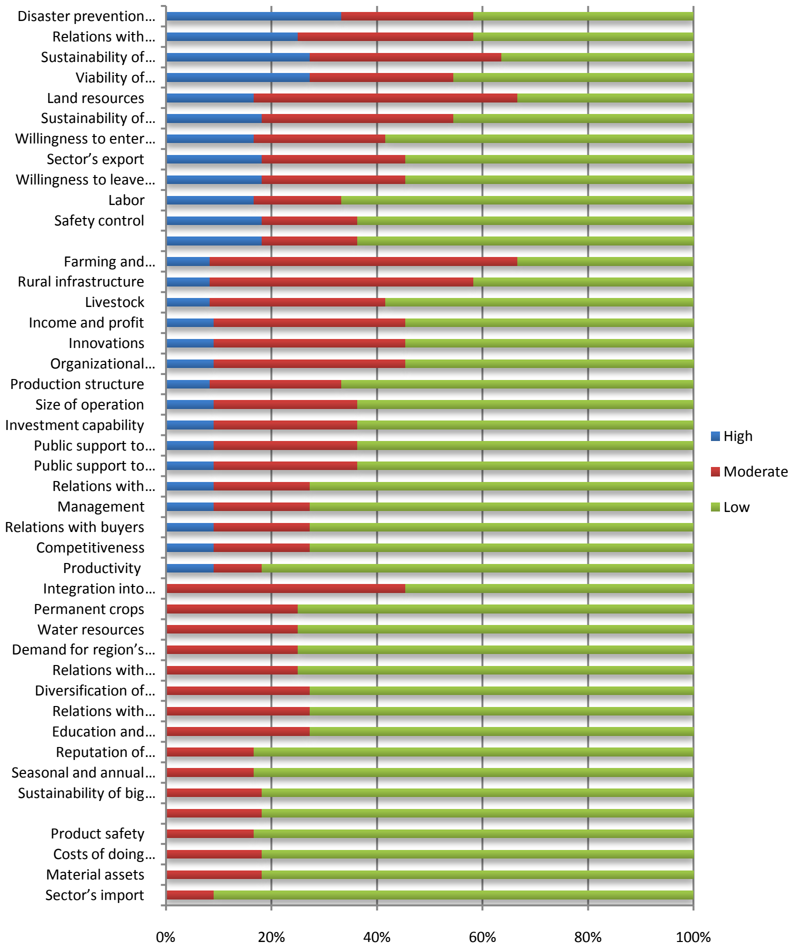


Figure 117. *Longer-term effects of March 2011 disasters on different aspects of agri-food sector in Iwate prefecture*
Source: assessment by panel of experts, 2014

For other parts of the country, a bigger part of the experts (almost 39%) only envisage a high or moderate long-term effect of the 2011 disasters on disaster prevention measures. A good number of the panel (almost 31%) also anticipates more substantial (mainly moderate) impact on sector's export and safety control. In all other areas of the agri-food sector development the greatest proportion of experts see no long-term implications for the rest of the country.

The expert panel has also assessed the long-term effects of the Fukushima nuclear disaster on different aspects of agriculture and food industries development.

The experts are unanimous that there will be a high long-term effect on food safety in agriculture (Figure 118). They also expect there will be a significant effect on relations with consumers, income and profit, and land resources in the sector. Furthermore, there will be high or moderate effects on sector's export, sustainability of small and middle size enterprises, reputation of products and services, diversification of activity, permanent crops, investment capability, labor, water resources, livestock, relations with research and education institutions, demand of products, willingness to leave present business, product safety, costs of doing business, public support to sector, and relations with community.

On the other hand, the long-term effects on rural infrastructure, relations with buyers, organizational structures, and management in that sector are mostly estimated as moderate. Finally, according to the experts the nuclear disaster will have only a low effect on productivity and willingness to enter that business. The strongest long-term effect of the nuclear disaster in food industries will be on safety control and sector's export (Figure 119). There will be also high and moderate consequences on sustainability of middle size enterprises, and reputation of products and services in this sector.

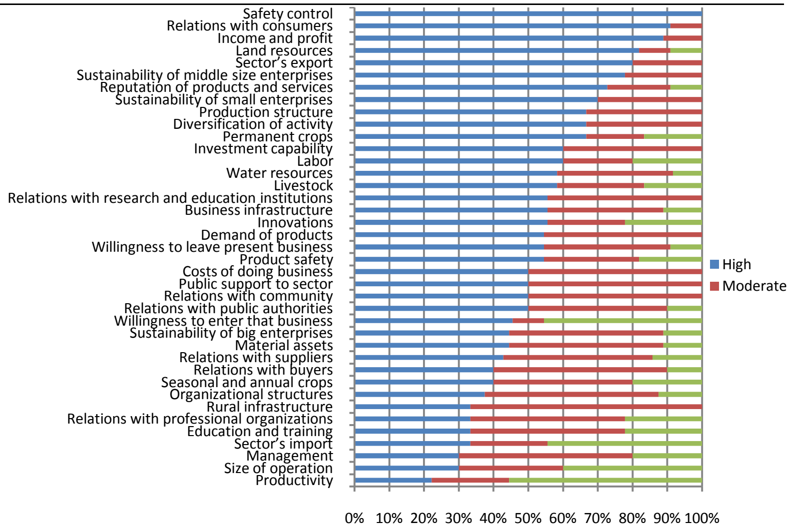


Figure 118. *Long-term effects of Fukushima nuclear disaster in agriculture*
Source: assessment by panel of experts, 2013

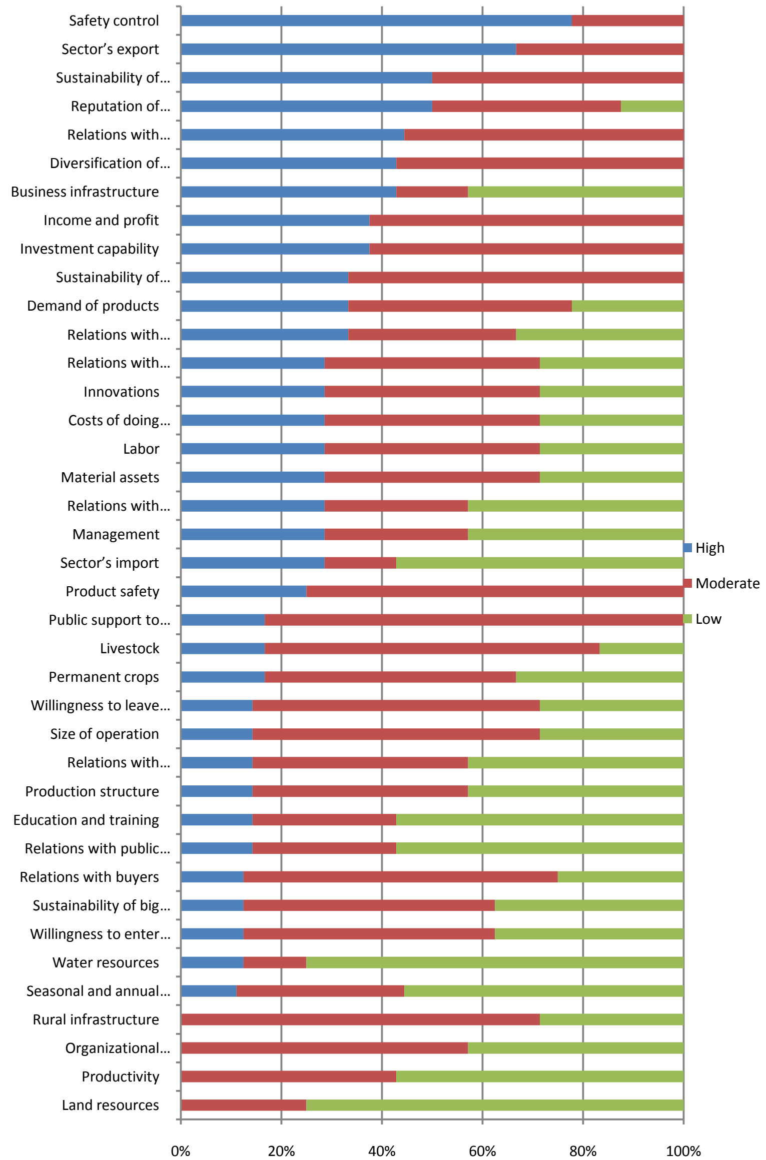


Figure 119. *Long-term effects of Fukushima nuclear disaster in food industries*
Source: assessment by panel of experts, 2013

The long-term effects on sustainability of small enterprises, product safety, public support to sector, willingness to leave present business, size of operation, relations with buyers, relations with consumers, diversification of activity, relations with consumers, income and profit, investment capability, sustainability of big enterprises, willingness to enter that business, rural infrastructure, and organizational structures, are predominately evaluated as moderate by the experts.

According to the most experts the long-term effects of the nuclear disaster on land and water resources, sector's import, productivity, relations with public authorities, relations with suppliers, management, education and training in the food industries are expected to be rather low.

Factors for persistence of negative impacts of 2011 disasters

The expert panel has identified the major factors for the persistence of the negative impacts of the 2011 disasters on agri-food sector in the most affected regions and nationwide.

According to the great majority of the experts the most important factors for the adverse effects' continuation in the agri-food sector of Fukushima prefecture are: the destruction of traditional communities, consumers unwillingness to buy, bad reputation, long time required for cleaning and restoration of lands, slow restoration of infrastructure and services, and high radiation (Figure 120).

More than a half of the experts also point out as critical factors for sustaining the negative impacts in the prefecture: the lack of consensus in local communities, lack of labor, insufficient support from the central government, bad communication, and health risk concerns. Furthermore, a good number of the experts also believe that crucial for maintaining the negative consequences in the prefecture has been: the slow process of returning evacuees back to home places, unresolved permanent radiation waste storage issue, low confidence in the official information, and the government's bans on production and/or sells.

According to the majority of the experts the most important factors for the persistence of negative impacts in agri-food sector of Miyagi prefecture are: the destruction of traditional communities, lack of consensus in the local communities, slow restoration of infrastructure and services, and lack of labor.

A good number of experts also underline as critical factors in this prefecture: the long time required for cleaning and restoration of lands, and insufficient support from the central government.

The majority of the experts are convinced that the most important factors for the persistence of the negative consequences from the 2011 disasters in Iwate agri-food sector are: the destruction of traditional communities, lack of labor, and lack of consensus in the local communities. In addition, numerous experts have pointed out the slow restoration of infrastructure and services as an important factor.

For the other parts of the country the majority has identified no single factor for the persistence of the adverse consequences of the triple disaster. Nevertheless, almost 31% of the experts estimate that the consumers' unwillingness to buy has been an important factor, while just above 15% specify as such: the bad reputation, low confidence in the official information, ineffective policies, lack of information, and overall state of the Japanese economy.

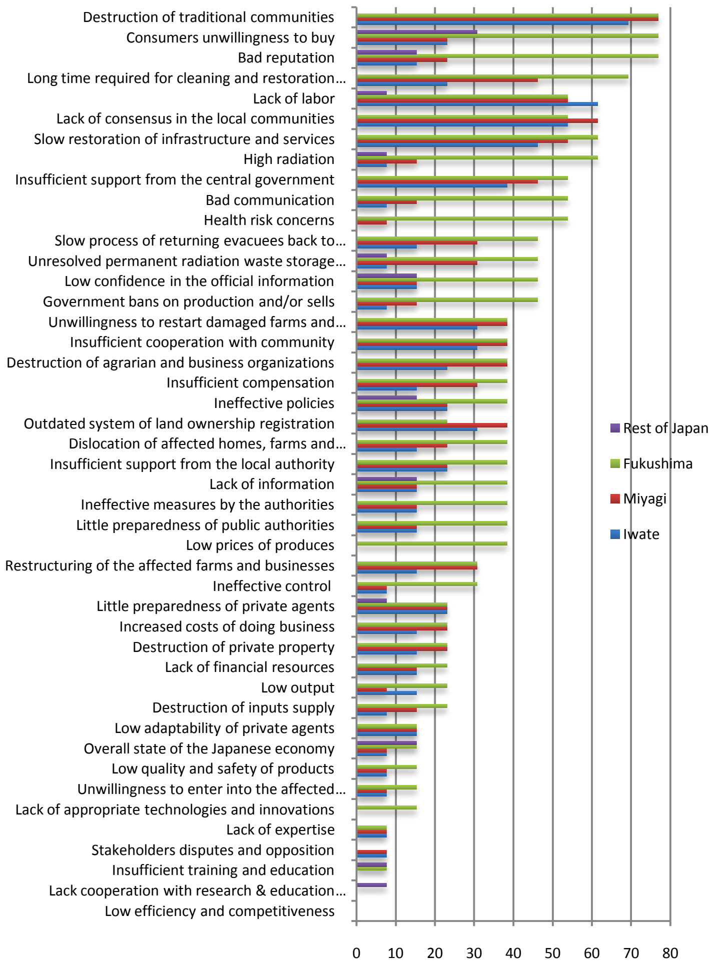


Figure 120. *Factors*[319] *for persistence of negative impacts of March 2011 disasters on agri-food sector (percent)*
Source: assessment by panel of experts, 2014

The expert panel has also identified the major factors for the persistence of negative impacts of the Fukushima nuclear disaster on agriculture, food industries and food consumption.

The most important factors for the persistence of the nuclear accident's negative impacts on agriculture are: the consumers unwillingness to buy, long time required for deactivating radiation,

[319] One expert added "Recent agricultural policy reform" as important factor for all regions.

insufficient support from the central government, and low prices of produce (Figure 121). The low confidence in official information, lack of information, bad reputation, and little preparedness of public authorities are also identified as significant factors for sustaining disaster's negative consequences in this sector.

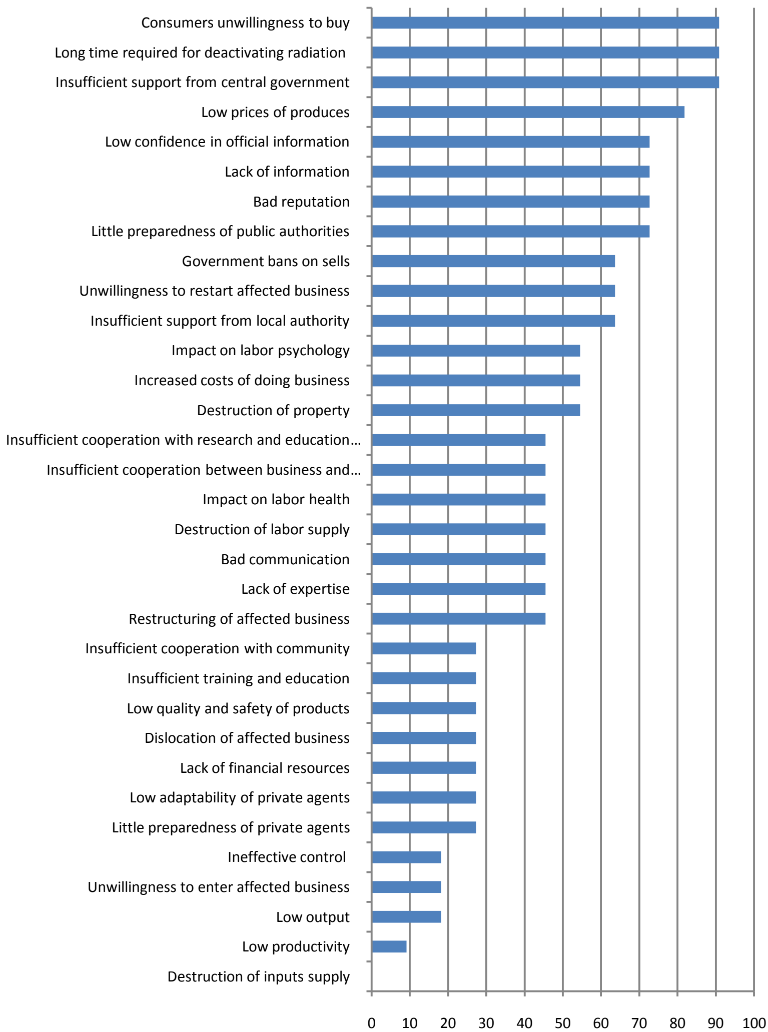


Figure 121. *Factors for persistence of negative impacts of Fukushima nuclear disaster on agriculture (percent)*
Source: assessment by panel of experts, 2013

The most important factors for the persistence of negative impacts of the nuclear disaster on food industries are: the lack of information, consumers unwillingness to buy, long time required for deactivating radiation, and little preparedness of public authorities (Figure 122). Besides, the bad reputation, insufficient support from the central government, and low confidence in official information are also ranked as key factors for the persistence of negative effects on food industries.

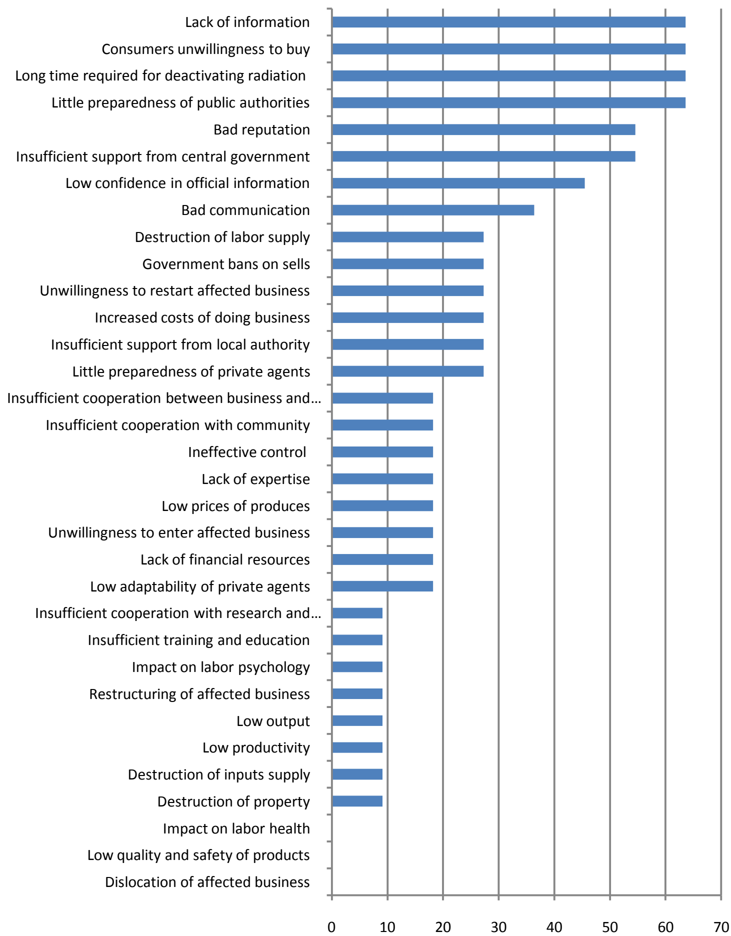


Figure 122. *Factors for persistence of negative impacts of Fukushima nuclear disaster on food industries (percent)*
Source: assessment by panel of experts, 2013

As far as the most important factors for the persistence of negative impacts of the nuclear disaster on food consumption is concerned, they are identified as: the lack of information, and low confidence in official information (Figure 123). In addition, a good portion of the experts believe that insufficient support from the central government and bad reputation are significant for sustaining negative impacts of that disaster on food consumption.

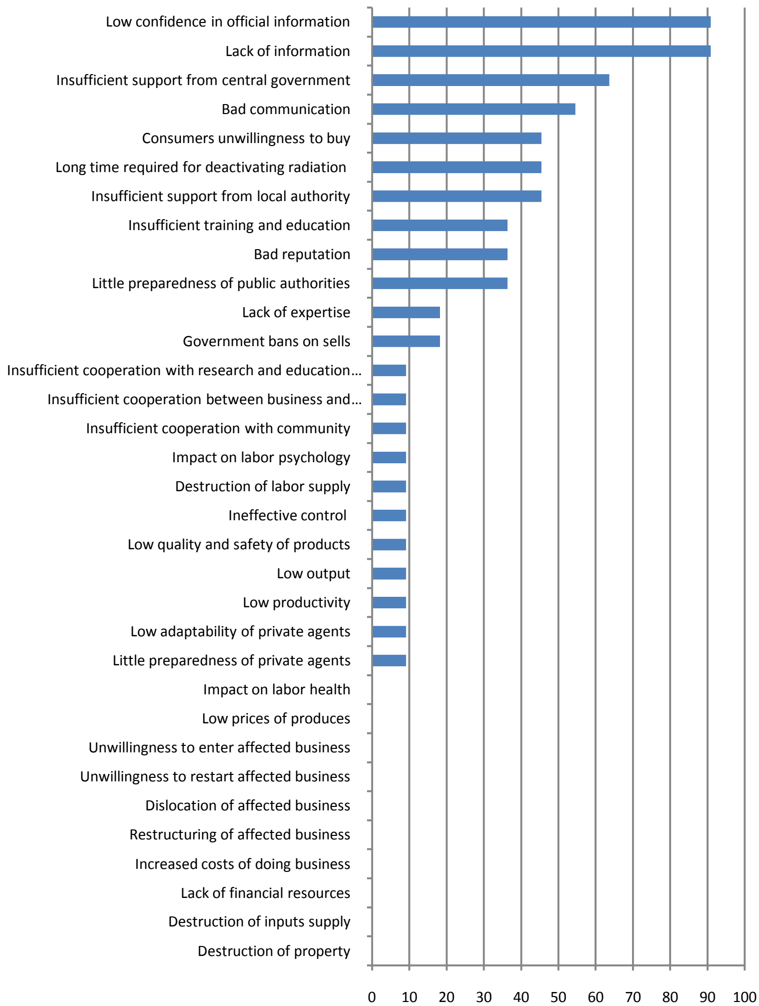


Figure 123. *Factors for persistence of negative impacts of Fukushima nuclear disaster on food consumption (percent)*
Source: assessment by panel of experts, 2013

Conclusion

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

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

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

Subsequently, the speed and extent of disaster recovery and post-disaster reconstruction differ quite substantially among individual agents, (sub)sectors, and (sub)regions. Besides, there are great uncertainties associated with the long-term social, health, economic, environmental, policy etc. consequences of the 2011 disasters.

Nevertheless, people in the disaster regions have proved their determination to overcome all challenges and rebuild their lives looking forward to future. The photo bellow captured one of the numerous celebrations that demonstrates the optimism and determination of people of all generations to overcome hardships and challenges.

Street dance in downtown Sendai

Photo: Hrabrin Bachev

A number of conclusions on the agricultural and food chain impacts could be also made.

Agriculture, food industry and food consumption have been among the worst hit by the disasters areas. Agri-food sectors of Fukushima, Miyagi and Iwate prefectures have been particularly severely affected in the short and longer term. There are also significant adverse consequences on other (neighboring) regions and entire food chains at a larger (regional, national, international) scale.

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 (small-big scale, specialized, diversified, integrated), particular agents (producers, processors, distributors, consumers, community and public organizations), individual sub-sectors (rice, vegetables, beef), and specific locations (evacuation zone, seaside).

Moreover, there have been enormous damages and long-term consequences on farming and rural households, important properties (farmland, livestock, orchards), 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.

In addition, the 2011 disasters have considerably aggravated some already existing problems of the agrarian and rural regions such as: aging and shrinking population, lack of labor and young entrepreneurs, low competitiveness and efficiency, income and services disparities, etc.

The specific responses to the 2011 disasters have highlighted the comparative advantages of traditional communities and non-governmental organizations, and certain less "efficient" but more resilient structures (such as small operators, partnerships) and sectors (one season crops, poultry, pig, processing). What is more, the disasters have had positive impacts on the development of certain (more resilient, adaptive) sectors in the most affected regions and some (traditional, prospective) sectors in other parts of the country.

The post disaster recovery and reconstruction have also given opportunities and induced considerable policies and institutional modernization in agrarian and other (e.g. energy, security) sectors, and improve disaster prevention and management, food safety information and inspection, technological and product innovation, jobs creation and investment (including in "new" areas such as research and innovation, ICT, renewable energy, robotization), farmlands consolidation and enhancement, infrastructural amelioration, organizational restructuring, etc.

Not least important, the failures of government bureaucrats to foresee, prevent, communicate, and deal with the March 2011 disaster and its consequences have thought individual agents to take decentralized actions – self-recovery and reconstruction, community and business initiatives, private and collective safety checks and decontamination measures, voluntary shipment restrictions, new production and marketing methods, movements for fundamental policies change, etc.

This study was just a first attempt to specify and assess the overall impact of the March 2011 disasters on Japanese agriculture and food chains, and present it to a wider world audience. 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.

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

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

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

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

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

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

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

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

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

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

Eleventh, it is important to learn from the past experiences and make sure that "lessons learned" are not forgotten. The impacts and factors of a disaster, disaster management, and post disaster reconstruction are to be continuously studied, knowledge communicated to public, and "transferred" to next generation. It is critical to share "good" and "bad" experiences with disaster prevention, management and recovery with other regions and countries, in order to prevent that happening again. It is particularly important to share the advance Japanese experience at international scale through media, visits, studies, conferences, etc. and turn Tohoku in a disaster risk management hub for other regions and countries. It is essential not to copy but adapt the positive Japanese experiences to the specific (institutional, cultural, natural) environment and risks structure of each community, subsector, region, and country.

References

Abe S. (2014). Press Conference by Prime Minister Shinzo Abe on the Upcoming Third Anniversary of the Great East Japan Earthquake, March 10, 2014.

Al-Badri D. & Berends, G. (2013). After the Great East Japan Earthquake: Political and Policy Change in Post- Fukushima Japan. Nordic Institute of Asian Studies Press.

Arirang News (2011). Highly Radioactive Substances Detected in Tokyo, May 15.

Asiaone News (2013). Solar sharing' spreading among Fukushima farmers, Asiaone News, June 26.

Aoki, M. (2012): Cesium contamination in food appears to be on wane, The Japan Times, September 25.

Akiyama N., Sato, H., Naito, K., Naoi, Y., Katsuta, T. (2012). The Fukushima Nuclear Accident and Crisis Management - Lessons for Japan-U.S. Alliance Cooperation, The Sasakawa Peace Foundation.

Akimoto S. (2014). Morphological abnormalities in gall-forming aphids in a radiation-contaminated area near Fukushima Daiichi: selective impact of fallout?, Ecology and Evolution published by John Wiley & Sons Ltd., doi. 10.1002/ece3.949

Bachev H., & Ito, F. (2013). Impacts of Fukushima nuclear disaster on Japanese agriculture and food chains, P. Gorawala & S. Mandhatri (Eds), *Agricultural Research Updates*, Vol.6, 1-75, New York: Nova Science Publisher.

Bachev H., & Ito, F. (2013). Impacts of Fukushima nuclear disaster on agri-food chains in Japan, *The IUP Journal of Supply Chain Management*, 10(4), X.

Bachev H., & Ito, F. (2016). Socio-economic impacts of the march 2011 earthquake, tsunami and nuclear accident on agri-food chains in Japan, *Economic Tought*, 3, 67-90.

BBC News, (2011). Anti-nuclear protests take place in Japan, March 25.

Belyakov, A. (2015). From Chernobyl to Fukushima: An interdisciplinary framework for managing and communicating food security risks after nuclear plant accidents, *Journal of Environmental Studies and Sciences*, 5(3), 404-417.

Biggs S., & Sheldrick, A. (2011). Tsunami Slams Japan After Record Earthquake, Killing Hundreds, March 11. Bloomberg.com.

Biodiversity Center of Japan, (2013). Impact of the Great East Japan Earthquake on the Natural Environment in Tohoku Coastal Regions, Nature Conservation Bureau, Ministry of the Environment.

Bird, W. (2012). As Fukushima Cleanup Begins, Long-term Impacts are Weighed, Biodiversity Energy Forests Policy & Politics Policy & Politics Pollution & Health Asia, January 9, 2012.

Bird, W. (2013). After Fukushima: Japan's new model for farms, *The Christian Science Monitor*, March 11.

Busby, C. (2012). Comparing Fukushima releases with Chernobyl An Update for the 1st Anniversary, [Retrieved from].

Britannica, (2014). Japan earthquake and tsunami of 2011, Britannica, Academic Edition.

Bullones, C.L. (2013). Fish with 2,500 times legal limit for radiation caught near Fukushima plant, The Japan Daily Press, January 21.

Burch, K. (2012). Consumer perceptions and behaviors related to radionuclide contaminated food: an exploratory study from Kansai, Japan, Norwegian University of Life Sciences.

Brumfiel, G. (2013). Fukushima: Fallout of fear, Nature, January 16.

Buesseler, K. (2014). Fukushima and Ocean Radioactivity, *Oceanography*, 25(1), 93-105.

Channel News Asia, (2013). Beta Burns on Fukushima cattle ignored by Japanese officials, Channel News Asia, August.
Chino M., Nakayama, H., Nagai, H., Terada, H., Katata, G., & Yamazawa, H. (2011). Preliminary estimation of released amount of 131I and 137Cs accidentally discharged from the Fukushima Daichi nuclear power plant into the atmosphere, *Journal of Nuclear Science and Technology*, 48(1), 129-134.
Chang, K. (2011). Quake Moves Japan closer to U.S. and alters Earth's Spin, *The New York Times*, 13 March.
City of Sendai, (2014). Fresh breeze of Change in Agriculture Starts Here, City of Sendai, March.
Cyberpunk World, (2014). Japan is building futuristic farm in Fukushima, January 8.
Daniell, J.E., Wenzel, F., & Vervaeck, A. (2011). The Socio-economic effects of the 2011 Tohoku earthquake, *Geophysical Research Abstracts* Vol.13, EGU2011-14270.
Deutsche Welle, (2011). Japan's tsunami victims only had 15 minutes warning, March 11.
Deutsche Welle, (2011). Quake shifted Japan by over two meters, March 14.
Fackler, M. (2014): Defying Japan, Rancher Saves Fukushima's Radioactive Cows, The New York Times, January 11.
Fisher N., Beaugelin-Seiller, K., Hinton, T., Baumann, Z., Madigan, D., & Garnier-Laplace, J. (2013). Evaluation of radiation doses and associated risk from the Fukushima nuclear accident to marine biota and human consumers of seafood, *Proceedings of the National Academy of Sciences*, 110(26), 10670-10675.
Foodwatch, (2011). Calculated Fatalities from Radiation. Officially Permissible Limits for Radioactively Contaminated Food in the European Union and Japan, German Society for Radiation Protection, Berlin
Fujita M., Nobuaki, H., Sagara, J., & Adam, B. (2012). The economics of disaster risk, risk management, and risk financing. Economic Impacts, IBRD-World Bank.
Futahira, S. (2013). Nuclear power plant accident and recovery of fishery, presentation at the JA Conference in Fukushima, May 18.
Fukumoto, M. (2013). Distribution of Artificial Radionuclides in Animals Left in the Evacuation Zone of the Fukushima Daiichi Nuclear Power Plant, in The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings, UNU-EHS, Bonn.
Fukushima Prefectural Government, (2012): Plan for Revitalization of Fukushima Prefecture.
Fukushima Prefectural Government, (2013): Outline of the Industrial Reconstruction and Revitalization Plan, March 2013.
Fukushima Minpo News, (2014). Kitakata farm accepts students as tour guests for 1st time since nuclear disaster, May 16.
Fukushima Minpo News, (2013-2014). Many issues, [Retrieved from].
Furutani, T., Uehara, K., & Murai, J. (2012). A study on community based reconstruction from nuclear power plant disaster - A case study of Minamisoma Ota Area in Fukushima, *Journal of Disaster Research*, 7(7), 432-438.
Fuyuki, K. (2013). Agricultural Recovery Efforts in Tsunami-Damaged Areas: Case Studies, in The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings, UNU-EHS, Bonn.
Hamada, N., & Ogino, H. (2013). Earthquake food safety regulations: what we learned from the Fukushima nuclear accident, *Journal of Environmental Radioactivity*, 111, 83-99.

Hiyama A., Nohara, C., Kinjo, S., Taira, W., Gima, S., Tanahara, A., & Otaki, J. (2012). The biological impacts of the Fukushima nuclear accident on the pale grass blue butterfly, *Scientific Reports 2*, No.570. doi. 10.1038/srep00570
Hasegawa, R. (2013). Disaster Evacuation from Japan's 2011 Tsunami Disaster and the Fukushima Nuclear Accident, IDDRI Study No.5.
Hori, C. (2012). Farm Land Policy and Agriculture Recovery after the Great East Japan Earthquake, Mizuho Research Institute Ltd.
JA-ZENCHU, (2011-2012). Multiple issues. [Retrieved from].
JANIC, (2013). Stories & Facts from Fukushima, Vol.1, March 25.
JETRO, (2013). Renewable Energy/Secondary Battery, November.
JICA, (2013). The Study of Reconstruction Processes from Large-scale Disasters - JICA's Support for Reconstruction, Final Report, Japan International Cooperation Agency.
Japan Finance Corporation, (2011-2014). Findings on the impact of the earthquake on food industry, 2011, 2012, 2013 surveys (in Japanese).
Japan Finance Corporation, (2011-2013). Findings of the impact of the Great East Japan Earthquake has given to farm management, 2011, 2012 surveys (in Japanese).
Japan Finance Corporation, (2011-14). Consumer Survey results on changes in purchasing behavior of consumers after Earthquake, 2011, 2012, 2013 surveys (in Japanese).
Japan Finance Corporation (2012). Financial support for environmentally friendly farming and scientific farming in Japan, Japan Finance Corporation, September 25.
Japan Finance Corporation (2013). 2012 corporate management, personal management, November, press release (in Japanese).
Japan Finance Corporation (2014): Findings on renewable energy in agriculture, January Survey (in Japanese).
JFS, (2011). Sunflower Project to Clean Up Radioactive Soil in Fukushima, Japan for Sustainability, August 31.
Japan Meteorological Agency, (2013). Earthquakes and Tsunamis, Meteorological Agency.
Japan Meteorological Agency, (2014). Information on the 2011 off the Pacific Coast of Tohoku Earthquake, Japan Meteorological Agency.
Geospatial Information Authority of Japan (2011). Subsidence investigation due to the 2011 Tohoku-Pacific Ocean earthquake, April.
Johnson, R. (2011). Japan's 2011 Earthquake and Tsunami: Food and Agriculture Implications, Congressional Research Service.
Goldman, J. (2011). Impact of the Japan earthquake and tsunami on animals and environment, Scientific American, March 22.
Government of Japan, (2012). Road to Recovery, March.
Gilhooly, R. (2013). Renewable village offers lifeline to Fukushima farmers, New Scientist 2950, December 31.
Gundersen, A., & Caldicott, H. (2012). The Ongoing Damage and Danger at Fukushima, Fairewinds Energy Education. Web. 6 Nov.
International Atomic Energy Agency, (2011). Fukushima Nuclear Accident Update Log, International Atomic Energy Agency, March 24.
International Atomic Energy Agency, (2011). Japan Earthquake Update, International Atomic Energy Agency, March 19.
International Atomic Energy Agency, (2011). Briefing on Fukushima Nuclear Accident, International Atomic Energy Agency, April 26, 2011.
International Atomic Energy Agency, (2011). IAEA international fact finding expert mission of the Fukushima dai-ichi npp accident following the great east Japan earthquake and tsunami. June.

International Bank for Reconstruction and Development, (2012). The Great East Japan Earthquake. Learning from Megadisasters, Knowledge Notes, International Bank for Reconstruction and Development/The World Bank, Washington DC.
Ishikawa, T., & Ishikawa, T. (2014). Japan farmland unproductive 3 years on, The Yomiuri Shimbun/Asia News Network, March 2.
Inajima, T., & Nakayama, M. (2011). Radiation Readings in Fukushima Reactor Rise to Highest Since Crisis Began, April 27.
Institute for Studies in Happiness, Economy and Society, (2011). How Did the Great East Japan Earthquake Affect Ecosystems and Biodiversity?
Institute for Radiological Protection and Nuclear Safety, (2012). Summary of the Fukushima accident's impact on the environment in Japan, one year after the accident, IRSN, February 28.
Inoue, K. (2014). Fukushima takes new approach to ease fears of radiation in food, The Asahi Shimbun, February 25.
Ishii, K. (2013). Les situations actuelles d'Odaka, 2013.4.12, manuscript provided by the author.
Ishii, K., & Morlans, S. (2013). La Reprise des Activites Agricoles dans les Regions Contaminees après L'Accident de Fukushima, *Géographie et Cultures*, 86, 65-82.
Iwate Prefecture, (2011). Iwate Prefecture Great East Japan Earthquake and Tsunami Reconstruction Plan, August.
Kachi, H. (2014). Short Supply Drives Fukushima Beef Prices Up, WSJ Japan Real Time Blog, January 17.
Kamiya, S. (2011). Debris removal, recycling daunting, piecemeal labor, The Japan Times, June 30.
Kageyama, Y. (2012). Japan farmers plant, pray for radiation-free rice, The Associate Press, May 28.
Kakuchi, S. (2013). Fukushima Fallout Hits Farmers, Inter Press Service, July 30.
Kaltofen, M. (2011). Radiation Exposure to the Population of Japan after the Earthquake, APHA, [Retrieved from].
Kawaguchi, Y. (2014): What Investors Have Learned from the Major Earthquake - Psychological Changes from the Viewpoint of Stock Prices and Housing Prices, The Japan News, March 6.
Kim, V. (2011). Japan damage could reach $235 billion, World Bank estimates, The Los Angelis Times, March 21.
Kirikawa, T. (2014). Progress on Treatment of Disaster Debris from Great East Japan Earthquake, *Japan Environment Quarterly*, 5, 15-25.
Koch, P. (2013). A Study of the Perception of Ecosystems and Ecosystem-Based Services Relating to Disaster Risk Reduction in the Context of the Great East Japan Earthquake and Tsunami, in The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings, UNU-EHS, Bonn.
Koizumi, N. (2011). Remarks from the chairperson of Food Safety Commission of Japan About the assessment of the effect of food on health of radioactive nuclides in foods, Food Safety Commission of Japan.
Kontar, Y., Santiago-Fandino, V., & Takahashi, T. (2014). Tsunami Events and Lessons Learned Environmental and Societal Significance, Springer.
Koyama, R. (2013): The Influence and Damage caused by the Nuclear Disaster on Fukushima's Agriculture, Nuclear Disaster on Fukushima's Agriculture, 商学論集第 81 巻第 4 (in Japanese).
Koyama, R. (2013). Towards Effective Countermeasures Against "Reputation Damage", Institute of International Studies and Training, November 29.

Kyodo News, (2011). Spinach with radiation 27 times higher than limit found in Japan, March 21.
Landline, (2013). Nuclear Farming, May 25.
Lisa, A. (2014). Fujitsu Converts Fukushima Microchip Factory into a Radiation-Free Lettuce Farm, Inhabitat, May 19.
Liou Y., Sha, H., Chen, T., Wang, T., Li, Y., Lai, T., Chiang, M., & Lu, L. (2012). Assessment of disaster losses in rice paddy fields and yield after tsunami induced by the 2011 Great East Japan earthquake, *Journal of Marine Science and Technology*, 20(6), 618-623.
Manoliu, C. (2014). Recovery and Resilience: Japanese Communities After The 3/11 Earthquake: An Actor Oriented Perspective, An STS Forum on Fukushima Interdisciplinary conversations about Fukushima & the NE Japan Disaster.
Matanle, P. (2012). The Great East Japan Earthquake, Tsunami and Nuclear Meltdown. An Assessment One Year On, The Japan Society of the UK Lecture Geographical Association Annual Conference, University of Manchester, April 14.
McCurry, J. (2013). Plummeting morale at Fukushima Daiichi as nuclear cleanup takes its toll, The Guardian, October 15.
McNeill, J. (2011). Quake, Tsunami Environmental Impact May be Minimal, Scholar Says, Georgetown University, March 22.
Ministry of Agriculture, Forestry and Fisheries, (2011). Response to Emergency Radionuclides in Foods after the Nuclear Power Plant Accident, Ministry of Agriculture, Forestry and Fisheries.
Ministry of Agriculture, Forestry and Fisheries, (2010-2014). Statistical yearbook of MAFF
Ministry of Agriculture, Forestry and Fisheries, (2013). Agricultural output of tsunami damaged municipalities, December 25. (in Japanese)
Ministry of Agriculture, Forestry and Fisheries, (2013-2014): Business conditions of agricultural and fisheries management bodies in affected areas (in Japanese).
Ministry of Agriculture, Forestry and Fisheries, (2014). Reconstruction master plan overview of the agriculture and rural, June 26. (in Japanese).
Ministry of Environment, (2012). The National Biodiversity Strategy of Japan 2012-2020.
Ministry of Environment, (2012). Estimated total amount of debris washed out by the Great East Japan Earthquake, Ministry of Environment.
Ministry of Environment, (2014). Progress on Off-site Cleanup Efforts in Japan, Ministry of Environment, October.
Ministry of Health, Labor and Welfare, (2012). Report of Survey on Health and Nutrition of National Public, Health Service Bureau, Ministry of Health, Labor and Welfare.
Ministry of Health, Labor and Welfare, (2013). Survey of Dietary Intake of Radionuclides (September to October 2012), Press Release June 21.
Ministry of Health, Labor and Welfare, (2014). Levels of Radioactive Contaminants in Foods Tested in Respective Prefectures, December 5.
Ministry of Education, Culture, Sports, Science and Technology, (2011). Readings at Monitoring Post out of 20 km Zone of Fukushima Dai-ichi NPP, Ministry of Education, Culture, Sports, Science and Technology, March 20.
Ministry of Education, Culture, Sports, Science and Technology, (2011). Results of the Survey on the Distribution of Radioactive Substances by MEXT, October.
Ministry of Education, Culture, Sports, Science and Technology, (2012). Response to the Great East Japan Earthquake.

Miyashita K. (2014). Minimizing the Contamination of Agricultural Environment toward Food Safety – With primary focus on the Fukushima nuclear disaster, Food and Fertilizer Technology Center publications.
Mizuno, T., & Kubo, H. (2013). Overview of Active Cesium Contamination of Freshwater Fish in Fukushima and Eastern Japan, Fukushima Update, Scientific Reports No.3.
Mori, N., Takahashi, T., Yasuda, T., & Yanagisawa, H. (2011). Survey of 2011 Tohoku earthquake tsunami inundation and run-up, *Geophysical Research Letters*, 38.
Morino Y., Ohara, T., & Nishizava, M. (2011). Atmospheric behavior, deposition, and budget of radioactive materials from the Fukushima Daichi nuclear plant in March 2011, *Geophysical Research Letters* No.38.
Møller, A., Hagiwara, A., Matsui, S., Kasahara, S., Kawatsu, K., Nishiumi, I., Suzuki, H., Ueda, K., & Mousseau, T. (2012). Abundance of birds in Fukushima as judged from Chernobyl, *Environmental Pollution*, 164, 36-39.
Monma, T., Goto, I., Hayashi, T., Tachiya, H., & Ohsawa, K. (2015). Agricultural and Forestry Reconstruction After the Great East Japan Earthquake Tsunami, Radioactive, and Reputational Damages, Springer.
Moqsud, M., & Omine, K. (2013). Bioremediation of Agricultural Land Damaged by Tsunami doi. 10.5772/56595.
Murayama, T. (2012). Social impacts induced by radiation risk in Fukushima, 'IAIA12 Conference Proceedings', Energy Future The Role of Impact Assessment, 32nd Annual Meeting of the International Association for Impact Assessment, Porto.
Nagashima, S. (2013). Works done by JA Fukushima for restoration, after 2 years from the disaster, presentation at the JA Conference in Fukushima, May 18.
Nakanishi, T., & Tanoi, K. (2013). Agricultural Implications of the Fukushima Nuclear Accident, Springer.
National Aeronautics and Space Administration, (2011). Tohoku Earthquake and Tsunami: Looking Back from Space, Earth Observatory, National Aeronautics and Space Administration, March 14.
National Aeronautics and Space Administration, (2012). Effects of the Tohoku Tsunami on the Kitakami River, Earth Observatory, National Aeronautics and Space Administration, March 11.
National Institute for Research Advancement, (2013). Status of Recovery and Current Problems in Three Disaster-hit Prefectures What the Data Tells Us Indexes for Recovery and Reconstruction following the Great East Japan Earthquake.
Nemoto, T. (2014). For Accelerating the Reconstruction from the Great East Japan Earthquake, Presentation of the Minister for Reconstruction, February 2014.
NHK World, (2011-2015). Multiple issues, [Retrieved from].
NISA, (2011). Seismic Damage Information, the 110th Release, 23 April, Nuclear and Industrial Safely Agency of Japan.
Nomura, T., & Hokugo, T. (2013). Situation of Compensation In Japan Based on the presentation at the NEA Workshop on "Nuclear damages, liability issues and compensation schemes", OECD NEA.
Novia, B., & Tatsuo, O. (2015). Investigating the impact of the 2011 Great East Japan Earthquake and evaluating the restoration and reconstruction performance, *Journal of Asiam Public Policy*, 8(3), 35-45.
Nuclear and Industrial Safety Agency, (2011). NISA News Release, Nuclear and Industrial Safety Agency, April 12.
Nuclear and Industrial Safety Agency, (2011). Accident of Tokyo Electric Power Company's Fukushima Daiichi nuclear power plant, the evaluation on the state

of the reactor core of Unit 3, Unit 2 Unit 1, Nuclear and Industrial Safety Agency, July 6. (in Japanese).
Nuclear Regulation Authority, (2012). Readings of soil monitoring (All Results for May 2011), Nuclear Regulation Authority, September.
Nuclear Regulation Authority, (2014). Monitoring information of environmental radioactivity level, Nuclear Regulation Authority.
Oacchioli, D. (2014). Health Risks, Oceanus, WHOI, 20-23.
Ogata, K., & Pushpalal, D. (2013). Japanese Literature Survey of Ecosystem Services in Disaster Risk Reduction, in The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings, UNU-EHS.
Oka, T. (2012). Application of cost-benefit analysis to the regulation of foodstuffs contaminated with radioactive substances, *Japan J. Health Physics*, 47(3) 181-188.
Okuyama, S. (2014). Three Years After the Nuclear Accident, The Japan News, April 22.
Organization for Economic Co-operation and Development, (2013). OECD Economic Surveys Japan, Organization for Economic Co-operation and Development, Paris.
Organization for Economic Co-operation and Development and NEA, (2012). Japan's Compensation System for Nuclear Damage As Related to the TEPCO Fukushima Daiichi Nuclear Accident, OECD and NEA.
Osawa, J. (2011). Radiation Detected in Tea Leaves in Japan, Wall Street Journal, 11 May.
Ranghieri, F., & Ishiwatari, M. (2014). Learning from Megadisasters. Lessons from the Great East Japan Earthquake, Word Bank, Washington DC.
Reconstruction Agency, (2014). Efforts and the current state of reconstruction, 26 August. (in Japanese).
Resilient ITS, (2014). Made in New Japan, Government of Japan.
Reuters, (2011). Japan to spend at least $13 billion for decontamination, October 20.
Rosen, A. (2013). Critical Analysis of the WHO's health risk assessment of the Fukushima nuclear catastrophe, [Retrieved from].
Yoshida, R. (2012). 869 Tohoku tsunami parallels stun, Japan Times, 11 March 2012.
Parvaz, D. (2014). Can Japan revive its nuclear ghost towns? Aljazeera, March 6, 2014.
Pushpalal, D., Rhyner, J., & Hossini, V. (2013). The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings.
Pushpalal, D. (2013). A Journey through the Lands of the Great East Japan Earthquake, in The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings, UNU-EHS, Bonn.
Pushpalal, D., Yan, Z., Thi, T., Scherbak, Y., & Kohama, M. (2013). Tears of Namie: An appraisal of Human Security of Township of Nanmie, in The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings, UNU-EHS, Bonn.
Satoyama Initiative, (2011). Monitoring the Biodiversity of Tsunami Affected Areas in Tohoku. [Retrieved from].
Science Council of Japan, (2011). Emergency Recommendation Regarding the Systematic Inspection against Rumors on Foods and Farming Stemming from the Nuclear Disaster September 6., Science Council of Japan.
Saito, M (2011). Radiation found in seaweed near crippled Japan plant, Reuthers, May 13.

Sekizawa J. (2013). Appropriate Risk Governance on Radionuclide Contamination in Food in Japan, in S. Ikeda and Y. Maeda (editors), Emerging Issues Learned from the 3.11 Disaster as Multiple Events of Earthquake, Tsunami and Fukushima Nuclear Accident, The Society for Risk Analysis Japan, 31-35.
Sendai City, (2011). Sendai City Earthquake Disater Reconstruction Plan.
Slodkowski, A. (2011). Japan anti-nuclear protesters rally after quake, Reuters, June 1.
Strand, P., Aono, T., Brown, J.E., Garnier-Laplace, J., Hosseini, A., Sazykina, A., & Steenhuisen, F. (2014): Assessment of Fukushima-Derived Radiation Doses and Effects on Wildlife in Japan, *Environment Science Technology Letters*, 1(3), 198–203.
Suppasri, A., & Mas, E. (2013). Field Guide of tsunami damage and reconstruction site visit in Miyagi prefecture, International Research Institute of Disaster Science.
Takada, A., & Song, Y. (2012). Fukushima Farmers Face Decades of Tainted Crops as Fears Linger, Bloombeg, March 19.
Takabe, I., & Inui, T. (2013). The Estimation of Great Earthquake Impacts on Japanese Labor Market, Agricultural Sector and GDP, Proceedings 59th ISI World Statistics Congress, 25-30 August 2013, Hong Kong, 722-728.
Takeuchi, T. & Fujioka, (2013): The agony of Fukushima farmers, in Stories & Facts from Fukushima, Vol.1, JANIC.
TEPCO, (2012-2014). Reports, [Retrieved from].
The Asahi Shimbun, (2011-2014). Muptiple issues, [Retrieved from].
The Japan Daily Press, (2013-2014). Muptiple issues, [Retrieved from].
The Japan News, (2014). Muptiple issues, [Retrieved from].
The Japan Times, (2011-2014). Muptiple issues, [Retrieved from].
The Mainichi Daily News, (2011-2012). Muptiple issues, [Retrieved from].
The National Diet of Japan, (2012): The official report of The Fukushima Nuclear Accident Independent Investigation Commission, Executive summary, National Diet of Japan.
The New York Times, (2011). Multiple issues, [Retrieved from].
The Telegraph, (2011): Fukushima caesium leaks 'equal 168 Hiroshimas, August 25.
Thompson, J., & Matsutani, M. (2013). Japanese fast-food chain Yoshinoya to sell Fukushima produce, Financial Times, October 1.
Todo, Y., Nakajima, K., & Matous, P. (2015). How Do Supply Chain Networks Affect the Resilience of Firms to Natural Disasters? Evidence from the Ggrea East Japan Eeartquake, *Journal of Regional Science*, 55(2), 209–229.
Tsumine, D., Tsubono, T., Aoyama, M., & Hirose, K. (2012). Distribution of oceanic Cs 137 from Fukushima Daichi nuclear plant simulated numerically by a regional ocean model, *Journal of Environmental Radioactivity*, 111, 100-108.
UFJ, (2011). The Economic Impacts of the Great Eastern Japan Earthquake: A Supply-Side Analysis, *UFJ Economic Review*, 6(3, 35-45.
Ujiie, K. (2011). An analysis of willingness to accept for radioactive contamination on agricultural products, [Retrieved from].
Ujiie, K. (2012). Japanese Consumer Evaluation of Radioactive Contamination on Food: Rationality and Emotion, ppt presentation provided by the author.
Uncanny Terrain, (2013). Update from Fukushima, [Retrieved from].
Umeda, S. (2013). Japan: Responses to the Great East Japan Earthquake of 2011, The Law Library of Congress, Global Legal Research Center.
United Nations Environment Programme, (2012): Managing post-disaster debris: the Japan experience Report of International Expert Mission to Japan -2, UNDP, June.
United Nations Scientific Committee on the Effects of Atomic Radiation, (2014). UNSCEAR 2013 Report, Sources, Effects and Risks of Ionizing Radiation, New York.
Urabe, J., Suzuki, T., Nishita, T., & Makino, W. (2013). Immediate Ecological Impacts of the 2011 Tohoku Earthquake Tsunami on Intertidal Flat Communities, PLOS/One.
U.S. Geological Survey, (2014). Magnitude 9.0 – Near the East Coast of Hohshu, Japan, U.S. Geological Survey.

Vervaeck, A., & Daniell, J. (2012). One Year Summary of Losses in the Japanese Earthquake/Tsunami of March 11th 2011, Eartquake-report.com
Waldenberger, F., & Eilker, J. (2014). The Economic Impact of the Tohoku Earthquake, L'Ecole des Haute Etudes.
Watanabe, A. (2011). Agricultural Impact of the Nuclear Accidents in Fukushima: The Case of Ibaraki Prefecture, in Disaster, Infrastructure and Society Learning from the 2011 Earthquake in Japan (1), 291-298.
Watanabe, N. (2013). Current State of Losses from the Nuclear Accident and Support Measures by JA-Affiliated Organizations, Norinchikin Research Institute.
Watts, J. (2011). Japan tsunami: A shortage of petrol and food but many bodies to bury, *The Guardian*, March 15.
Watts, J. (2011). After Japan's quake and tsunami, freezing weather threatens relief efforts, *The Guardian*, March 16.
World Health Organization, (2011). Japan earthquake and tsunami Situation Reports.
World Health Organization, (2012). Preliminary dose estimation from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami, WHO, Genève.
World Health Organization, (2013). Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation, World Health Organization, Genève.
Wines, M. (2011). Japan Nuclear Crisis Erodes Farmers' Livelihoods, The New york Times, March 29.
World Wide Fund, (2013). Japan Report on the Nature and Livelihood Recovery Project. A prelim assessment of ecological and social-economic changes in selected areas affected by the Great East Japan Earthquake, 2011, World Wide Fund
Yasunaria, T., Stohlb, A., Hayanoc, R., Burkhartb, J., Eckhardtb, S., & Yasunarie, T. (2011). Cesium-137 deposition and contamination of Japanese soils due to the Fukushima nuclear accident, PNAS, [Retrieved from].
Yonekura, H. (2013). Resettlement after the Great East Japan Earthquake and Tsunami in Tohoku, in The Great East Japan Earthquake 11 March 2011 – Lessons Learned and Research Questions, Conference proceedings, UNU-EHS, Bonn.

ISBN: 978-605-2132-48-7 (e-Book)
KSP Books 2018

Hrabrin Bachev

Ph.D in Economics, Agricultural Academy, Sofia. M.Sc in Agricultural and Industrial Economics, University of Economics, Sofia. Researcher and teaching at University of Missouri, Columbia, USA; University of Toronto, Toronto, Canada; Kyoto University, Kyoto, Japan; Tohoku University, Sendai, Japan; Kyushu University, Fukuoka, Japan, National Agriculture Research Center, Tsukuba, Japan; Birkbeck College of London University, London, United Kingdom; Catholic University of Louvain, Leuvain-la-Neuve, Belgium; INRA, Montpellier, France; Central European University, Budapest, Hungary. More than 300 academic papers, contributions to books and books in 40 countries of Europe, North America and Asia. Incorporating the new developing interdisciplinary New Institutional and Transaction Cost Economics (combining Economics, Organization, Law, Sociology, Political and Behavioral Sciences) into agrarian and food sector to analyze diverse modes of governance (market, private, public, hybrid, formal, informal, local, regional, transnational), and factors and prospects of institutional and organizational modernization in agri-food sector.

KSP BOOKS

e-ISBN
978-605-2132-48-7