Fukushima nuclear disaster – implications for Japanese agriculture and food chains

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1. Introduction

On March 11, 2011 at 14:46 JST the Great East Japan Earthquake occurred with the epicenter around 70 kilometers east of Tōhoku. It was the most powerful recorded earthquake ever hit Japan with a magnitude of 9.03 Mw. The earthquake triggered powerful tsunami that reached heights of up to 40 meters in Miyako, Iwate prefecture and travelled up to 10 km inland in Sendai area. The earthquake and tsunami caused many casualties and immense damages in North-eastern Japan. According to some estimates that is the costliest natural disaster in the world history [Kim]. Official figure of damages to agriculture, forestry and fisheries alone in 20 prefectures amounts to 2,384.1 billion yen [MAFF].

The earthquake and tsunami caused a nuclear accident[3] in one of the world's biggest nuclear power stations - the Fukushima Daiichi Nuclear Power Plant, Okuma and Futaba, Fukushima prefecture. After cooling system failure three reactors suffered large explosions and level 7 meltdowns leading to releases of huge radioactivity into environment [TEPCO].

Radioactive contamination has spread though air, rains, dust, water circulations, wildlife, garbage disposals, transportation, and affected soils, waters, plants, animals, infrastructure, supply and food chains in immense areas. Anomalous "hot spots" with radioactive elements from Fukushima reactors have been discovered in places far beyond the adjacent region more than 300 km to the South. Thus direct and indirect radiation effects from the disaster have been felt by a good part of the Japanese population [Wikipedia].

The levels of radiation in air, waters, soils, sewage system, material assets, food products etc. have been monitored in the affected regions and around the country. Besides, many assessments have been made by various agencies on Fukushima disaster's impacts on human health, economy, households' livelihood, natural environment etc.

There are numerous publications on impacts of the Fukushima nuclear disaster on agricultural lands, farm crops and livestock, agricultural and food products, farmers, local communities, consumers behavior, agri-food trade etc. [Fujita et al.; Johnson; MAFF; Koyama, 2013; Murayama; Nakanishi and Tanoi; Oka; Ujiie; Yasunaria et al.; Watanabe]. Nevertheless, due to the scale of contamination and affected agents, impact's multiplicities and evolution, spillovers, and long time horizon, and the lack of "full" information and

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[3] On March 14, at 11:00 am there was a hydrogen explosion at the Fukushima Daichi.

models of analysis, the overall impacts of Fukushima disaster on Japanese agrarian and food sector is far from being completely evaluated [Koyama].

The goal of this paper is to assess diverse impacts of Fukushima nuclear disaster on Japanese agriculture and food chains.

First, we present the framework of analysis of impacts of Fukushima disaster on agriculture and food chains.

Second, we assess the immediate and short-term radiation effects, and effects on nearby population, safety regulation and inspection system, markets and consumer's behavior, agrarian and food products, and health, and economic impacts on farming and agri-businesses.

Third, we assess the overall shorter and longer-term impacts on agriculture, food industries, and consumers in Fukushima region, neighboring regions, and other parts of Japan.

2. Framework for analyzing impacts of Fukushima disaster on agriculture and food chains

There have been multiple effects from the Fukushima nuclear disaster on the Japanese agriculture and food chains (Figure 1).

We have tried to identify, describe and "assess" diverse type of impacts from the nuclear disaster including:

- *direct and indirect effects*;
- *immediate, short-term, and long-term effects*;
- *radiation, production, economic, health, physiological, technological, organizational, environmental, academic, social, and political effects;*
- *expected, real, likely, perceived, and modeled effects;*

We have also tried to assess various impacts from the nuclear disaster on:

- *individual stages of the agri-food chain* - inputs supply, farming, storage, wholesaling, transportation, processing, distribution, retailing, and consumption;

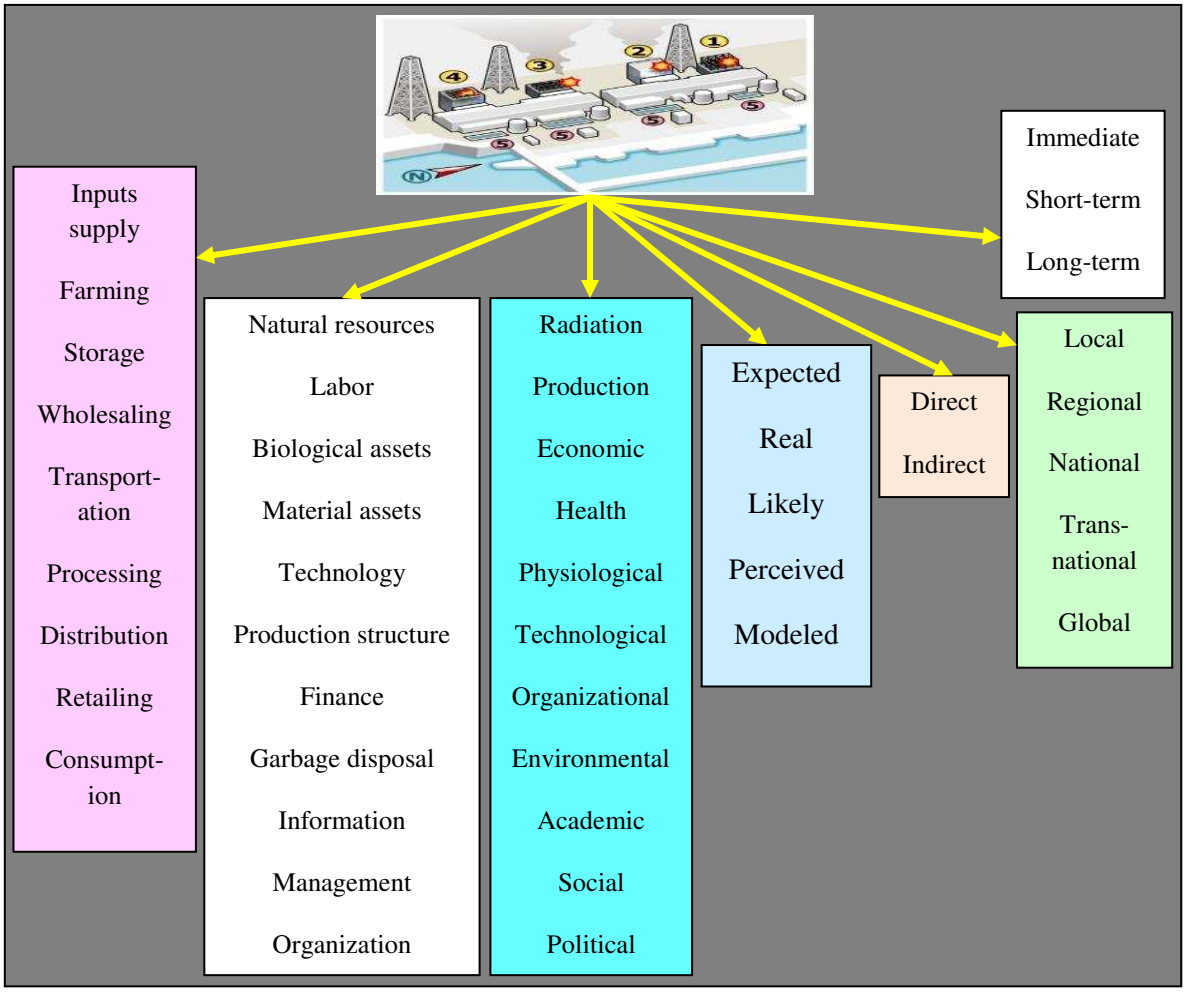
- *individual components of the agri-food chain* - natural resources, labor, biological assets, material assets, technology, production structure, finance, garbage disposal, information, and management;

- *different spacial scales* – local, regional, national, trans-national, and global.

Specification and assessment of individual effects is 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. We have tried to extend 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 major components.

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

Figure 1. Type of impacts of Fukushima disaster on agriculture and food chains



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

In June 2013 we have organized an expert assessment to identify the levels of short and longer terms impacts on agriculture, food industries and consumers in Fukushima regions, neighboring regions, and other parts of Japan, most affected areas and factors of persistence of negative impacts, and longer-term impacts on major resources, production and organization structures, efficiency and sustainability, relations with diverse agents, international trade etc. in agriculture and food industries.

The number of experts has been eleven, including four researchers (two from Fukushima University, one from Tohoku University, and one from Tsukuba University), two representatives of the prefectural government in Fukushima, two farmers, two representative of farmers associations from Fukushima prefecture, and one representative of food industry organization from Fukushima prefecture.

The personality of experts have been identified after a careful study of their positions in the affected agri-food chains, decision-making, and post-disaster evaluation and governance as well as their research, publications and presentations in that area. In addition,

multiple consultations with the leading analysts in the field have been made before selecting the members of the expert panel[4].

We asked the experts to specify the overall impacts on agriculture, food industry, and food consumption in different regions affected by the disaster. Since individual effects have quite different time span and individual experts have quite different horizon we did not specify the duration of the "short-term" and the "longer term" but let the experts to decide on that matter.

The prepared list of factors for persistence of the negative effects from the nuclear accidents has been based on extensive study of the most commonly cited factors by the officials, experts, stakeholders, analysts etc. The same was true for the list of most likely affected in the long-term aspects of agriculture and food industries (various resources, performanced, behavior, markets, costs, governance, international trade etc.). There was also an option for the experts to include other (new) factors and assess their importance for agriculture, food industries and food consumption.

A Japanese translation of the expert assessment form has been provided to all experts who were not fluent in English.

3. Immediate and shorter terms effects of Fukushima nuclear disaster

Radiation effect

On May 24, 2012, TEPCO released estimate of radiation releases due to the Fukushima Daiichi nuclear disaster [TEPCO]. According to this data 538,100 terabecquerels (TBq)[5] of iodine-131, caesium-134 and caesium-137 was released, including 520,000 TBq released into the atmosphere between March 12-31, 2011 and 18,100 TBq into the ocean from March 26 to September 30, 2011. A total of 511,000 TBq of iodine-131 was released into the atmosphere and the ocean, 13,500 TBq of caesium-134 and 13,600 TBq of caesium-137. Releases of other radioactive nuclides into air, groundwater and ocean have been also reported such as strontium, plutonium-238, 239, 240, and 241 (120 GBq), and neptunium-239 (7.6 TBq). 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[6].

On August 24, 2011, the Nuclear Safety Commission (NSC) published the results of the recalculation of the total amount of radioactive materials released into the air during the incident. The total amounts released between 11 March and April 5 were revised downwards to 130 PBq for iodine-131 (I-131) and 11 PBq for caesium-137 (Cs-137) [JAIF, 2011a].

According to the survey conducted by the Ministry of Education, Culture, Sport, Science and Technology (MEXT) in June the radioactive iodine-131 and caesium-137 were spread northwestward and southwards of the plant (JAIF, 2011b). In November 2011, the

[4] One of the twelve members of the selected expert panel (the Managing Director of the Consumer Cooperatives Union) did not fill in the assessment form but gave us in-depth interview on these issues.

[5] *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.

[6] In January 2012 due to human activities at the plant, the emissions rose again up to 19 thousand Bq.

Ministry 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[7].

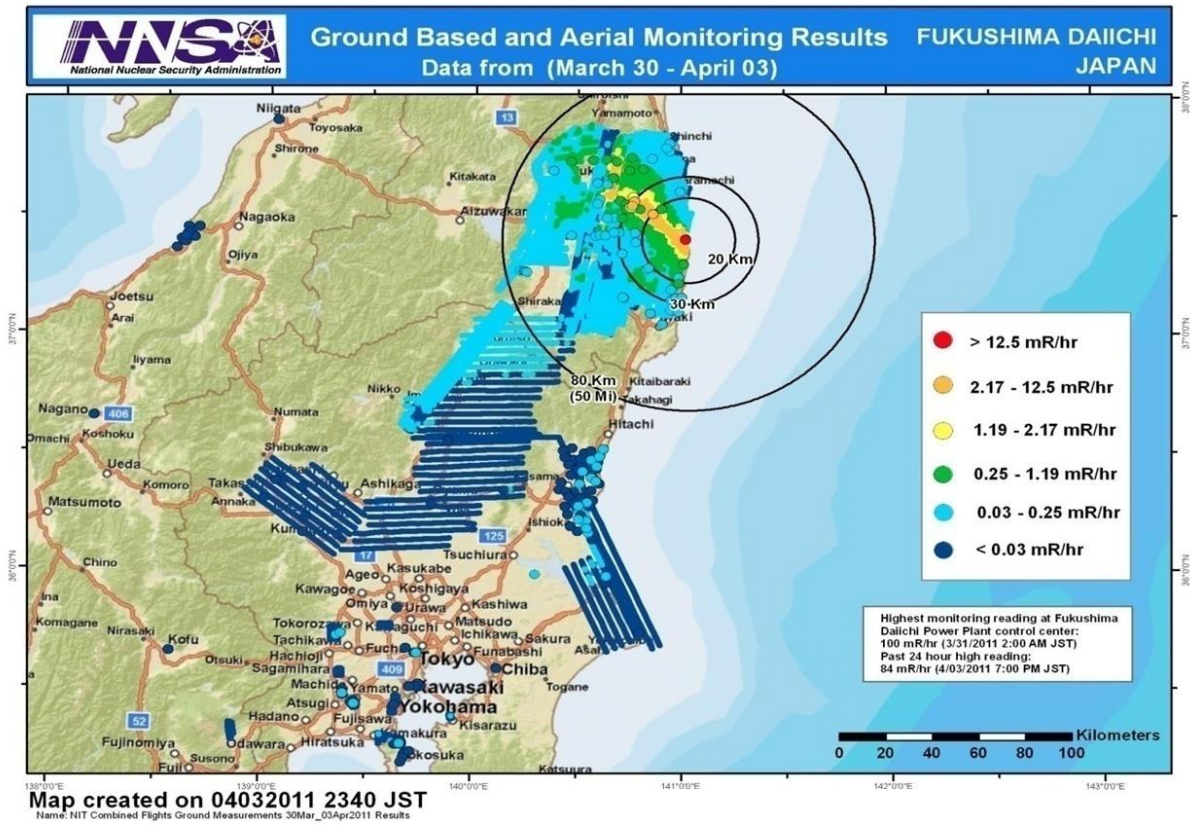
Dust particles contaminated with radioactive iodine and cesium were found in homes, soils, car filters, children shoes etc. more than 100 miles from the Fukushima site [Kaltofen]. High contamination of radioactive tellurium-129m[8] was also found in big areas around the plant [The Mainichi Daily News, 2011a]. On October 12, 2011 a concentration of 195 Bq/kg of Strontium-90 was found in the sediment on the roof of an apartment building in Yokohama city, some 250 km south from the plant [The Mainichi Daily News, 2011b]. Plutonium fallouts were detected in all samples as the highest levels of Pu-239 and Pu-240 combined being 15 becquerels per square meters[9] in Fukushima prefecture and 9.4 Bq in Ibaraki prefecture [JAIF, 2011c].

Higher than normal levels of radiation were detected in large areas surrounding the plant and beyond (Map 1). For instance, in Fukushima city, 60 km away from the crippled reactors up to 307,000 becquerels of cesium per kilogram of soil[10] was detected on September, 14, 2011 [The Mainichi Daily News, 2011c]. Experts studies also found out that cesium 137 had strongly contaminated the soils in large areas of eastern and northeastern Japan [Yasunaria et al.].

According to experts' study of soil samples as much as 400 times the normal levels of radiation could remain in communities beyond a 30-km radius from the Fukushima" site [Asahi Shimbun]. For instance, tests concluded in April, 2011 revealed radioactive cesium in amounts of 2.0-3.2 kBq/kg in soil from the Tokyo districts Chiyoda and Koto [Arirang News]. On December 13, 2011 extremely high readings of radioactive cesium (90,600 Bq/kg, 11 times the governmental limit) were detected in a groundsheet at the Suginami Ward elementary school in Tokyo [NHK World, 2011a]. On May 5, government officials announced that radiation levels in Tokyo sewage had spiked up to 170,000 Bq/kg in late March [Saito]. Besides, numerous anomalous "hot spots" have been discovered in areas far beyond the adjacent region – e.g. radioactive cesium from the reactors at Fukushima was found in Kanagawa more than 300 km to the south [Osawa].

[7] On April 19, 2011 the official "safe" radiation exposure levels was drastically increased from 1 mSv to 20 mSv per year (20 times higher than the US exposure limit).
[8] since Tellurium has no biological functions it would not accumulate in human body.
[9] compared to a global average of 0.4 to 3.7 Bq/kg from the atomic bomb tests.
[10] Triple the amount for contaminated soil that by governmental orders should be sealed into concrete.

Map 1. Contaminated areas around Fukushima Daichi nuclear power plant



Source:
http://en.wikipedia.org/wiki/File:NIT_Combined_Flights_Ground_Measurements_30Mar_03Apr2011_results.jpg

Radiation monitoring in 47 prefectures showed wide variation, but an upward trend in 10 of them on March 23, 2011. No deposition could be determined in 28 prefectures until 25 March [IAEA]. The highest value obtained for iodine-13 was in Ibaraki (480 Bq/m2) and Yamagata (750 Bq/m2) and for cesium-137 in Yamagata (1200 Bq/m2). Measurements made in a number of locations showed the presence of radionuclides in the ground which reached up to 163,000 Bq/kg of Cs-137 and 1,170,000 Bq/kg of I-131 on March 20, 2011 [MEXT].

The extent of radioactive contamination has been monitored and updating constantly[11]. The latest data show that environmental radioactivity levels in most prefectures are still higher than the period before the nuclear accident (Table 1).

Table 1. Environmental radioactivity at 1m height in 47 prefectures of Japan (μSv/h)

Prefecture (monitoring post)	Usual readings before March 11, 2011	June 10, 2013
Hokkaido (Sapporo)	0.02-0.105	0.038
Aomori (Aomori)	0.017-0.102	0.035
Iwate (Morioka)	0.014-0.084	0.036
Miyagi (Sendai)	0.0176-0.0513	0.053

[11] Detailed map with distribution of radiation dose can be found at http://ramap.jmc.or.jp/map/eng/

Akita (Akita)	0.022-0.086	0.054
Yamagata (Yamagata)	0.025-0.082	0.094
Fukushima (Fukushima)	0.037-0.046	0.79
Ibaraki (Mito)	0.036-0.056	0.076
Tochigi (Utshunomiya)	0.030-0.067	0.078
Gunma (Maebashi)	0.016-0.049	0.068
Saitama (Saitama)	0.031-0.060	0.046
Chiba (Ichihara)	0.022-0.044	0.056
Tokyo (Shinjuku)	0.028-0.079	0.056
Kanagawa (Chigasaki)	0.035-0.069	0.041
Nigata (Nigata)	0.031-0.153	0.064
Toyama (Imizu)	0.029-0.147	0.065
Ishikawa (Kanazawa)	0.0291-0.1275	0.053
Fukui (Fukui)	0.032-0.097	0.060
Yamanashi (Kohu)	0.040-0.066	0.051
Nagano (Nagano)	0.0299-0.0974	0.065
Gifu (Karamigahara)	0.057-0.110	0.066
Shizuika (Shizuoka)	0.0281-0.0765	0.038
Aichi (Nagoya)	0.035-0.074	0.065
Mie (Yokkaichi)	0.0416-0.0789	0.065
Shiga (Otsu)	0.031-0.061	0.061
Kyoto (Kyoto)	0.033-0.087	0.045
Osaka (Osaka)	0.042-0.061	0.078
Hyogo (Kobe)	0.035-0.076	0.070
Nara (Nara)	0.046-0.080	-
Wakayama (Wakayama)	0.031-0.056	0.081
Tottori (Touhaku)	0.036-0.110	0.072
Shimane (Matsue)	0.033-0.079	0.053
Okayama (Okayama)	0.043-0.104	0.065
Hiroshima (Hiroshima)	0.035-0.069	0.078
Yamaguchi (Yamaguchi)	0.084-0.128	0.076
Tokushima (Tokushima)	0.037-0.067	0.066
Kagawa (Takamatsu)	0.051-0.077	0.061
Ehime (Matsuyama)	0.045-0.074	0.084
Kochi (Kochi)	0.019-0.054	0.034
Fukuoka (Dazaifu)	0.034-0.079	0.058
Saga (Saga)	0.037-0.086	-
Nagasaki (Omura)	0.027-0.069	0.053
Kumamoto (Uto)	0.021-0.067	0.043
Oita (Oita)	0.048-0.085	0.052
Miyazaki (Miyazaki)	0.0243-0.0664	0.030
Kagoshima (Kagoshima)	0.0306-0.0943	0.031
Okinawa (Uruma)	0.0133-0.0575	0.020

Source: Nuclear Radiation Authority, http://radioactivity.nsr.go.jp/en/

In Fukushima prefecture dosimeters are installed in many locations showing current level of environmental radiation. Radiation levels varies according to location (and even within the same locality) and it still much higher than the levels before the disaster (Table 2).

Table 2. Environmental radioactivity in Fukushima prefecture on June 11, 2013 (μSv/h)

	Ken-poku, Fukushima City	Ken-chu, Koriyama City	Ken-nan, Shirakawa City	Aizu, Aizu Wakamatsu City	Minami Aizu, Minami Aizu Town	Soso, Minami Soma City	Iwaki, Iwaki City Taira
Direction and distance from nuclear power plant	North west, about 63km	West, about 58km	South west, about 81km	West, about 98km	West south West, about 115km	North, about 24km	South southwest, about 43km
Normal value*	0.04	0.04-0.06	0.04-0.05	0.04-0.05	0.02-0.04	0.05	0.05-0.06
June 11, 2013	0.35	0.18	0.13	0.07	0.05	0.15	0.09

**radioactivity levels surveyed in 2010*

Source: http://www.worldvillage.org/houshano_deta/houshano_e.pdf

On 12 November, 2011 officials published a radiation map covering a wider area showing soil radiation of cesium-134 and cesium-137 between 30,000 and 100,000 Bq/m2 in Ichinoseki and Oshu (Iwate prefecture), in Saku, Karuizawa and Sakuho (Nagano prefecture), in Tabayama (Yamanashi prefecture) and elsewhere [The Mainichi Daily News, 2011d]. The extent of radioactive contamination of soils has been monitored and updated. Nevertheless, the accurate radioactive contamination of all agricultural lands has not been investigated yet [Koyama, 2013]. The contamination with radioactive materials differs widely for each individual farm field even within a specific location. For instance, samples taken from 10 rice paddies in a village in Fukushima prefecture revealed values ranging from 400 Bq/kg up to 4,000 Bq/kg, some rice paddies in Iitatemura (20-30 km from the nuclear plant) gave off readings as high as 15,031 Bq/kg etc. [Koyama, 2012].

Decontamination of farmlands outside the evacuation zone has been mostly completed and farming resumed in many places. According to the officials "appropriate reduction of radiation" has been achieved to allow the safe production. Nevertheless, latest figure shows a slow progress as merely 8% of the lands outside evaluation zones were decontaminated by the end of 2012, and as much as 62% of the affected farmland is still not restored [NHK Wold, 2013a,c]. According to experts still there are many hot spot with excessive contamination.

Since October 2012 a soil screening project started in Fukushima-shi on 28,382 ha with 24721 agricultural cooperative members. Mapping is done by 7 full time stuff and many volunteers with modern instruments (equipped with GPS) measuring contamination of soil and air. Project is expected to be completed in April 2014 (and continue afterwards if funding is available) and samples are taken in 3 points of each of the 28392 paddy fields and 10058 orchards. Results up to date show a great variation of radioactivity between 1000-3000 Bq/kg in paddies and up to 10000 Bq/kg for orchards (Interview with project leader Mr.Park, June 17, 2013).

The emission of radioactivity into the sea represents the most important individual emission of artificial radioactivity into the sea ever observed. By April 15 Iodine-131 radiation in seawater 330 m south of a key discharge outlet of power station had reached levels 6,500 times higher than the legal limits [The New York Times]. On May 13, 2011, more than 45% of seaweed samples collected near the plant showed 10,000 Bq/kg or five times higher than the Japanese standard for food of 2,000 Bq/kg for Iodine-131 and 500 Bq/kg for radioactive Cesium [Saito]. Nevertheless, measurements in autumn 2011 found

only a weak concentration of radioactivity in the seawater and limited accumulation in sediments apart from the coastal waters near the nuclear plant [Buesseler et al.].

The latest data (June 11, 2013) indicates that radioactivity concentrations of Cs-134 and Cs-137 in the seawater around the coast and offshore of Fukushima prefecture in the outer layer vary between 0.0038-0.11 Bq/L and 0.01-0.27 Bq/L while in the lower layer they are between 0.057-0.11 Bq/L and 0.010-0.22 Bq/L accordingly [Nuclear Radiation Authority].

As of October 2012, regular sampling of fish and other sea life off the coast of Fukushima showed that cesium levels had not decreased after the accident and that total cesium levels in bottom-dwelling fish were with levels above the regulatory limits, leading to a fishing ban for some species [Buesseler].

The nuclear plant has been continuing to pose seriose challanges associated with the safe storage and disposal of radioactive materials. Since last year there have been registered five leakiges of radioactive materials into ground from the plant's facilities [BBC]. On August 10, 2013 it was detected that 300t of highly contaminated water leacked from a storage tank and would eventually slip into the sea [NHK World, 2013b]. On September 2, 2013 it emerged that radiation level near 3 storage tanks is 18 times higher than previousely tought [NHK World, 2013c]. Concequently the Government announced a 470 million USD plan to take over the responsibility for sorting out the leaking crisis.

Effects on nearby population

Since March 12, 2011 the authorities have been implementing a 20 km (800 sq km) exclusion zone and other restricted areas around the Fukushima nuclear power plant[12].

Currently the affected area is divided into following categories (Map 2):

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

2) Areas to which evacuation orders are ready to be lifted[13] - entry is permitted but overnight stay is not permitted;

3) Areas in which residents are not permitted to live where annual integral dose of radiation is expected to be 20 mSv or more. Entry is not recommended but allowed during daytime;

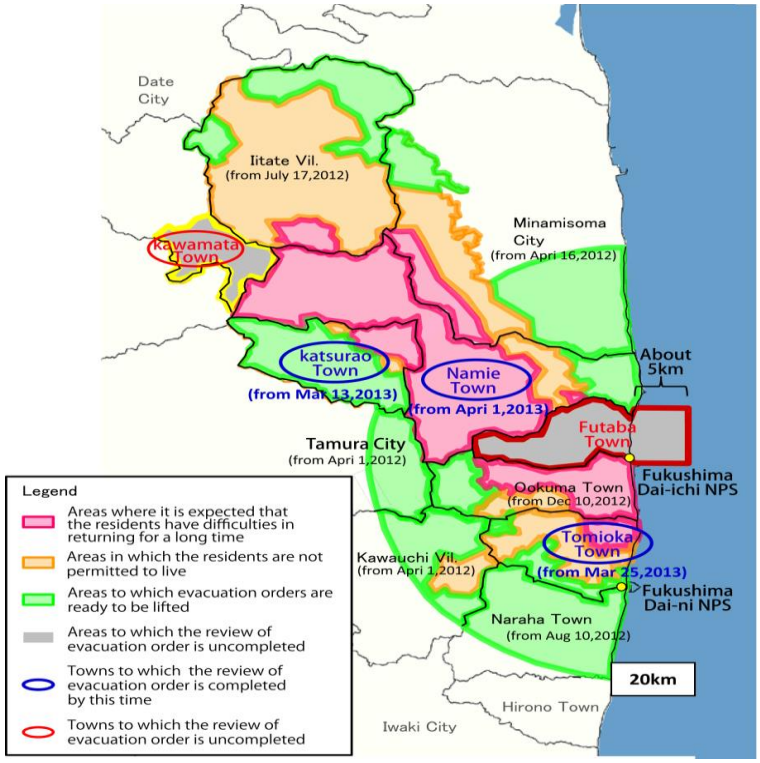
4) No entry areas where the annual integral dose of radiation is expected to be 20 mSv or more within five years and the current integral dose of radiation per year is 50 mSv or more;

5) Specific spots recommended for evacuation.

[12] On April 22, 2011, Fukushima Prefecture was divided into: 1) Restricted Area in 20 km radius around nuclear plant where entry is prohibited. 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 to commute to workplace whose continued operation is approved by local administrators. 3) Evacuation prepared areas in case of emergency - 20-30 km radius from Fukushima Daiichi Nuclear Power Plant where certain groups (pregnant women, with special needs) are not permitted. 4) Specific Spots Recommended for Evacuation - sites with a cumulative dose of 20mSv/y and up.

[13] it is confirmed that the annual integral dose of radiation will definitely be below 20mSv.

Map 2: Restricted areas in Fukushima prefectures as on April 1, 2013



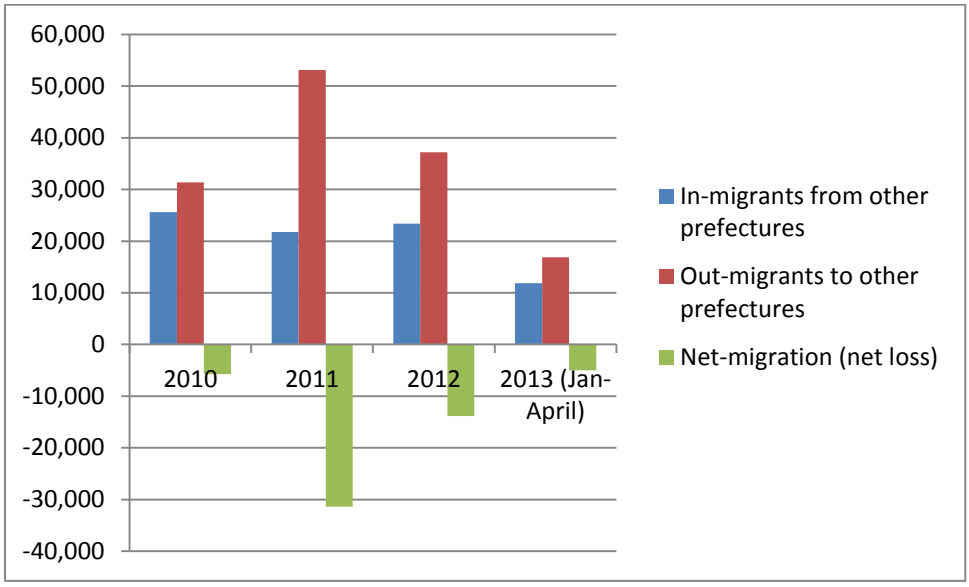
Source: JANIC

Two years passed after the nuclear accident and 154,148 Fukushima residents are still displaced, including 57,135 of them outside the prefecture [JANIC]. Most people especially younger one have been reluctant to return to home places due to the health risk, lack of basic infrastructure and services, delayed decontamination process, reduced employment opportunities etc. What is more, official figure shows that the overall population of Fukushima prefecture has been decreasing due to out-migration of population since the nuclear accident (Figure 1).

There are no comprehensive estimates on the overall damages but some assessment range the total economic loss in the evacuation zone from 250 to 500 billion USD [NewsonJapan.com; Gundersen and Caldicott]. Much of the damages on the economy, individuals livelihood and possessions, physical and mental health, environment, lost community relations etc. can hardly be expressed in a quantitative (e.g. monetary) terms. Cesium-137 has a half-life of 30 years, and it takes about 10 half-lives for any radionuclide to disappear. Therefore, cesium will maintain "ownership" of the exclusion zones for many years to come.

Farms and food chain companies' property (farmland, crops, livestock, homes and other possession, material assets, intangible such as brands, good reputation, relations etc.) and related infrastructure alike were contaminated, lost value and abandoned while livelihood and businesses of many significantly destructed.

Figure 1: Number of in-migrants, out-migrants and net losses in population in Fukushima prefecture



Source: Statistics Japan, Ministry of Internal Affairs and Communications

There are no precise figure on the number of farms and agri-food businesses, and the total agricultural and related population from the evacuated and affected by the radiation areas. However, the available data show that negative impact of farms and farm households is quite significant. Table 3 summarizes the number of affected farms, farm population, farming areas, areas of paddy fields, orchards, livestock and poultry in the evacuated areas in Fukushima prefecture.

According to the estimates of the Fukushima prefecture in March 2012 the number of farmers in evacuation area was 5400 households and the farming area was 11,000 ha comprising 8% of the total farmers and 9% of the total farming area in the prefecture in 2010. At the same time, the numbers of beef cattle in evacuation area was 10,836, milk cows 1,980 and pigs 40,740 accounting respectively 15%, 12% and 22% of the overall numbers of livestock in 2011. The estimate figure for chickens in the evacuation area was 1,589 or 30% of the total number in the prefecture in 2009.

According to the recent estimates in JA Soma the damaged area from the nuclear power plant accident reaches 5,439 ha and the damaged farmlands is 4,155 ha [Nagashima]. Consequently, in the 20 km evacuation area the number of farms decreased from 364 to 101 and the livestock heads from 4864 to 2261.

Many who left the affected areas are refusing to come back and start revitalization because of the health risk, destructed business and community infrastructure (schools, medical facilities etc.) etc. That is especially true for the younger generation who chose to stay away from contaminated areas. For instance, in Kawagugi merely less than a third of younger generation has returned until now [Landline].

Table 3: Number of farms, farming areas, livestock in evacuated area in Fukushima prefecture (estimated data from 2010)

Indicators	Evacuation area including:				
	Evacuation area total	**% in Fukushi-ma total**	**In hazard area**	**In emergency evacuation preparation zone**	**In planned evacuation area**
1.Number of farms	7654	10.68	4123	2272	1259
Total farmland (a)	1,534,398	12.63	788,971	414,321	331,106
- Rice paddy	1,124,843	12.42	637,207	326,749	160,887
% of rice paddy	73.31				
- Upland	392,963	15.68	138,064	85,365	169,534
- % of upland	25.61				
- Permanent crops	16,592	2.83	13,700	2,207	685
% of permanent crops	1.08				
2.Number of farms above 30a or 500000 yen income	7454	10.57	4022	2232	1200
Total farmland (a)	1,390,223	12.01	731,921	405,020	253,282
- Rice paddy	1,053,231	12.01	591,859	320,478	140,894
% of rice paddy	75.76				
- Upland	322,493	14.39	128,105	82,665	1,877
- % of upland	23.20				
- Permanent crops	14,499	2.54	11,957	1,877	665
% of permanent crops	1.04				
3.Number farm population	10,616	9.74	5,477	3,172	1,967
4.Farms with milk cows	127	16.89	52	34	41
Number of cows	2,434	13.96	1,167	705	562
5.Farms with beef cattle	814	22.12	282	311	221
Number of beef cattle	9,097	17.24	3,364	2,955	2,778
6.Farms with pigs	9	13.85	7	0	2
Number of pigs	4,808	13.41	4,416	0	392
7.Farms with hens	18	10.17	9	4	5
Number of hens	92,712	24.04	90,872	1,660	180
8.Farms with boilers	10	17.86	4	1	5
Number of boilers	995,743	29.21	478,000	12,000	505,743

Source: Fukushima Prefectural Government

Moreover, many farmers fear that "disaster still 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).

According to a recent survey in JA Futaba (where all farmers were evacuated) merely 25% of the farmers "want to farm their own land again". Even combining the answers to "continue farming in other lands" the farmers who want to continue farming is just 38% and those who don't want to continue is 33% [Nagashima]. According to the survey of prefectural government as much as 50% of farms do not return back to their land in Fukushima.

In Fukushima the number of people who wish to buy land and start farming is 92, while 9 have already started farming, 4 are planning to start, and 9 are ongoing farming

[Nagashima]. Similarly, the number of individuals who wish to rent land in and start farming is 39, while 10 have already started, 5 are planning, and 6 are ongoing farming. In addition, 209 wish to make kitchen garden, 59 have already started such gardens, 11 are planning to start, and 9 are ongoing that practice. Besides, 42 wish to rent land out and start farming, 12 have already done so, 5 are planning to start, and 5 are ongoing.

According to the official it is still not clear when the thousands of evacuated farms will return back to their land (interview with Ma. Satou, June 17, 2013). For instance, nearly 60% of evacuees continue living as evacuees 6 months after it was declared safe for residents to return [The Japan News]. Despite that the decontamination work on farmland, houses and roads is completed radiation in forests around houses is still quite high.

The overall number of affected farms, agri-businesses and their damages is unknown. However, it is not disputed that most severely affected by the disaster have been farmers from Fukushima and neighboring prefectures. Total number of farms in Tohoku, Kanto and Chūbu regions which have been greatly (directly or indirectly) impacted by the accident is quite big (Table 4).

Table 4: Number of Agricultural Management Entities in Tohoku, Kanto and Chūbu regions in 2010-2011

Prefectures	Total	Juridical person	Non-juridical person	Local authorities/ Property ward
Tohoku region				
Aomori	44 667	422	44 219	26
Iwate	57 001	620	56 356	25
Miyagi	50 741	347	50 390	4
Akita	48 521	394	48 106	21
Yamagata	40 831	363	40 459	9
Kanto region				
Ibaraki	71 542	542	70 994	6
Tochigi	48 463	359	48 101	3
Gunma	32 567	518	32 043	6
Saitama	45 167	387	44 772	8
Chiba	55 387	672	54 710	5
Tokyo	7 455	50	7 396	9
Kanagawa	15 612	233	15 377	2
Chūbu region				
Niigata	68 245	1 003	67 228	14
Toyama	22 906	433	22 471	2
Ishikawa	17 669	328	17 341	0
Fukui	20 086	277	19 805	4
Yamanashi	21 309	232	21 075	2
Gifu	64 289	845	63 429	15
Gifu	37 287	473	36 803	11
Shizuoka	40 102	443	39 658	1
Aichi	45 005	602	44 398	5
Mie	33 601	377	33 223	1

Source, MAFF

The feeling of people in the most affected areas can be expressed by the statement of one of the interviewed by us expert Mr.Muto, a Chairman of the Rural Development Association in Nihonmatsu: "More and more anxiety is occurring because it is unknowing when this disaster will be over. There are 1500 nuclear fuel rods inside the power plant number 4, high radiation around Daiichi Nuclear power plant, and 400t of polluted water coming out every day. Nobody will listen our claims about the safeness and trustworthy. The place we live is here. We cultivate, produce, do inspection and eat, do inspection and cultivate, and on and on. I feel shame to getting used to this cycle. We must find and promote more efficient countermeasure speedily" (June 14, 2013).

Contamination of agrarian and food products

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

On March 19, 2011, the Ministry of Health, Labor and Welfare (MHLW) announced that levels of radioactivity exceeding the legal limits had been detected in milk produced in the Fukushima area and in certain vegetables in Ibaraki prefecture. For instance, on March 21, levels of radioactivity in spinach grown in the open air in Kitaibaraki, Ibaraki prefecture, (around 75 km south of the nuclear plant) were 24,000 Bq/kg of iodine-131, and 690 Bq/kg of cesium [Kyodo News].

Distribution of spinach and kakina was restricted in Ibaraki, Totigi, Gunma, and Fukushima prefectures as well as milk from Fukushima. On March 23, similar restrictions were placed on more leafy vegetables (komatsuna, cabbages) and all flowerheads brassicas (like cauliflower) in Fukushima, while parsley and milk distribution was restricted in Ibaraki prefecture. IAEA reported that virtually all milk samples and vegetable samples taken in Fukushima (March 18–21) and Ibaraki (March 16–22) prefectures were above the safe limit [IAEA]. Samples from Chiba, Ibaraki and Tochigi prefectures also had excessive 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 the regulatory levels.

Other agricultural products from Tochigi and Ibaraki prefectures have also been found to exceed the government limits such as pasture grass collected on May 5, approximately 11 times the state limit of radioactive cesium [NHK World, 2011b]. Hay and straw were found contaminated with cesium 80 kilometers from the reactors.

Contaminated beef was traced on farms as far as 100 km away from the Fukushima power plant. The cesium was found in meat from animals fed by contaminated rice straw[14]. By July 26, 2011 it was known that more than 2,800 cows fed with cesium-contaminated food

[14] Similar contamination did no affects pigs and chickens since they are not fed with rice straw.

were shipped to markets in 46 of the prefectures (with exception of Okinawa)[15]. Measurements of some beast shipped form Miyagi were 1,150 Bq/kg. All transport of beef raised in Fukushima prefecture was prohibited after July 19, 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[16]. 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[17].

In addition, Ministry of Agriculture, Forestry and Fishery (MAFF) 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, 2011d].

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. Number of places for testing rice within the city also increased from 38 to 300. Farmers who already started harvesting were ordered to store crop until the post-harvest tests is available [JAIF, 2011f].

On November 16, radioactive cesium of 630 Bq/kg was detected in rice harvested in the Oonami district of Fukushima city [NHK World, 2011c]. 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 kilometers 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 Daiichi reactors. Consequently prefectural government decided to control more than 2300 farms in the whole district. On 29 November orders were given to 2381 farms in Nihonmatsu and Motomiya to suspend part of rice shipments in addition to already halted shipments at 1941 farms in 4 other districts (including Date), totaling 4322 farms [The Mainichi Daily News, 2011e].

[15] Even in July radioactive beef was found on sale in 11 prefectures (until then testing had only been performed on skin and exterior of livestock while animal feed and meat cuts not checked).

[16] All cattle have to be checked for radiation exposure before shipment, and the government asked prefecture to temporarily reduce the number of shipments to match its inspection capability.

[17] Late July at one farm rice-straw was discovered with radioactive cesium levels exceeding safety limit. Traders started to avoid all cattle from Shimane and beef prices plummeted.

On May 11, 2011 cesium levels in tea leaves from Kanagawa prefecture were reported to exceed government limits [Osawa]. 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, 2011e].

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 kilometers 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 it was announced that shiitake mushrooms grown indoors at a farm in Soma (north from Fukushima Daiichi 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, 2011f].

In March and October food was served to 800 people in Yokohama city with highly contaminated dried shiitake-mushrooms[18] 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, 2011d].

On February 7, 2012 noodles contaminated with radioactive cesium (258 Bq/kg) were found in Okinawa [The Mainichi Daily News, 2012c]. “Okinawa soba” was apparently produced with water filtered through contaminated ashes[19] from wood originating from Fukushima prefecture. On February 10, 2012 MAFF 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. Consequently MHLW started regularly tests on baby food products. Previous tests in July-August on 25 baby products did not reveal any contamination [The Mainichi Daily News, 2011h].

On March 20, 2011 MEXT announced that radioactive substances were detected in tap water in Tokyo, and Tochigi, Gunma, Chiba and Saitama prefectures [The Japan Times, 2011]. Later it was reported that between 16 and-21 of March the contamination in drinking water in Tokyo, Fukushima and Ibaraki was above regulatory limits [IAEA, 2011b]. On March 24, iodine-131 was detected in 12 of 47 prefectures, of which the level in Tochigi was the highest at 110 Bq/kg. Caesium-137 was detected in 6 prefectures but always below 10

[18] Test-results of mushrooms showed 2,770 Bq/kg in March and 955 Bq/kg in October [JAIF, 2011h].

[19] 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.

Bq/kg. On March 25, tap water was reported to have reduced to 79 Bq/kg and to be safe for infants in Tokyo and Chiba but still exceeded limits in Hitachi and Tokaimura. On April 27 radiation in Tokyo's water supply fell to undetectable levels for the first time since 18 March (Inajima and Nakayama). On July 2 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.

Some tests also 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, 2011j]. A study of the effects of radioactive contamination following the Fukushima Daiichi nuclear 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.]. A year after the nuclear disaster scientists found ("unexpected") mutated butterflies suggesting that mutations have been passed down from the older generations.

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, 2012a]. 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, 2012b]. 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 Fukushima Daiichi 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 limits [JAIF, 2012].

High levels of radioactive cesium were found in 23 varieties of freshwater fish sampled at five rivers and lakes in Fukushima prefecture between December 2011 and February 2012 and in 8 locations on the open sea. On July 2, 2012 the Ministry of the Environment (ME) published that it had found 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. ME has been closely monitor freshwater fish as radioactive cesium might remain for much longer periods in their bodies.

After detection of radioactive cesium above legal limits in Sand lances caught off the coast of Ibaraki, prefectural government banned fishing [NHK, 2011b]. Marine fish was found less contaminated and showed levels between 2.15-260 Bq/kg. Marine fish might be more capable of excreting cesium from bodies, because 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 of radioactive cesium was measured in animal plankton 3 km offshore [JAIF, 2011k].

June 2012 report on radiation tests on almost 14,000 commercial fish catches in international Pacific and Japanese waters since March 11, 2011 revealed that 56% of Japanese fish catches were contaminated with human-made radioactive isotopes (cesium-137 and -134) as 9.3 percent of the catches exceeded the official ceiling [MAFF]. Radiation levels remain especially high in species like cod, sole, halibut, landlocked kokanee, carp, trout, and eel. Furthermore, in a 'murasoi'-fish caught in January 2013 at the coast of Fukushima an enormous amount of radioactive cesium was found at 2540 times the legal limit for seafood.

On March 31, 2012 MHLW published a report on radioactive cesium found in food. Between January-March 15, 2012 at 421 occasions food was found containing more than 100 Bq/kg cesium in 8 prefectures: Chiba, Fukushima (285 finds), Gunma, Ibaraki (36 finds), Iwate, Miyagi, Tochigi (29 finds) and Yamagata. Mostly it involved fish (landlocked salmon and flounder) and seafood, Shiitake-mushrooms, and meat of wild animals [The Mainichi Shimbun, 2012d].

In August 2012 MHLW found 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 are showing excessive contamination [Aoki].

The number of inspections around the country multiplied in the last year, and result show that in milk, wheat and burley, chicken and egg tests no radioactive cesium above safety limits is found, while in other agricultural food products (but mushrooms and wild edible plants) the number of tests above safety limit is insignificant (Table 5). The latest data indicate that the number of cases with radioactive contamination in tested cached marine fish has dropped as well [http://www.jfa.maff.go.jp/e/inspection/index.html].

Table 5: Results of inspections on radioactivity levels in agricultural products in Japan

Category	March, 2011 - March 31, 2012			April 1, 2012- January 31, 2013	
	Number of samples	Above provisional limit	Above the new limit	Number of samples	Above the maximum limit
Rice	3,217	1	9	10.2 million	71
Wheat and burley	566	1	27	1,816	0
Vegetables	11,998	139	385	16,440	5
Fruits	2,724	28	321	4,299	13
Pulse	698	0	16	4,324	21
Mushrooms and wild edible plants	4,193	323	2,070	5,882	599
Tea/Tea infusion*	2,232	192	1,562	825*	13*
Raw milk	1,914	1	7	2,054	0
Beef	92,683	157	1092	130,090	2
Pork	529	0	6	716	1
Chicken	225	0	0	353	0
Egg	419	0	0	425	0

Source: www.maff.go.jp/j/kanbo/joho/saigai/s_chosa/other/result_agri_2012.html

http://www.maff.go.jp/j/kanbo/joho/saigai/s_chosa/result_agri_2011.html

For the period March 19, 2011-March 31, 2013 the Fukushima Agricultural Technology Center (FATC), equipped with advanced facilities, has tested 81502 agri-food items from Fukushima prefecture. In the last year contamination above safety limit has been found in 1.8% of all tested items (Table 6). Radiation detection in fish, and mushrooms and wild edible plants have been considerable (14.6% and 8.2% respectively), while for milk, meat and eggs it was nil, and for other major items insignificant.

Table 6: Results of inspections on radioactivity levels in food products in Fukushima prefecture

Items	March, 2011 - March 31, 2012		April 1, 2012- March 31, 2013	
	Number of samples	Above provisional limit	Number of samples	Above the maximum limit
Vegetables and fruits	5,976	145	7,264	7
Milk	651	15	441	0
Meat	5,001	0	6,310	0
Eggs	221	0	144	0
Mushrooms and wild plants	956	127	1,090	90
Fish	3,330	227	6,037	879
Forage for livestock	773	162	1,664	48
Brown rice	1,724	0	35,238	71
Cereals without rice	607	3	2,169	10
Others	51	2	68	1
Total	19,290	681	60,425	1,106

Source: http://www4.pref.fukushima.jp/nougyou-centre/

Effects on food safety 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. 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 (Table 7).

Table 7: Summary of food restrictions imposed by government in Japan

Item	Shipping restrictions					Consumption restrictions
	Fukushima	Ibaraki	Tochigi	Gunma	Chiba	Fukushima
Raw milk	3/21 – 4/8: Kitakata, Bandai, Inawashiro, Mishima, Aizumisato, Shimogou, Minami-aizu 3/21 – 4/16: Fukushima, Nihonmatsu, Date, Motomiya, Kunimi, Ootama, Kooriyama, Sukagawa, Tamura (excl. former Miyakoji), Miharu, Ono, Kagamiishi, Ishikawa, Asakawa,	3/23 – 4/10: All areas				

	Hirata, Furudono, Shirakawa, Yabuki, Izumizaki, Nakajima, Nishigou, Samegawa, Hanawa, Yamatsuri, Iwaki 3/21 – 4/21: Souma, Shinchi 3/21 – ongoing: All other areas					
Spinach	3/21 – ongoing: All areas	3/21 – 4/17: All areas except Kita-ibaraki, Takahagi 3/21 – ongoing: Kita-ibaraki, Takahagi	3/21 – 4/21: Nasushiobara, Shioya 3/21 – ongoing: All other areas	3/21 – 4/8: All areas	4/4 – 4/22: Asahi, Katori, Tako	3/23 – ongoing: All areas
Kakina	3/21 – ongoing: All areas	3/21 – 4/17: All areas	3/21 – 4/14:All areas	3/21 – 4/8: All areas		3/23 – ongoing: All areas
Chrysanthemum	3/23 – ongoing: All areas				4/4 – 4/22: Asahi	3/23 – ongoing: All areas
Bok choi	3/23 – ongoing: All areas				4/4 – 4/22: Asahi	3/23 – ongoing: All areas
Korean lettuce	3/23 – ongoing: All areas				4/4 – 4/22: Asahi	3/23 – ongoing: All areas
Other non-round leafy vegetables	3/23 – ongoing: All areas					3/23 – ongoing: All areas
Round leafy vegetables (such as cabbage)	3/23 – ongoing: All areas					3/23 – ongoing: All areas
Brassicaceaebuds (broccoli, cauliflower, etc.)	3/23 – ongoing: All areas					3/23 – ongoing: All areas
Turnip	3/23 – ongoing: All areas					
Parsley		3/23 – 4/17: All areas			4/4 – 4/22: Asahi	
Celery					4/4 – 4/22: Asahi	
Shiitake	4/13 – 4/25: Iwaki 4/13 – ongoing: Shinchi, Date, Iitate, Souma, Minami-souma, Namie, Futaba, Ookuma, Tomioka, Naraha, Hirono, Kawamata, Katsurao, Tamura, Kawauchi					4/13 – ongoing: Iitate

	4/18 – ongoing: Fukushima 4/25 – ongoing: Motomiya					
Sand lanceyoung	4/20 – ongoing: All areas					4/20 – ongoing: All areas

Source: http://en.wikipedia.org/wiki/Radiation_effects_from_Fukushima_Daiichi_nuclear_disaster

On 17 March 2011, MHLW introduced Provisional regulatory limits for radionuclides in agri-food products. On 29 March 2011, the Food Safety Commission of Japan (FSC) 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 MHLW decided to use the ongoing provisional regulation values for the time being and set up provisional regulation value for radioiodines in seafood on the next day.

In order to meet growing public safety concerns since April 1, 2012 new and more stringent than international standards[20] official limits on radioactive elements in food items have been enforced in the country (Table 5).

Table 5: Limits on radioactive elements in foodstuff in Japan (Bq/kg)

Food item	Old norm	New norm
Rice, meat, vegetables, fish	500	100
Milk, milk-powder, infant-food	200	50
Drinking water	200	10

Source: Ministry of Health, Labor and Welfare

In addition, MAFF provided advice on creation of food inspection plans and supporting inspection equipment installations in affected prefectures; 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 for 2012 (February 28, 2012); revised provisional tolerable levels for producing animal and fishery products below the standards limits for radionuclides in foods (February 3 and March 23, 2012) etc.

[20] E.g. safety limits for radioactive substances in EU and USA for grains are accordingly 1250 Bq/kg and 1200 Bq/kg, for vegetables 500 Bq/kg and 1200 Bq/kg etc.

At FATC, in Koriyama city, advance laboratories for emergency radiation monitoring of agricultural produces have been 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. Samples of vegetables and fruits are shipped for testing on Monday, Wednesday, and Thursday, beef from Thursdays to Saturday, seafood on Tuesday, raw milk on Wednesdays, grains, mushroom, mountain plant, honey and feed crop on Friday, and irregularly for pork, chicken, horse meat and chicken eggs. 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 has been analyzed.

In addition, all rice bags[21] produced in Fukushima prefecture are checked in the Agricultural Cooperative inspection cites to assure safety. Until May 8, 2013 the number of checked rice bags amounted 10,324,565 and merely 71 of them have been found with radiation above safety limit or 0.00068% of the total number.

Furthermore, there have emerged many private and collective inspections systems introduced by farmers and rural associations, food processors, retailers, local authorities, consumer organisations, independent agents etc. For instance, in Nihonmatsu-shi, Towa town, there was a sharp decline in well-developed before the accident tourism and agricultural sells. Radiation measurement of farm products was introduced by the local Rural development association in June 2011. It has been done in own laboratory by an equipment supplied by a private company and costs 500 yen per test for farmers. Due to timely introduction of safety inspection and 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). Municipality has also introduced 60 points for inspections of food for self-consumption which is free for producers.

According to the Fukushima Food Industry Orgnaisation many the member companies bought own equipment for radiation checks of ingrediants, water and final produces, or use outside safety checks to avoid risks, and/or deal with harmful humors, and secure customers. The Fukushima Consumer Cooperatives Union (FCCU) also has 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.

Besides, various voluntary restrictions on sale have been introduced by farmers, farmers' organizations, food industry, and local communities[22]. 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).

[21] one baggage is 30 kg.

[22] List of products presently subject to government or voluntary restrictions is presented in Appendix 1.

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[23], the water, food and soil tests have not always been accurate, consistent and comprehensive. Food safety inspections are basically carried out at distribution stage (output for shipment or export)[24], and do not (completely) cover produces for farmers markets, direct sells, food exchanges and self-consumption[25].

Furthermore, capability for radiation safety control in Fukushima prefecture is significantly higher than in other affected regions, while radiation contamination has "no administrative borders". In fact most food is regularly inspected in Fukushima prefecture and it is much safer than in other prefectures where such strict tests are not carried out at all.

What is more, many of the privately and collective employed testing equipments are not with high precision, and/or samples are properly prepared for analysis (e.g. 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 most of the fresh vegetables and fruits are consumed. Moreover, there are untested wild plants and/or produced food which are widely consumed by local populations. For instance, radioactive contamination in forestry trees leaves have been found far away in Nagano prefecture[26].

Furthermore, there are considerable discrepancies in measurements of radiation levels in air and food done in a specific location. For instance, in Nihontatsu-shi laboratories of the NGO and the Government are located across the street (50m of each other) but they often register different radiation in environment and food.

Agri-food inspections and regulations are conducted in vertically segmented administration with "own" policies and not well-coordinated procedures. For instance, soil surveys and inspection of agricultural produce is conducted by MAFF, monitoring of air radiation levels by MEXT, regulations on value determination of food products by MHLW, and training associated with food safety by Consumer Affairs Agency (CAA).

Similarly, 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 common framework for centralizing and sharing all related information and database, and making it immediately available to interested parties and public at large. What is more, there have been on-going discussions among experts about "safety limits" and that lack of agreement additionally confuses producers and consumers alike.

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[23] 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.

[24] Cropping itself has not been restricted and inspection carried at ex-post production- shipping stage.

[25] Nevertheless, Fukushima prefecture and municipalities are strengthening their inspections for self-consumed agricultural products in recent months.

[26] Some people dispute that the radiation was there even before the accident, when inspections were not carried due to natural or manmade (e.g. nuclear tests in neighboring countries) radiation.

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).

Nevertheless, there has been attempt to improve coordination and cooperation between different agencies. 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 items are found the FATC is informed and the later take decision for ceasing shipments. Similarly, Soil screening project in Fukushima is coordinated by FCCU with participation of number of regional agencies and volunteers from the entire 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 with control at production "planning" stage. The later is to be based on detailed contamination maps of each agricultural field [Koyama]. Depending on degree of radiation dose 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).

Some farmers started to be nervous about the efficiency of the applied methods. In some places they discuss to cease inspections which is associated with significant costs (time for preparation of samples, shipment, payments for tests) with no adequate compensation received or recovery of farming 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).

Effects on markets and consumer behavior

Due to genuine or perceived health risk many Japanese consumers stop buying agricultural, fishery and food products originated from the affected regions ("Norther 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; Koyama; Watanabe]. That has been a result of lack of sufficient capabilities in the inspection system, inappropriate restrictions (initially covering all shipments in a prefecture rather than from contaminated localities), revealed rare incidences of contamination in generally safe origins, low confidence in official "safety" limits and inspections, lack of good

communication, harmful rumors ("Fu-hyo"), and in certain cases not authentic character of traded products.

Consequently, the demand for many traditional farm produces from the affected 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 MAFF emergency inspection for radioactive contamination of rice[27] the circulation of all rice produced in Fukushima prefecture stopped in 2011-2012 [Koyama, 2013]. Furthermore, since autumn 2011 and 2012 radiation measurement tests for radiation level in all beef and package of rice have been carried out in Fukushima prefecture. Up to April 10, 2013 almost 10.3 million bags of rice were checked by JA Fukushima and 99.78% of them were under 25Bq while radiation above 100Bq was found in only 71 bags or 0.0007% of the total [Nagashima]. Despite these safety checks many consumers in the big cities and in the region alike continue to avoid Fukushima products [Takeuchi and Fujioka]. In end of March 2013 the rice sales from Fukushima is almost half of what it was before the disaster while rice prices considerably lower. Similarly, sales of vegetables as ingredients for school lunch have decreased; only 3 out of 16 JA farmers market recovered the sales (positive trends are mostly for markets in the South part of the prefecture), most have their 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 bellow the pre-disaster level etc. [Nagashima].

"Fukushima label" for agri-food produce which once representing a high quality and safety after the accident brought rejections and significantly less than usual market value. The same has been experienced by some food processors in affected regions. For instance, manufacturers of natto[28] 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, 2011m]. 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 "two years have passed after the disaster and for school lunch there are still harmful rumors. Factories in Fukushima are unable to join the tender in some areas. Inspection and showing the results are needed to breakthrough this situation. His company is doing well since it supplies all ingredients outside of the prefecture and have a proper safety control system put in place (June 5, 2013).

Some popular food chains such have introduced "no Fukushima beef" policy in their restaurants around the country (including in Fukushima prefecture).

Research has proved that consumers' attitude toward the agricultural products from affected by the nuclear disaster regions changed dramatically [Burch; Ujiie, 2012]. A half of the surveyed consumers in Tokyo and Osaka said they 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]. Recent survey of the same researcher shows that in the first month of 2013 indicate that while consumers still maintain

[27] 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).
[28] fermented soybeans normally packed in rice-straw.

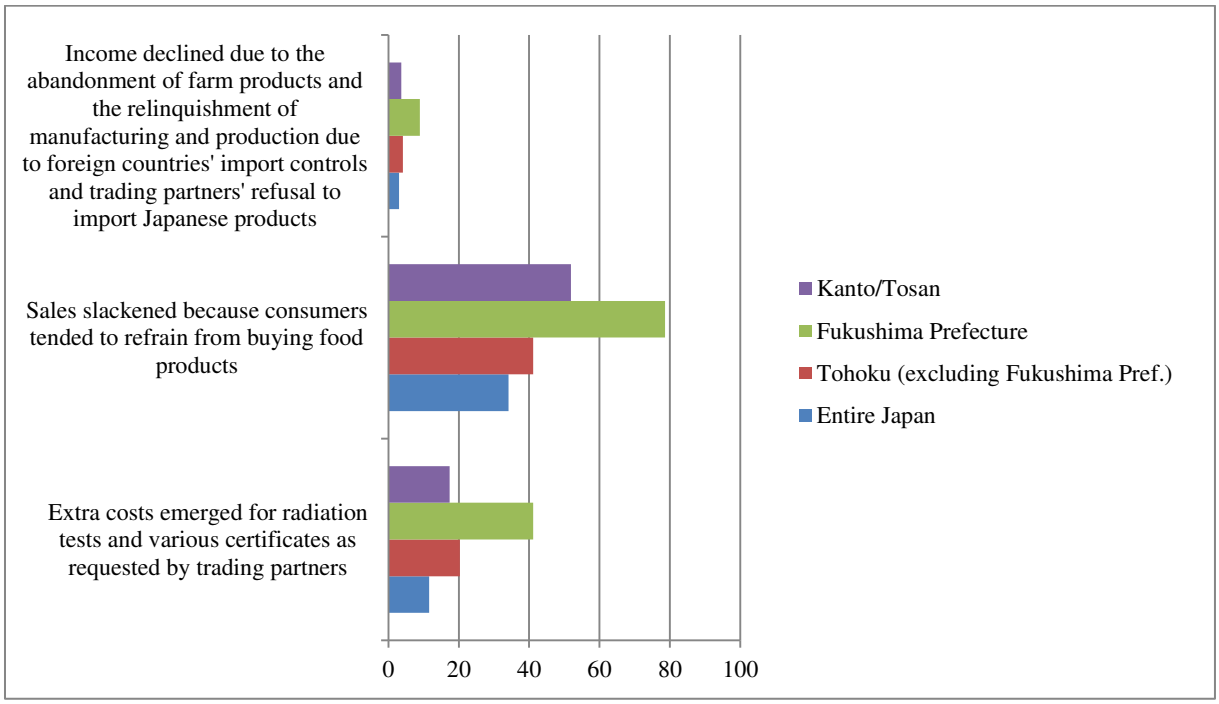
the high risk conscious the "origin of product" factor is playing less important role is their choice (unpublished survey data provided by the author).

Interviewed by us Mr. Nagashima, working at Agricultural Cooperative in Fukushima pointed out that "Recovery will be done in certain period of time but even if the result of inspection is "ND", there will be some percent of customers who will not accept to eat Fukushima products" (June 6, 2013).

What is more, even residents of Fukushima avoid buying local products. Recent 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) in general (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. Is time only the way to solve this problem?" (June 14, 2013).

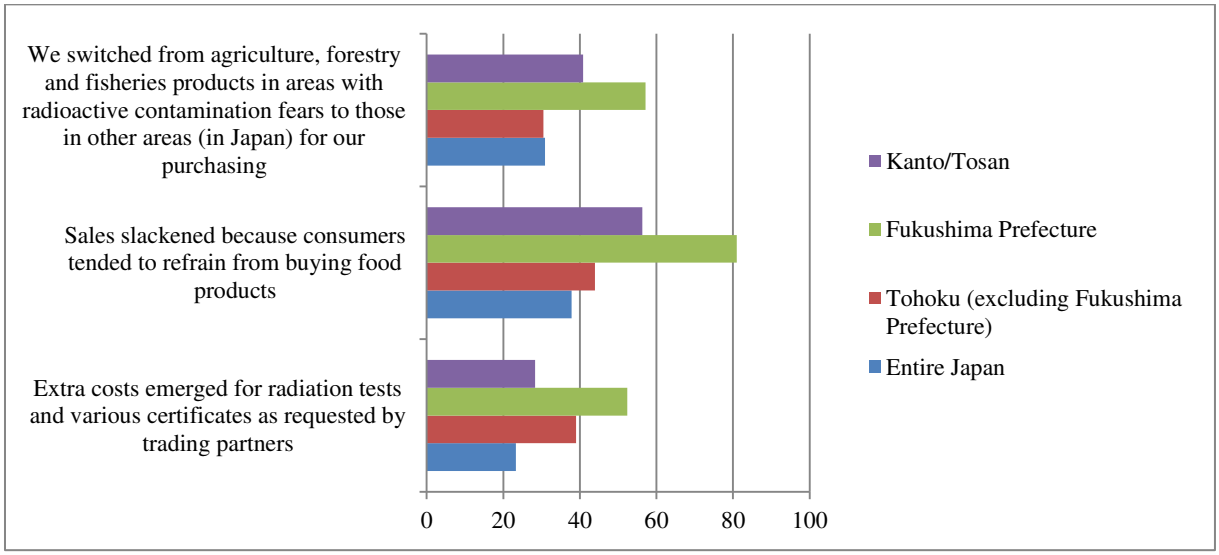
Countrywide survey of MAFF found out that more than a third of surveyed Japanese farmers (Figure 2) and almost of 38% of food industry personnel (Figure 3) indicate that "Sales slackened because consumers tended to refrain from buying food products". The later figures are much higher for the most affected by the disaster regions. Moreover, 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 those in other areas (in Japan) for our purchasing" and that amounts for more than 57% in Fukushima prefecture (Figure 3).

Figure 2: Effects of TEPCO nuclear plant accident on farmers (%, multiple answers)



Source: MAFF, Survey conducted in January-February 2012

Figure 3: Effects of TEPCO nuclear plant accident on food industry (%, multiple answers)



Source: MAFF, Survey conducted in January-February 2012

In order to facilitate communication with consumers in the big city, Fukushima organic agriculture network opened a shop cum restaurant in Tokyo in March 2013. Fukushima farmers sell agricultural products that passed radiation screening and serve Fukushima cuisine cooked with their vegetables. They believe that sincere dialogue between farmers and consumers on radiation is the most important factor for the restoration of agriculture in Fukushima [Takeuchi and Fujioka].

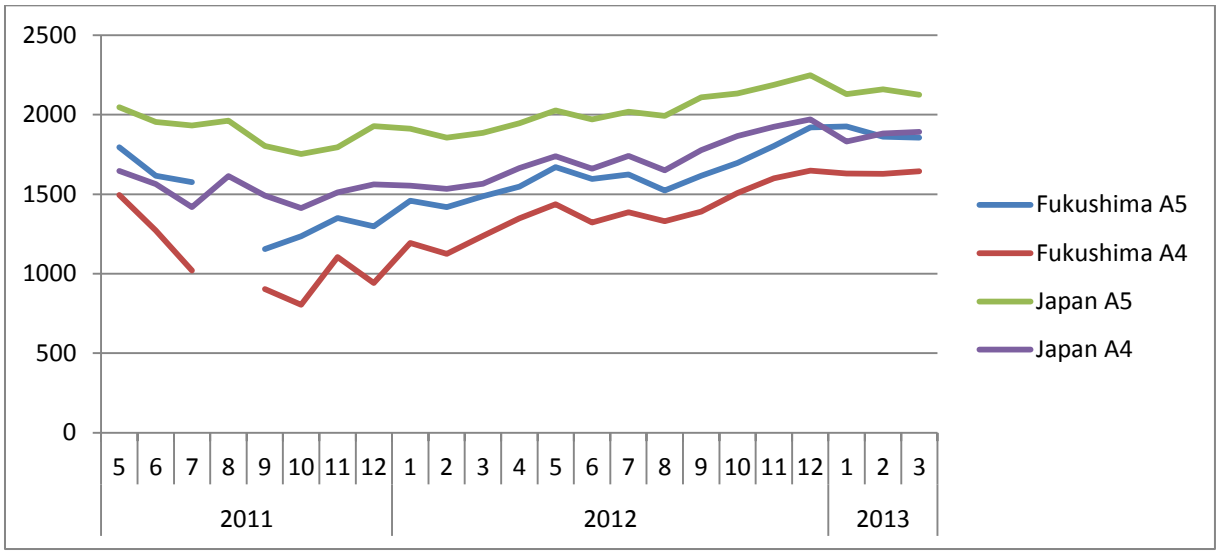
After the accident, the prices of major farm produces from the most affected regions significantly declined while prices from other regions went up. For instance, in 2011 the price of peaches from Fukushima dropped 100 to 200 Yen, and asparagus around 300 Yen compared to the same products from other regions [Murayama]. 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 free of radioactive substances [MAFF].

The effect of the nuclear disaster on price level can be demonstrated by the dynamics of beef cattle prices. There was a considerable decline in the wholesale prices of beef cattle in Fukushima prefecture and in Japan after the accident (Figure 4). The prices in the country have been recovered and there has been gradual recovery of beef prices in Fukushima prefecture as well. Nevertheless, prices for different category of beef are still 12-13% lower in Fukushima comparing to Japan. The similar trends have been observed for other major products in Fukushima such as peaches and cucumbers [Nakashima].

According to experts the prices of fruits in Fukushima prefecture (mostly bought for gifts) largely recovered since the consumers choice of these products is not determined by the price level but the "origin of product" factor.

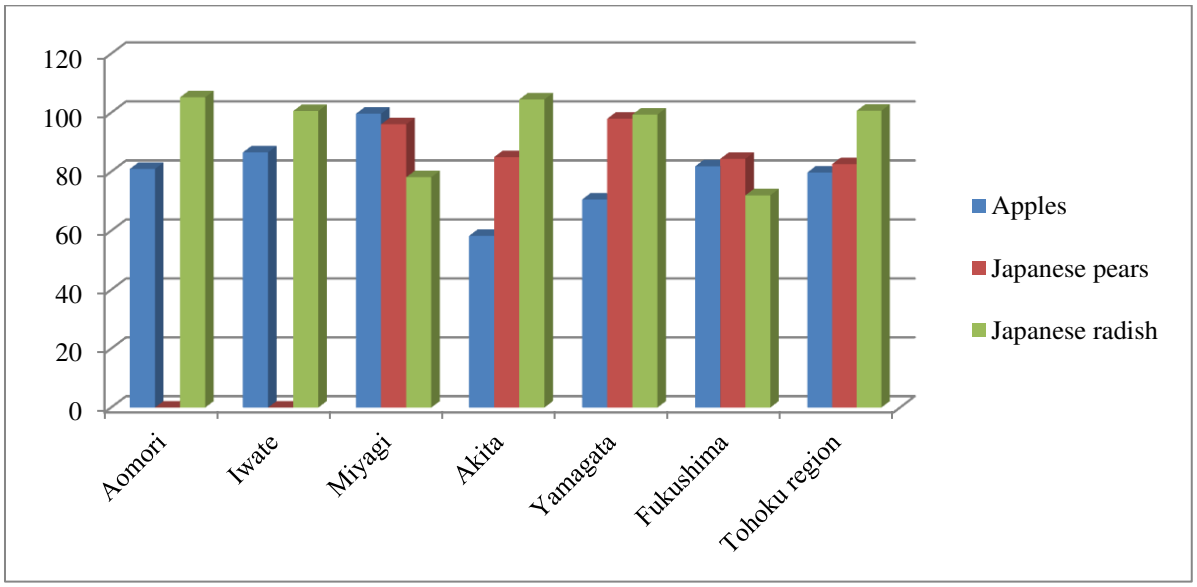
Furthermore, there has been a considerable decrease in shipments of major farms products from many of the affected regions as well. For instance, in 2011 there was a big decline in shipments of important produces such as apples, Japanese pears and Japanese radish from Fukushima and other prefectures of Tohoku region (Figure 5).

Figure 4: Evolution of wholesale prices for beef cattle (yen per kg)



Source : Central JA Union for Fukushima Prefecture

Figure 5: Dynamics of shipments of farm products from Tohoku region in 2011 comparing to 2010 (%)



Source: Statistical yearbook of MAFF

On the other hand, 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 increased. However, there are no studies on these effects of the nuclear disaster yet[29].

Recent data shows that demands for Fukushima (Ibaraki and Northern Honshu) agricultural products (e.g. rice, beef, vegetables) have been recovering fast while the farm-

[29] Uijie studies is proving 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

gate and wholesale prices in the most affected regions (Fukushima, Ibaraki) are still lower than in other part of the country. That is consequences of a number of factors: 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) have been profiting enormously getting a higher margin.

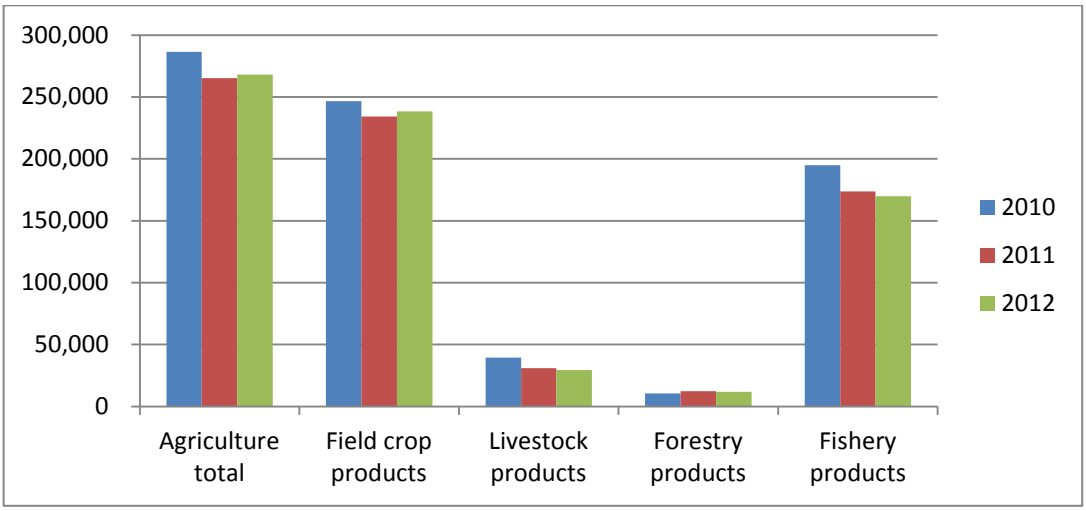
National data on 2011 daily intake per person for food groups are still not available. Thus we could only guess weather thare has been changes in the consumption pattern as consequence of the consumers risk concern, higher procurement costs or other reasons comparing to the period before the accident.

On the top of all these, around 40 countries imposed restrictions on agri-food imports from Japan after the nuclear accident, including major importer such China, United States, Indonesia, Malaysia and South Korea. The European Union required food and animal feed from 12 prefectures to be checked prior the export to prove that radioactive iodine and cesium levels do not exceed EU standards. In addition, agri-food items from 35 other prefectures had to be shipped along with a certificate of origin to verify where the products were produced.

Few months after nuclear crisis some countries (like Canada, Thailand) lifted or eased restrictions on Japanese food imports. Rice exports to China with government-issued certificates of origin and produced outside the prefectures Chiba, Fukushima, Gunma, Ibaraki, Niigata, Nagano, Miyagi, Saitama, Tokyo, Tochigi and Saitama became possible in April 2012. In October 2012, EU also substantially eased import restrictions from 11 prefectures but kept restrictions for products from Fukushima prefecture.

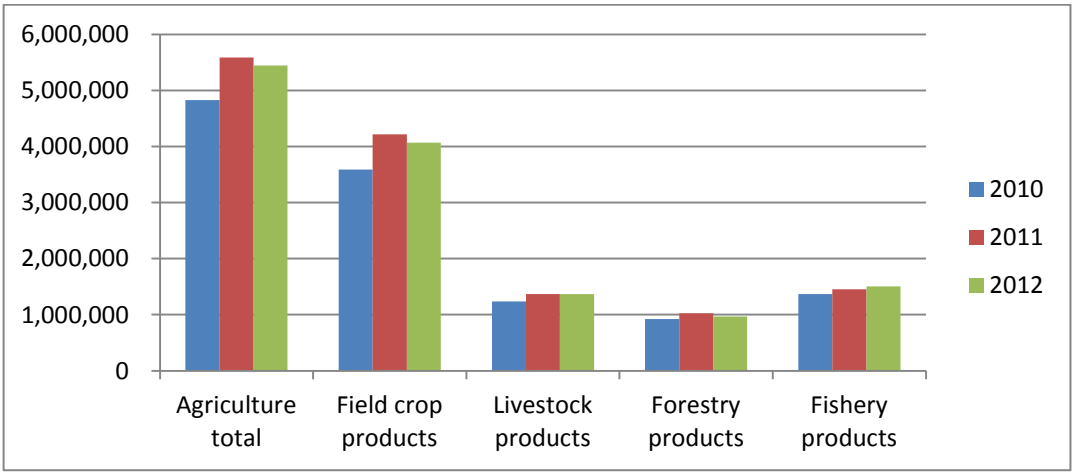
Due to foreign countries' import restrictions the value of Japan's farm and livestock product exports declined substantially - in April-December 2011 export plunged by 40.9 billion yen (11%) from the year before [MAFF]. There has been also a decline in post 2010 agricultural and fishery export of Japan (Figure 6), while import of agricultural, forestry and fishery products increased (Figure 7).

Figure 6: Dynamics of agricultural, forestry and fishery export of Japan (million yen)



Source: Statistical yearbook of MAFF

Figure 7: Dynamics of agricultural, forestry and fishery import of Japan (million yen)



Source: Statistical yearbook of MAFF

Economic effects on farming, agri-business and consumers

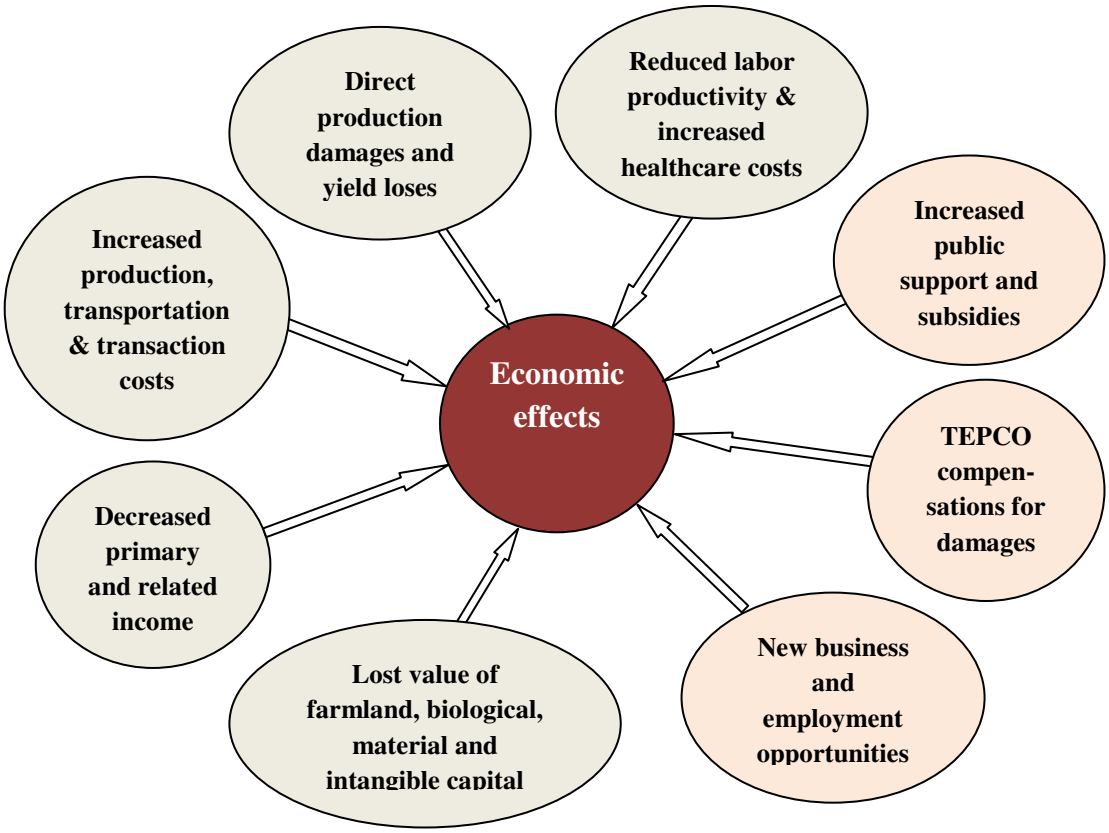
It is quite difficult to access the enormous economic impacts from the Fukushima nuclear disaster on Japanese farms, agri-businesses and final consumers. The scale and directions of the negative effects have been huge. For example, recent estimates on public costs for decontamination of lands "up to reasonable level of radiation" in Fukushima prefecture are 50 billions USD, or 4 times higher than the initial expectations of 11 billions [NHK World, 2013a]. Public spendinsg for cleaning up the evacuation zone alone have been 20 billions USD. In addition, there have been enourmos costs of individuals, households, private organizations, collectives and communities which are very difficult to assess.

What is more, some of the economic impacts could hardly be measured in quantitative (e.g. monetary) terms as: the 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.) etc.

Principally the immediate and shorter-term negative effects on farms and agri-business have been in a number of directions (Figure 8):

Figure 8: Economic effects from Fukushima nuclear disaster on farms and agri-business



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. Furthermore, 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 estimated losing nearly $31,000 every month from the sales ban not including the cost of feeding his herd.

2. Decreased income due to production and/or shipment restrictions and low market demands for local 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. Similarly, there was a ban or delays of shipment of beef and other major produces. What is more, as a result of voluntary restrictions, declined consumer demands, reduction in the number of local population (evacuation and/or outmigration) and tourists, and "harmful humors" many farmers and business lost significant markets and income after the accident.

For instance, before the disaster Fukushima prefecture was known as "Tokyo's vegetable basket" and it was Japan's second largest producer of peaches, third largest producer of Japanese pears, fourth largest producers of rice, fifth largest producer of apples,

twelfth largest producer of grapes etc. Orders of all these major produces plunged after the nuclear power plant crisis due to fears about radiation even though radiation levels were well below the government limits. The same was 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 etc. The great majority of surveyed by the Fukushima Food Industry Organization (FFIO) companies report lower income due to the decline in sales after the accident (February, 2013). Likely wise, popular agri and rural tourism and other related businesses and services in affected areas have been badly damaged after the disaster.

Some studies estimate the tsumani 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 and by 2,939.10 tons in Fukushima, equivalent to a total annual loss of $US 1411 Mio [Liou et al.]. It is estimated that such loss will be undoubtfully enlarged by several orders of magnitude when the contamination of nuclear radiation on the surrounding environment is considered.

Some of the direct damages on farms production and marketing have been specified with compensation claims of farmers to TEPCO. For instance, recent data indicates that total claims of farmers from Fukushima prefecture account for 102,800 million yens. In addition, food industries companies have lost hundreds of millions from canceled orders, reduced demands and prices, and increased costs.

Furthermore, agriculture and agri-business have been major employers for family and non-family labor in many of 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.

3. Increased production, transportation and transaction costs in the agri-food chain. Many farmers and business have seen their costs associated with post-disaster recovery, destructed inputs supply, shifting to new suppliers from other regions or countries, decontamination of crops, farmlands, material and biological assets etc. increased. A number of appropriate technologies have been tested and recommended for farmers such as: removal of the thin layer of topsoil, inversion tillage, high pressure washing fruit trees without rough bark, removal of rough bark for fruit trees with rough bark, tea trimming etc [MAFF]. Distributing potassium to inhibit plants from absorbing radioactive matters and zeolite as adsorbent to radioactive matters have also been used, and the first method has proved to be quite effective [Nagashima]. Some experts[30] argue that organic farming is the way to revitalize Fukushima agriculture, but it is similarly associated with increased costs[31].

All these measures and methods have been accompanied with additional production and learning costs to farmers and their organizations. Furthermore, there have been additional

[30] On June 6, 2013 we attended a crowded public lecture at Fukushima University of such expert Prof.Hasagawa who himself set up organic farm and advocating it as a way for reconstruction of Fukushima agriculture. A documentary about organic farmers facing Japan's nuclear crisis can be seen at http://uncannyterrain.com/blog/

[31] Most organic products in Japan have been (self)certified by the farmers organization while independent organic certification is still insignificant part (0.02%) of the overall production.

costs to protect labor and clean equipments used in contaminated environment, to adapt new structure of products and technologies with reduced radiation absorption, partial and complete dislocate business etc.

Many livestock farmers had to buy forage from other locations to feed animals because their own grass was contaminated, and that occurred significant extra costs. In May, 2011 about 20,000 livestock farmers in seven prefectures were asked by MAFF to refrain from grazing cattle for the time being because radioactive substances in excess were found in pastures. That affected 700,000 head of cattle and cost an additional 50 billion yen a year in forage [Yomiuri Shimbun].

Similarly, disrupted supply for agricultural and food produces within and from the affected regions have to be met with additional costs for food-chain businesses, public authorities, and consumers alike. For instance, most surveyed by the FFIO companies report lower income due to higher costs of alternative supply of ingredients from other prefectures[32] (February, 2013). Nevertheless, the overall amount of the costs for the initial emergency supply and continuing alternative food supply is hardly to be estimated.

Moreover, there have been considerable transaction costs for adaptation to new more strict official safety standards, and 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) 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.

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. Similarly, there have been significant individual and collective costs associated with the negotiation, application, disputing etc. of claims for damages from TEPCO etc. Most of the surveyed by the FFIO companies also 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 organisations, consumers and clients information, "hard working", products safety promotions through meetings, website, labeling[33], etc. (February, 2013).

Last but not least important, there have been huge increase in "public relation" costs of prefectural and local governments aimed at improving the damaged image of Fukushima products.[34] However, the precise scale and impact of all these private, collective and social transaction difficulties and costs are impossible to quantify.

4. 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. The total amount of these long-term damages is quite hardly to clarify. For instance, highly

[32] One company even moved its factory to another prefecture.

[33] On the other hand, some of the surveyed companies indicate they stopped using "Fukushima made" label in order to facilitate transactions.

[34] For instance, the "public relation" item accounts a sizable portion of the overall budget of Fukushima prefectural government.

popular Fukushima brand products such as Iidate beef and Anpo gaki (persimmon) has been destructed.

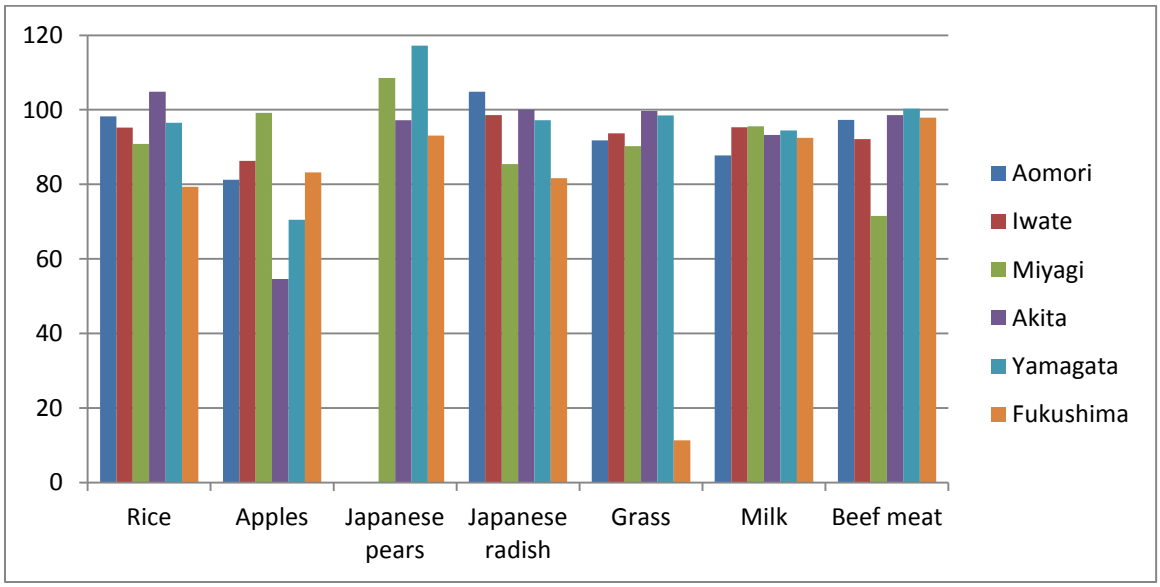
5. There has been unspecified effect on the reduction of labor productivity, increased healthcare and recreation costs etc. due to the nuclear accident. The extent of these kind of economic damages has not been studied yet.

Diverse economic effects have been quite unlike for the different agents and various regions. The greatest negative impacts on costs and sales have been experienced by farms and businesses in Fukushima and neighboring regions. For instance, 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 these figures are much higher than in other regions of the country (Figure 2 and Figure 3).

Similarly, 3% of surveyed 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 2). The later share for farmers in Fukushima prefecture is almost three times higher.

The combined impact on agricultural production has been generally negative for all major products in Fukushima prefecture and Tohoku region (Figure 9). Neighboring Ibaraki prefecture has been similarly affected where for instance tea leaves production in 2011 declined 89% comparing to 2010 level [MAFF].

Figure 9: Dynamics of major productions in Tohoku region in 2011 comparing to 2010 (%)



Source: Statistical yearbook of MAFF

On the other hand, some farmers and agri-businesses from non-contaminated regions have got positive effects on their businesses due to increased prices, and better production and sales opportunities on the wake of Fukushima disaster.

There are official estimates on some of the economic damages from the Fukushima nuclear disaster. 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 8). These figures cover damage of products that cannot be sold, because of the restrictions on planning and distribution, and loss of the value caused by rumors. However, this 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). According to experts the later losses are quite difficult to measure and "compensate" [Koyama, 2013].

Table 8: State of agricultural product damages in areas affected by the nuclear disaster

	Vegetables	Livestock	Fruit	Rice	Regional Total	Fukushima prefecture
Evacuated/restricted area share (%)	42.4	68.0	48.9	35.9	-	-
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 : The Tohoku Department of Agricultural Administration, MAFF Statistics

Note 1) Evacuated/restricted areas are calculated from portions of the north and central areas of the prefecture that have records of distribution restrictions and evacuation/entering restrictions.

Note 2) Evacuated/restricted areas share is a ratio of the appropriate region's production comprising the total for Fukushima Prefecture for each agricultural produce type.

"JA Group Tokyo Electric Co., Ltd. Nuclear Accident Agriculture and Livestock Damage Compensation Countermeasures Convention of Fukushima Prefecture" has been established in May 2012 to deal with the compensation problems. It comprises all JA within 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 meeting are held monthly to decide on the amount of demands for compensation and bring it to TEPCO.

In 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) and horticulture (Table 9). The amount of money received as compensation for the same period accounts for 73% of the claimed damages. The latest figures show that demanded compensation in Fukushima is 109,200,000,000 yen and the received compensation are 97,200,000,000 yen or 89% of the demand. Most of the claims are for horticulture and livestock damages. According to the experts compensation payments to farmers in neighboring prefectures is at lower rate - e.g. in Miyagi prefecture it is 50%.

Table 9: Breakdown of Fukushima Prefecture Union Compensation Claims (100 million yen)

Claims	On May 1, 2012		On May 1, 2013	
	Value	Share in total (%)	Value	Share in total (%)
Rice	11	1.8	32	2.9
Horticulture	130	20.8	264	24.2
Fruit	62	9.9	75	6.8
Milk	18	2.9	20	1.8
Livestock disposal	99	15.8	100	9.2
Other livestock damages	85	13.6	162	14.8
Pasture	27	4.3	50	4.6
Untitles 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 continues to receive claims for damages of farmers and agri-food business from around the country. However, the total amount of claims received by and paid to different affected agents is not easy to find.

There are still many problems related to the compensation of damages from TEPCO. For farmers and agriculture cooperatives in Fukushima prefecture the major issues can be summarized as: three month delays in payment; not paying the full amount that was 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 is not decided yet (how long the compensation will last); insufficient amount of compensation to restart farming; additional (inspection, administrative, radiation map preparation etc.) costs and damages of organizations such as JA are not compensated yet; support for damages not clearly specified in the Dispute Reconciliation Committee for Nuclear Damage Compensation guidelines [Koyama, 2013; Nagashima]. Difficulties experiencing by some older age farmers associated with the paper works in compensation procedures is also pointed out as a problem [Ishii]. According to experts the efforts of farmers who did not market their products through cooperatives are particularly big (interview with Prof.Komatsu, June 17, 2013). We have also found that some of the "safety tests" costs currently incurring by farmers (e.g. for voluntary and self inspections) and consumer associations (e.g. Consumer cooperatives) and due to be compensated in unclear future, are also a problem.

The important issue how certain claims will be compensated is still disputed by parties and unspecified. For instance, JA Union, Fukushima prefecture, and 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 projects support emergency management of national companies raising cattle for consumption, support measures for emergency rice straw provisions, and measures to allow undisturbed distribution of cattle and programs sponsoring free rice straw in Fukushima prefecture.

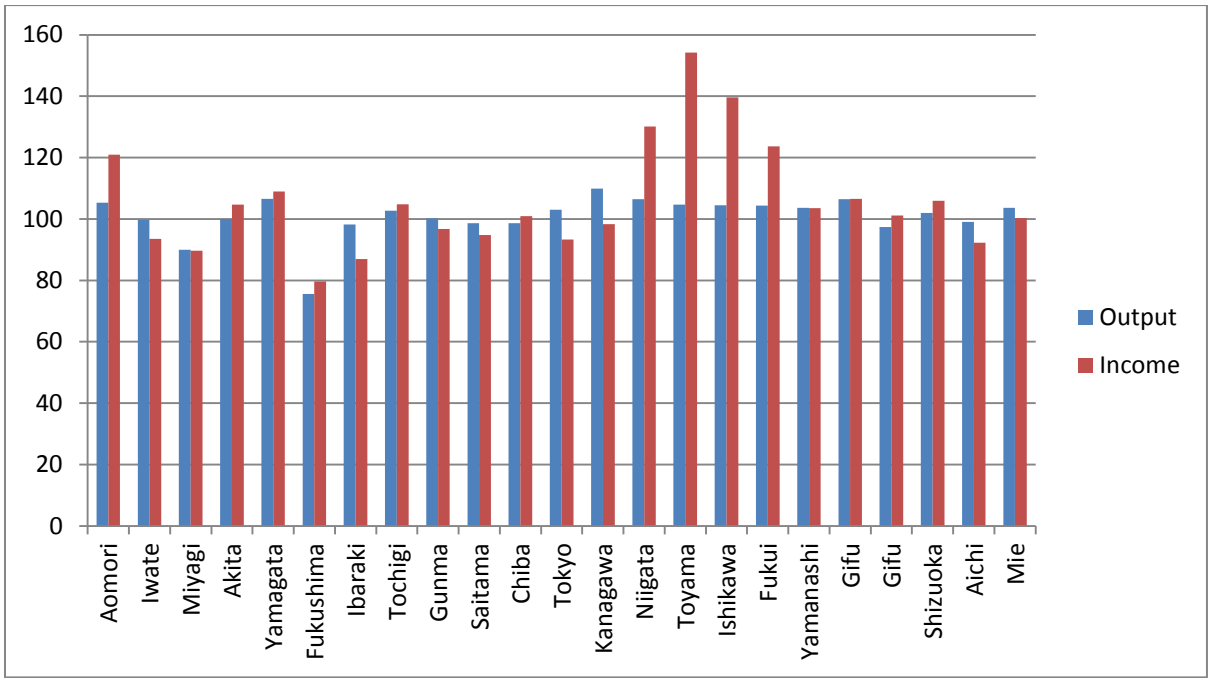
In areas where restrictions are placed on planting, a standard compensation "per 10 are" is guaranteed. However, there are problems with uniform compensation, including differences in the amount of products per 10 are, discrepancies in farming method (e.g. organic, conventional farming), unlike value added of produce etc.

Furthermore, compensation claims negotiations are conducted individually and it is quite difficult for an individual farmer to negotiate effectively with TEPCO. For example, compensation for areas with new planting restrictions in 2012 was 59,000 yen per 10 are while there were cases of people purchasing rice for own 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 are receiving compensation on lost income according to the Government guidance. Nevertheless, according to the expert procedures are quite costly and associated with great paper works, hiring layers, lengthily negotiation etc.

The nuclear crisis has got unlike aggregate impact on agricultural output and income in different regions around the Fukushima nuclear plant (Figure 10). For example, in a period when overall Japanese agricultural production was progressing in Fukushima and Miyagi prefectures there was a considerable decline in the total output. The later was combined with a sizable reduction in the total income in both prefectures as well as in the neighboring Ibaraki prefecture. At the same time, farmers in some other prefectures in the region (such as Aomori, Nigata, Toyoma, Ishikawa and Fukui) have seen their income significantly increased far above the augmentation of the total output.

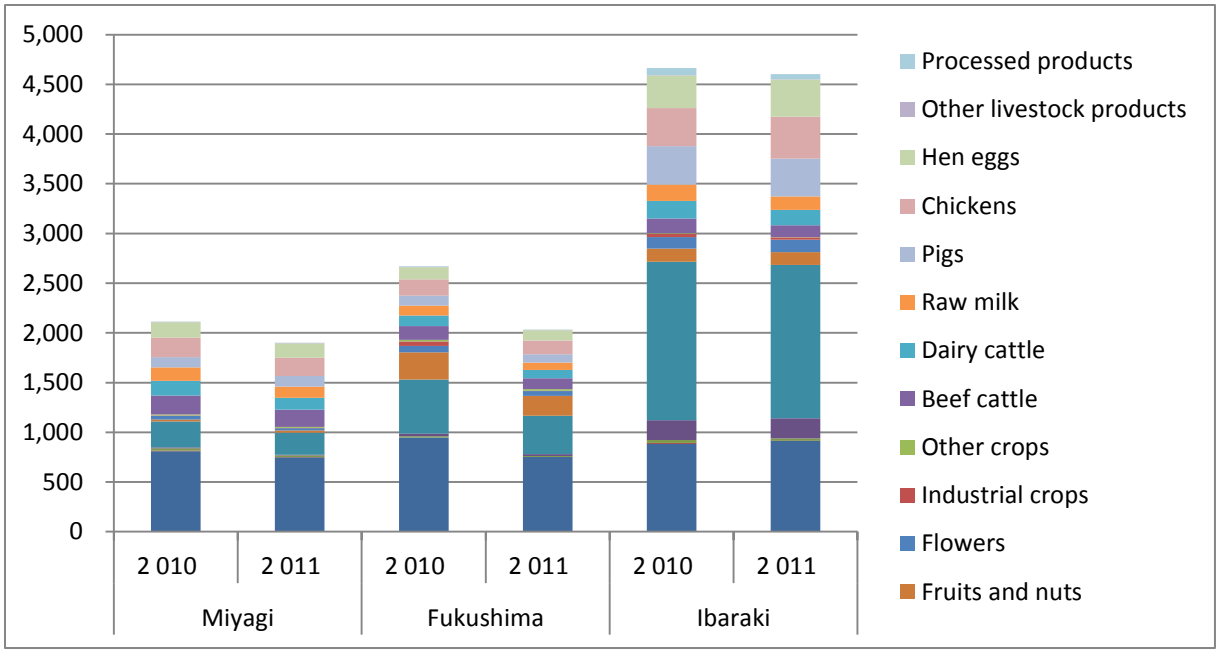
Figure 10: Dynamics of agricultural output and income in 2011 comparing to 2010 (percent)



Source: Statistical yearbook of MAFF

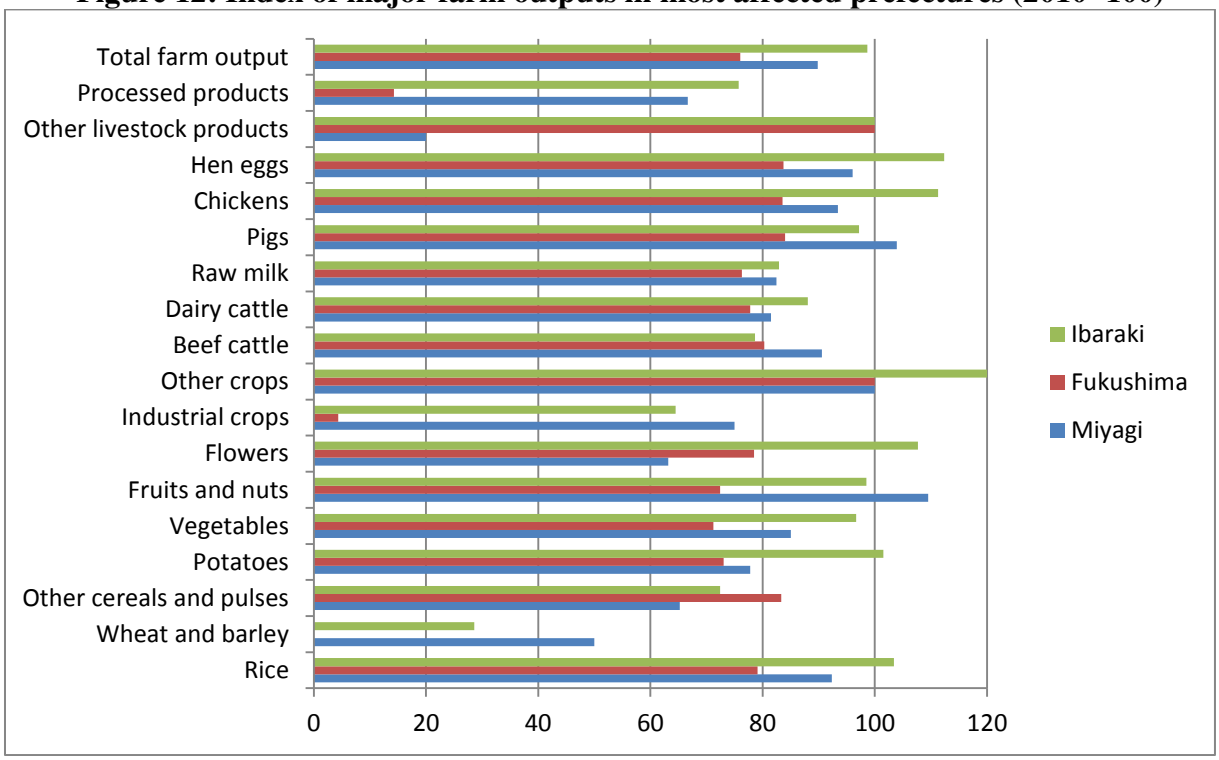
The biggest decline in the farm outputs was in Fukushima prefecture, followed by Miyagi and Ibaraki prefectures (Figure 11). Due to the a decrease in production and/or farm gate prices there was 24% decline of the output of Fukushima farms. For certain major products like rice, vegetables, fruits, industrial crops, raw milk and cattle meat the drop off were considerable (Figure 12).

Figure 11: Dynamics of farm output in most affected prefectures (100 million yens)



Source: Statistical yearbook of MAFF

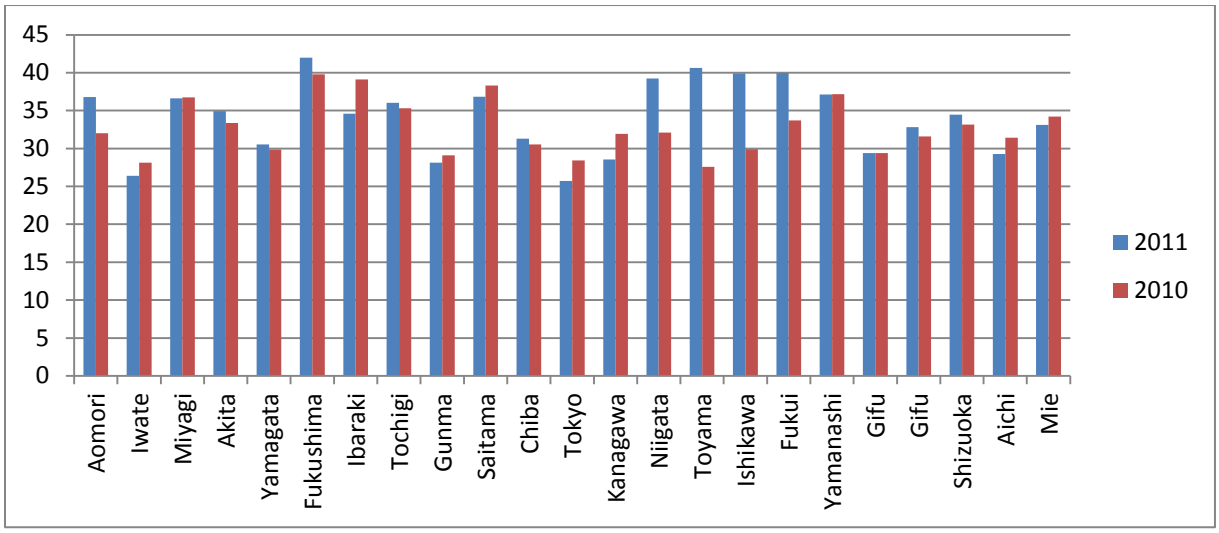
Figure 12: Index of major farm outputs in most affected prefectures (2010=100)



Source: Statistical yearbook of MAFF

Nevertheless, due to undertaken private, collective and public measures there was not significant negative impact on the profitability of farms in most part of the region (Figure 13). While in Ibaraki and some other affected prefectures the share of agricultural income in the output declined, in most prefectures that share either did not change (e.g. Miyagi) or even improved (like in Fukushima).

Figure 13: Share of agricultural income in agricultural output (percent)



Source: Statistical yearbook of MAFF

The food industry in Fukushima and neighboring regions has been also severely affected by the nuclear accident. For instance, recent survey of 55 food industry companies in Fukushima prefecture show that three quarters of them have seen sales declined after the nuclear accident (Table 10). Moreover, in 40% of companies the 2012 sale decreased comparing to 2011. Consequence of 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 companies with no income changes say that is a result of received compensations.

Last but not least important, there has been a great negative economic impact(s) on final consumers in the affected regions and Japan as a whole in terms of increased direct (higher prices and procurement costs) and transactions costs (for information, searching, assurances etc.) for supply of safe agri-food products from alternative regions and/countries or guaranteed sources.

The negative consequences 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 also starting to forget the disaster. Under these conditions, farmer's willingness to work is decreasing, decline in new farmers is accelerating and abandoned farmlands are increasing. De-industrialization of agriculture in Fukushima is a major concern" (June 6, 2013).

Table 10: Impact of Fukushima nuclear disaster on food industry companies in Fukushima prefecture

	Companies with changes in sales						Companies with changes in income		
	No	Decrease				Increase	Increase	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
Sub-sectors	grocery, milk, fermented milk drink , wrapping	pickles, canned food, breed, confectionary, noodles, ramen, liqueurs, sake, flours, soya source, chicken and pork meat	ramen, pickles, and delicatessen, milk and milk drink, chicken meat, flours, delicatessen, fruits and vegetables, wrapping	pickles, honey, peach, cucumber, dried persimmon, sake, noodles, beer, milk and yogurt, miso	kimchi, chicken meat, soya sauce	cut vegetables, miso, pickles, fish processing, sake, ice cream and frozen desserts, konnyaky and tokoroten, 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, February 2013 survey

There have been also a number of positive effects on farms and business associated with the Fukushima nuclear disaster.

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 regarding the nuclear disaster totaled about 106.2 billion yen [MAFF].

The Government support to prefectures and farmers to recovery from 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 raised cattle. In places where shipping restrictions are imposed funds have been provided for the purchase and disposal of the beef facing delayed shipment or already in distribution chains.

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 introduced in affected areas. There has been a huge public support for all decontamination efforts – e.g. national budget for decontamination for the period of 2012-2013 comprises 1.1482 trillion yen [Koyama, 2013].

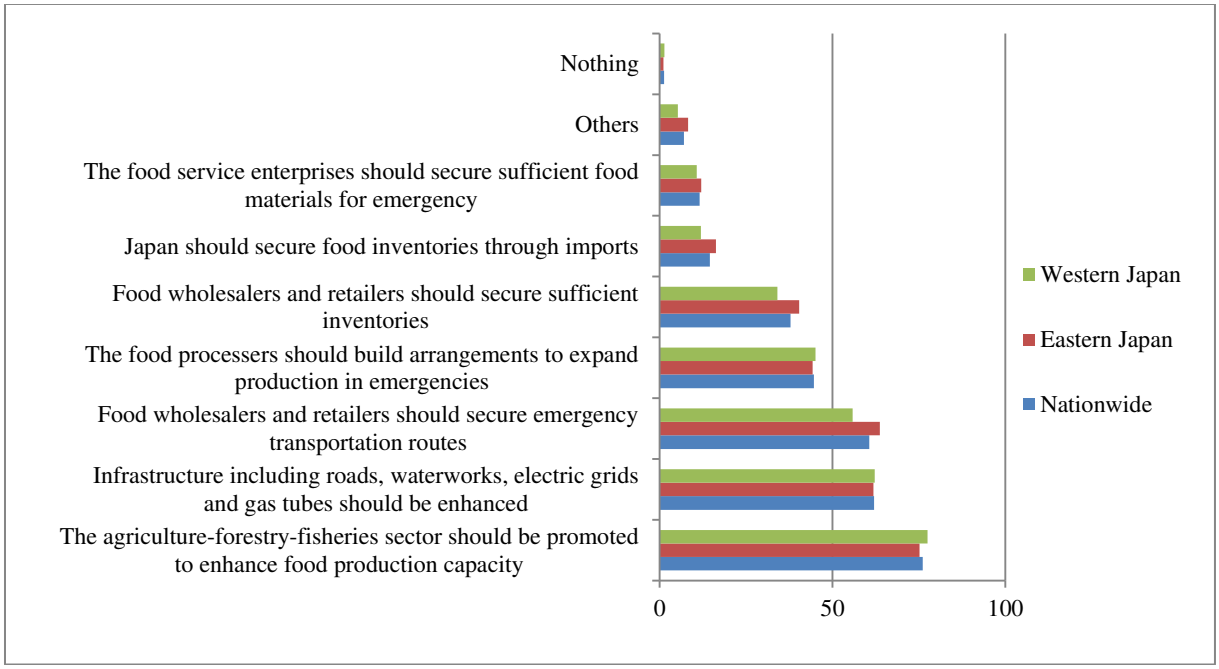
Further enlargement of the loans with a credit line of 100 billion yen and interest-free loan under the "Act on Temporary Measures on Financial Support of Farmers has been also introduced. Farms having 30% and more harvest reduction and over 10% of property damages can apply up to 2 million yen for persons and 20 million yen for companies with 3-6 years redemption period. What is more, for special cases 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" [MAFF].

Furthermore, there has been also significant support from diverse agricultural (agricultural cooperatives), business, academic, non-governmental etc. organizations. All they intensify their activities in the affected regions and multiply relations with individual farmers

and agri-business companies. That has been associated with increased "outside" service supply and likely positive effects on activity, innovations, incomes etc.

The public food safety policies have been also positively affected. For instance, the Great East Japan Earthquake and 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]. A great part of the surveyed consumers have also strongly recognized the importance of different food supply arrangements (Figure 14).

Figure 14: Measures considered to be required for stable food supply in Japan



Source: MAFF, Survey conducted in January-February 2012

There have been a number of challenges in public support response as well. Most important among them are: delay in establishing Reconstruction Agency (February 2012) for coordinating multiple recovery efforts in affected areas; lack of clear government guidelines for the nuclear disaster recovery, lack of detailed contamination map for all affected agricultural lands, using extension officers for obtaining samples for monitoring tests while suppressing their ability of management consulting, introducing technology, and forming areas of production badly needed by farmers in affected areas [Koyama, 2013].

Furthermore, in some places there were problems associated with the effective disposal of contaminated soils, ashes of burned household garbage, livestock etc. due to the lack of enough facilities and/or strong objections by residents [The Mainichi Daily News, 2012e].

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. 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 there are opening up more entrepreneurial, employment and income opportunities for agricultural and general population.

In 2013 some producers have resumed experimentally rice growing in order to revitalize farming in areas where restriction are (or ready to be) lifted. For instance in Minami-soma 162 farmers are taking part in the experimental test including 130 ha of the total 6,900 ha paddy fields in that community [Ishii].

Furthermore, some young entrepreneurs have seen new business opportunities in the most contaminated areas. For example, Mr. 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]. 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.

Similarly, Dutch bio-farming company Waterland International and a Japanese federation of farmers made an agreement in March 2012 to plant and grow camelia on 2000 to 3000 ha [The Mainichi Shimbun, 2012b]. 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 would be done to find out whether camelia was capable of extracting cesium from the soil since experiment with sunflowers had no success.

Furthermore, 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 explore economies of scale and scope, increase productivity and efficiency and improve competitiveness of farming enterprises[35].

Optimism of business prospects 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).

Health effect

The levels of radiation exposure of population varied according to the direction from the Fukushima plant. On March 16, 2011 MEXT measured radiation levels of up to 330 μSv/h 20 km North-west of the power plant [NHK, 2011b]. At some locations around 30 km from the plant, the dose rates rose significantly in 24 hours on March 16–17: in one location from 80 to 170 μSv/h and in another from 26 to 95 μSv/h.

The level of radiation has been decreasing since March 2011. Environmental radioactivity has been closely monitored in all big cities. There have been installed radiation measurement equipments in many public places around Fukushima prefecture showing

[35] One of the suggested new policy of the present Japanese government is also associated with lifting restricting for corporate farming.

radiation level. Nevertheless, people living and working in different location are exposed to diverse levels of radiation[36]. What is more even in the same locations the radiation level often differs due to the different precision of instruments or local hot spots. Despite that in some places radiation level is less than the level in some onsen regularly visited by many Japanese, or certain medical check-ups, many people show a great concern on current figures.

Thanks to timely undertaken measures radiation levels remained well below the norms required to damage human health[37]. According to the 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 [NISA]. Other reports also states that no confirmed long-term health effects to any person had been reported as a result of radiation exposure from the nuclear accident [IAEA, 2011c].

Recent report of 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. 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 [NII].

Nevertheless, it is known that when a large amount of radioactive cesium enters ecosystem and 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, and children are many times more susceptible than adults to the effects of the ionizing radiation their internal organs are exposed to. According to local residents the cases of diverse complains and hospitalization in Fukushima has been increasing since the nuclear disaster.

On the top of that, it was recently announced that estimates for the radioactive exposure were wrong for 16,118 out of the around 420,000 people covered by survey in Fukushima prefecture in the firsts months after the nuclear disaster [The Japan Times, 2013]. Morover, as much as 12,460 of them received higher doses than previously estimated some getting more than the official annual safety limit.

Therefore, the entire health impact of the nuclear disaster is hardly to be assessed. What is more, it is believed that the health effects of the radiation release have been "primarily psychological rather than physical effects". Even in the most severely affected areas, radiation doses never reached more than a quarter of the radiation dose linked to increased cancer risk. Nevertheless, people who have been evacuated have suffered from depression and other mental health effects [Brumfiel]. Furthermore, general consumers "lose peace of mind" having food with (lower than official safety limit but nevertheless) radiation contamination. What is more, due to the deficiency of the inspection system there is no guarantee that contaminated food does not enter supply chain [Koyama].

[36] Updates on current and accumulated dose of radiation can be found at: http://radioactivity.nsr.go.jp/en/

[37] 100 mSv represents the level at which there is a definitive increased risk of cancer.

Many farmers from the area and beyond whose saw their businesses and livelihood destructed also suffered stress and anxiety [Murayama; Watanabe]. **"**For the first time in my life I'm afraid of my own crops. Now we buy everything from the markets, grown far away from the reactor's reach" said 60 year Mr. Fukuda, a third-generation rice and vegetable farmer whose 50-acre spread sits a few miles from the ailing power plant. A 64-year-old farmer in Sukagawa was pushed over the edge since he lost "everything he had ever worked for during his life"[38]. One day after the government imposed a ban on the sale of cabbages he took his life [The New York Times, 2011b].

Finally, the "health effect" on farm livestock and other domestic and wild animals is hardly to be assessed. Many of the farm livestock in the contaminated area has been slathered. The exception was the case of M.Yoshizawa, who kept his 300 cows alive inside the nuclear evacuation zone in defiance of a government kill order[39]. Despite losing many cows to an outbreak of disease, he has seen his herd grow to 350 with new births and the adoption of strays from neighboring farms [Uncanny Terrain]. Full impacts on health and genetics of living livestock and animals in other affected areas are to be examined in future.

4. Expert assessments on short and long-terms impacts of Fukushima nuclear disaster

Levels and factors of shorter terms impacts

According to all experts the Fukushima nuclear accident has had a significant negative overall short-term impact on agriculture in Fukushima region (Figure 15). Furthermore, most experts agree that the overall impact from the disaster 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 evacuation areas and in other parts of the prefecture. The common view is that "in the areas of restriction to entry, stay and residence, recovery of agriculture remains difficult while other areas are affected by bad reputation".

A significant majority of experts evaluate the overall short-term impact of the nuclear disaster on agriculture in neighboring regions as moderate negative. The rest believe that there is a negative impact but some of them assess it as significant and others as insignificant.

As far as the impact of the Fukushima nuclear disaster on agriculture in other parts of Japan is concerned it is estimated as insignificant negative or none by the good part of the experts. What is more, more than 27% of experts assess as positive the overall impact of the disaster on agriculture in other parts of the country.

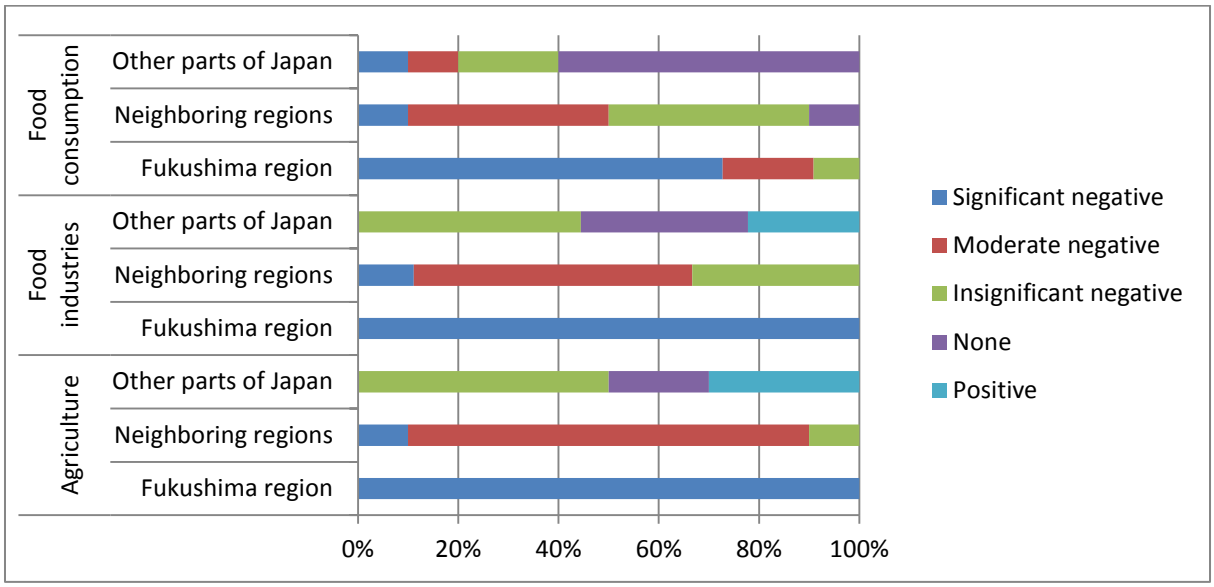
Similarly, the overall short-term impact on food industries in Fukushima region is evaluated by experts as significant negative. "Decreasing sales caused by the contamination and harmful rumors" are the major reasons for the negative consequences of the nuclear

[38] 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 prohibition was announced.

[39] .Possibly in retaliation for his outspoken activism and media presence, Mr.Yoshizawa lost his permit to enter the evacuation zone [Uncanny Terrain].

accident on the food industries in that region. However, experts believe that "recovery of the regional food industries will be faster than in agriculture in a longer term".

Figure 15: Overall short-term impact of Fukushima nuclear disaster



Source: assessment by panel of experts, June 2013

The negative impact of the disaster on food industries in neighboring regions is mostly assessed as moderate while in other parts of Japan as insignificant or none. Furthermore, more than 18% of experts judge as positive the overall short-term impact of the Fukushima nuclear disaster on the food industries in other parts of the country.

All experts evaluate as negative the overall short-term impact of the Fukushima nuclear disaster on food consumption in the Fukushima region. Moreover, a great part of them assess that the level of the negative impact is significant. The biggest segment of the experts also indicate that there is a negative impact on food consumption in neighboring regions mostly assessed as moderate or insignificant.

According to the majority of experts there is no short-term impact on the nuclear disaster on food consumption in other parts of the country. Nevertheless, a good part of them evaluate the short-tem consequences as negative mostly as insignificant.

The most badly affected areas from the Fukushima nuclear disaster of the agriculture in Fukushima region are specified by experts 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 people, secured market, external exposure to radiation, vegetables, rice, milk, beef, mushrooms, fruits (Table 10). Some experts are especially concerned with the "decrease of current and future farmers" as a

result of diminishing the willingness to farm and moving farmers to other prefectures as well as with "decreasing consumption of local products by local people".

Table 10: 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 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	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 Excluded from tenders local factories Decreased naming "Made in Fukushima" Management Seafood produces	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. 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 produces	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

(*) numbers of listing Source: assessment by panel of experts, June 2013

According to experts the most badly affected areas from the Fukushima nuclear disaster of agriculture in neighboring regions are: 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, beef.

As far as agriculture in other parts of the country is concerned the most badly affected areas from the Fukushima nuclear disaster are listed as: 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.

The most badly affected areas from the Fukushima nuclear disaster of food industries in Fukushima region are identified by experts 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, seafood produces.

According to experts the most badly affected areas from the Fukushima nuclear disaster of food industries in neighboring regions are: 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 is concerned the most badly affected areas from the Fukushima nuclear disaster are specified as: restriction of shipping abroad, changes in buying ingredients.

The most badly affected areas of food consumption from the Fukushima nuclear disaster in Fukushima region are determined by experts 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, 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, increased costs for buying water etc.

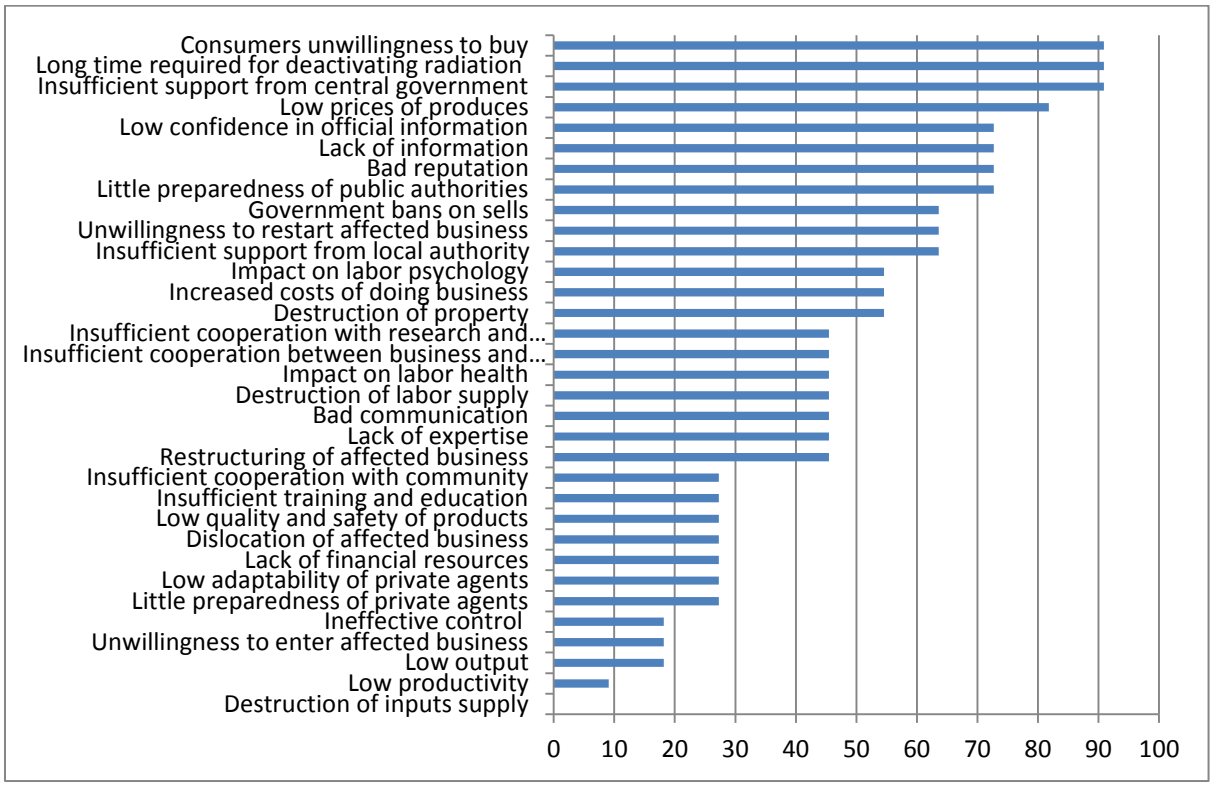
The most affected areas of food consumption in other parts of Japan are listed as: avoiding East Japan products, avoiding Fukushima products, increased costs for buying water etc., increased anxiety.

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.

According to the expertise the most important factor for persistence of the negative impacts on agriculture are: "consumers unwillingness to buy", "long time required for deactivating radiation", "insufficient support from the central government", and "low prices of produces" (Figure 16). The "low confidence in official information", "lack of information",

"bad reputation", and "little preparedness of public authorities" are also identified as a significant factors for sustaining the negative consequences from the disaster in agriculture.

Figure 16: Factors for persistence of negative impacts of Fukushima nuclear disaster on agriculture (percent)

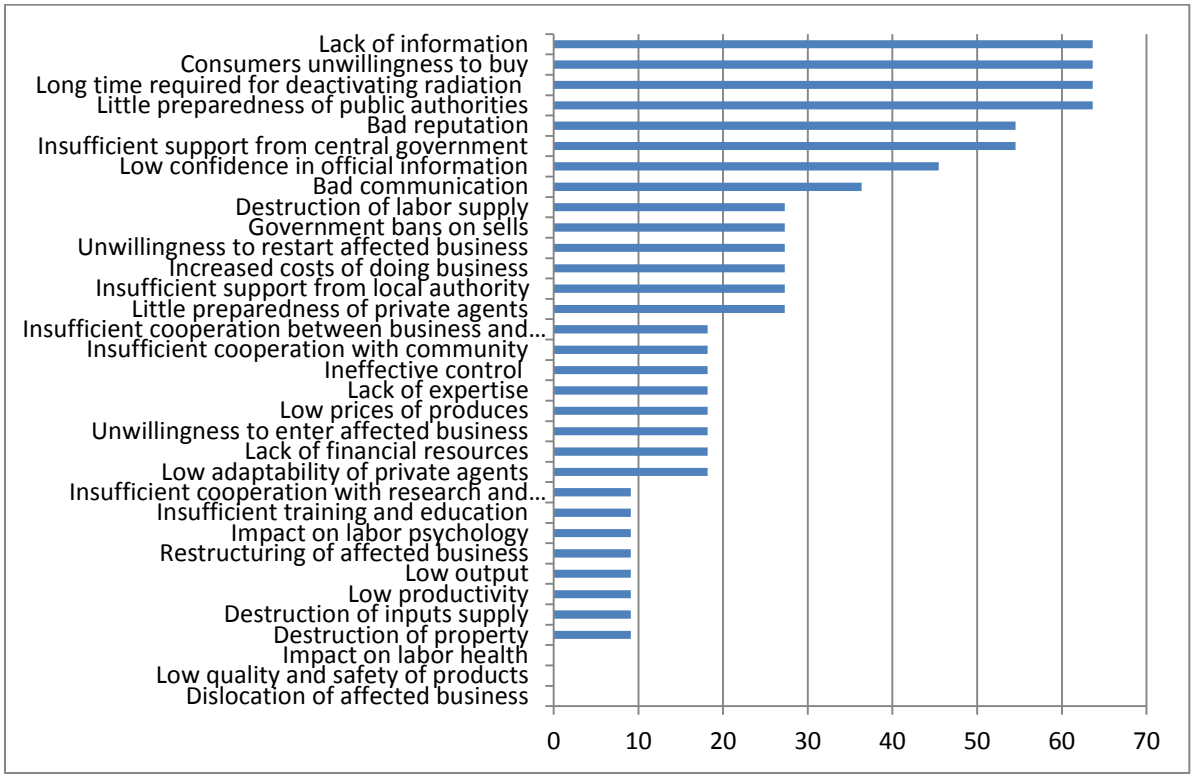


Source: assessment by panel of experts, June 2013

The most important factors for persistence of the negative impacts of the nuclear disaster on food industries are specified by experts as: "lack of information", "consumers unwillingness to buy", "long time required for deactivating radiation", and "little preparedness of public authorities" (Figure 17). Besides, "bad reputation", "insufficient support from the central government" and "low confidence in official information" are also ranked as key factors for persistence of the negative consequences on food industries.

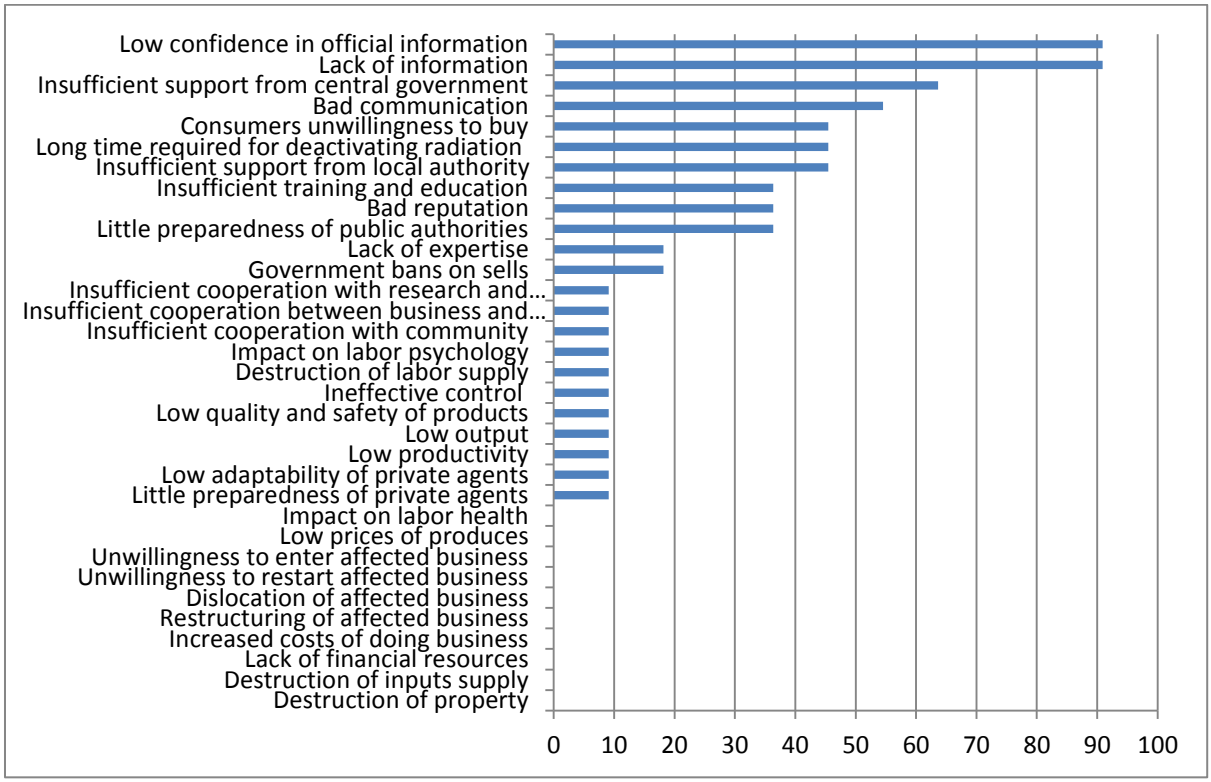
As far as the most important factors for persistence of the negative impacts of the nuclear disaster on food consumption is concerned they are identified by experts as: "lack of information", and "low confidence in official information" (Figure 18). In addition, a good portion of experts also believe that "insufficient support from the central government" and "bad reputation" are significant factors for sustaining negative impacts of the disaster on food consumption.

Figure 17: Factors for persistence of negative impacts of Fukushima nuclear disaster on food industries (percent)



Source: assessment by panel of experts, June 2013

Figure 18: Factors for persistence of negative impacts of Fukushima nuclear disaster on food consumption (percent)

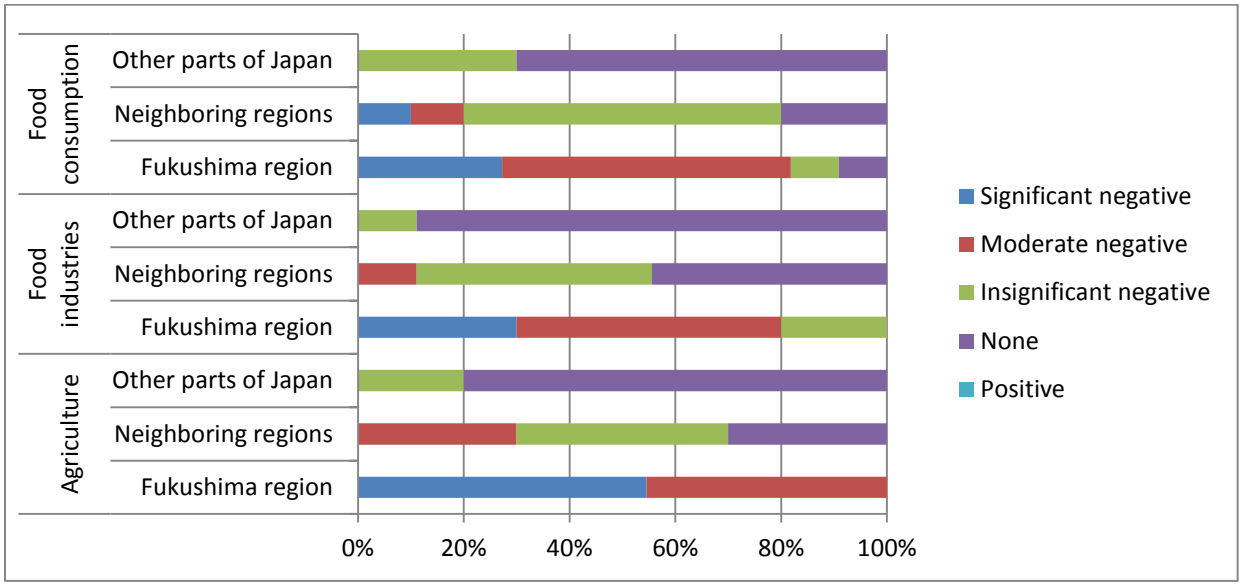


Source: assessment by panel of experts, June 2013

Longer term impacts

All experts think that the overall long-term impact of the Fukushima nuclear disaster on agriculture in Fukushima region will be negative. What is more, the biggest part of them assesses this impact as significant while the rest evaluate it as moderate (Figure 19).

Figure 19: Overall long-term impact of Fukushima nuclear disaster



Source: assessment by panel of experts, June 2013

Most experts evaluate the overall long-term impact on agriculture in neighboring regions as insignificant or none. Nevertheless, some good part of the experts believes that there will be moderate negative impact of the nuclear disaster on agriculture in these regions.

The overall long-term impact of the Fukushima nuclear disaster on agriculture in the other parts on Japan is estimated as none by the majority of experts.

All experts assess as negative the long-term impact of the Fukushima nuclear disaster on food industries in Fukushima region. Moreover, most of them believe that effect will be moderate, some good portion ranked it as significant, while the smallest segment evaluate it as insignificant.

The majority of the members of the expert panel estimate as insignificant or none the overall long-term impact of the nuclear disaster on food industries in neighboring regions. However, there is some part of the experts who believes that there will be moderate negative long-term consequences on the food industries in these regions.

The overall long-term impact of the nuclear accident on the food industries in other part of the country is predominately assessed as nil and only a small portion of the experts evaluate it as insignificantly negative.

A great majority of the experts think that the overall long-term impact of the Fukushima nuclear disaster on the food consumption in Fukushima region would be negative. The most part of them ranked is a moderate but a considerable portion among them assesses it as significant as well.

The overall long-term impact on food consumption is predominately estimated as insignificant or none by the experts. Nonetheless, one fifth of the experts believe that there will be significant or moderate negative consequences related to food consumption in these regions.

The greatest part of the experts does not expect any long-term impact of the nuclear disaster on the food consumption in the other part of Japan. However, a good segment of the experts assess the overall long-term impact on food consumption in the rest of Japan to be insignificant negative.

Expert panel has also assessed the long-term effects of the Fukushima nuclear disaster on different aspects of agriculture and food industries development.

Experts are unanimous that there will be a high long-term effect on food safety in agriculture (Figure 20). They also believe there will be significant effect on "relations with consumers", "income and profit", and "land resources" in this sector. Furthermore, according to experts 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".

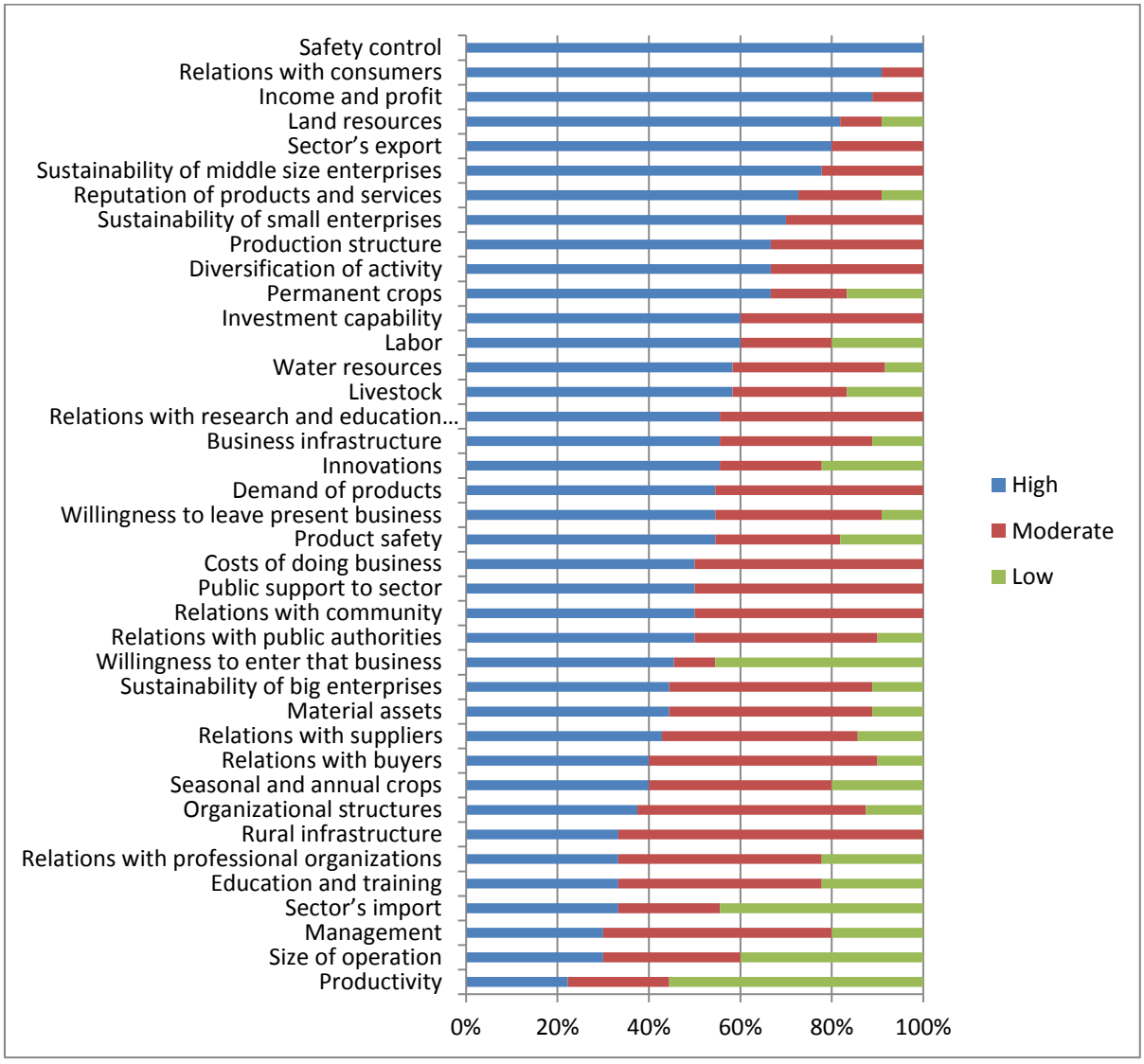
On the other hand, the long-term effect on "rural infrastructure", "relations with buyers", "organizational structures" and "management" in that sector is mostly estimated as moderate. Finally, according to experts the nuclear disaster will have only low effect on the "productivity" and "willingness to enter that business".

According to the experts the strongest long-term effect of the nuclear disaster in food industries will be on the "safety control" and "sector's export" (Figure 21). There will be also high and moderate consequences on the "sustainability of middle size enterprises" and "reputation of products and services" in this sector.

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" and "willingness to enter that business", "rural infrastructure" and "organizational structures" are predominately evaluated as moderate by experts.

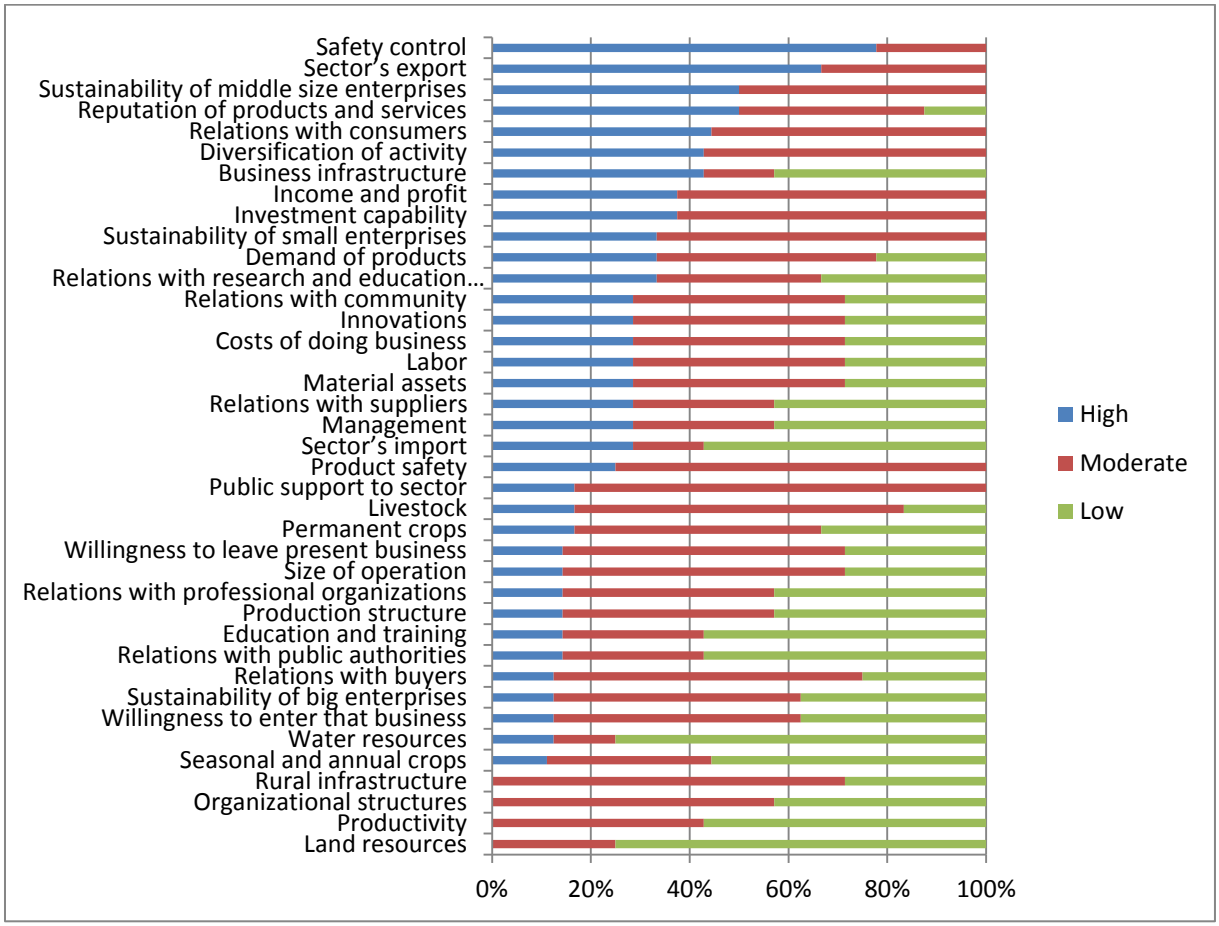
According to the most of experts the long-term effects on the nuclear disaster on "land and water resources", "sector's import", "productivity", "relations with public authorities", "relations with suppliers", "management", and "education and training" in the food industries is expected to be rather low.

Figure 20: Long-term effects of Fukushima nuclear disaster on agriculture



Source: assessment by panel of experts, June 2013

Figure 21: Long-term effects of Fukushima nuclear disaster on food industries



Source: assessment by panel of experts, June 2013

5. Conclusion

This study has been just a first attempt to specify and assess the multiple impacts of the Fukushima nuclear disaster on Japanese agriculture and food chains. Understandably the research is not complete due to the "short" period of time after the disaster, shortage of comprehensive data, great controversy in information and opinions, and difficulties to adequately assess longer terms consequences. All these weaknesses have been only partially compensated by the wide use of diverse information sources as well as experts and stakeholders assessments throughout the study.

In future more interdisciplinary research is to be carried out in order to proper understand and fully evaluate diverse impacts and factors of the nuclear disaster on agri-food chains in Japan involving better precision, assessment of levels and interrelations etc. in larger temporal and spacial scales. That will be definitely facilitated by the increasing amount of the available new data and publications on this important issue as well as by improving the methods of analysis.

References:

Aoki, M. (2012): Cesium contamination in food appears to be on wane, Japan Times, September 25.

Arirang News (2011): Highly Radioactive Substances Detected in Tokyo, May 15.

Asahi Shimbun (2011): High radiation levels found beyond 30-km radius, April 9.

BBC (2013): BBC News, August 24.

Brumfiel G. (2013): Fukushima: Fallout of fear, Nature, January 16 http://www.nature.com/news/fukushima-fallout-of-fear-1.12194

Buesseler, K. (2012): Fishing for Answers off Fukushima, Science, 338: 480.

Buesseler, K., S. Jayne, N. Fisher, I. Rypina, H. Baumann, Z. Baumann, C. Breier, E. Douglass, J. George, A. Macdonald, H. Miyamoto, J. Nishikawa, S. Pike, and S. Yoshida (2012): Fukushima-derived radionuclides in the ocean and biota off Japan, Proceedings of the National Academy of Sciences.

Burch K. (2012): Consumer perceptions and behaviors related to radionuclide contaminated food: an exploratory study from Kansai, Japan, Mater thesis,Norwegian University of Life Sciences, http://brage.bibsys.no/umb/retrieve/3988/UMB-Karly%20Burch-Consumer%20perceptions%20and%20behaviors%20related%20to%20radionuclide%20contaminated%20food--an%20exploratory%20study%20from%20Kansai,%20Japan.pdf

Fujita, M., H. Nobuaki, and J. Sagara (2012): Economic Impacts of GEJE, Knowledge note 6-3, http://wbi.worldbank.org/wbi/Data/wbi/wbicms/files/drupal-acquia/wbi/drm_kn6-3.pdf

Futahira, S. (2013): Nuclear power plant accident and recovery of fishery, presentation at the JA Conference in Fukushima, May 18.

IAEA (2011a): Briefing on Fukushima Nuclear Accident, April 26, http://www.iaea.org/newscenter/news/2011/fukushimafull.html

IAEA (2011b):Japan Earthquake Update, March 19.

IAEA (2011c): IAEA international fact finding expert mission of the Fukushima dai-ichi npp accident following the great east Japan earthquake and tsunami". June 2011, http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2011/cn200/documentation/cn200_Final-Fukushima-Mission_Report.pdf

Inajima T., and M. Nakayama (2011): Radiation Readings in Fukushima Reactor Rise to Highest Since Crisis Began, April 27 http://www.bloomberg.com/news/2011-04-27/tokyo-water-radiation-falls-to-zero-for-first-time-since-crisis.html

Gundersen, A. and H. Caldicott (2012): The Ongoing Damage and Danger at Fukushima, Fairewinds Energy Education. Web. 6 Nov. 2012. http://fairewinds.org/content/ongoing-damage-and-danger-fukushima

Ishii K. (2013): Les situations actuelles d'Odaka, 2013.4.12, manuscript provided by the author.

Hamada N., and H.Ogino (2012): Food safety regulations: what we learned from the Fukushima nuclear accident, Journal of Environmental Radioactivity, Volume 111, 83–99.

JAIF (2011a): NSC Recalculates Total Amount of Radioactive Materials Released, September 5, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1315203996P.pdf
JAIF (2011b): Earthquake-report 213 Radioactive iodine spread south of nuclear plant, September 22, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1316751455P.pdf
JAIF (2011c): Earthquake-report 221: Plutonium detected 45 kilometers from nuke plant, September 30, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1317442784P.pdf
JAIF (2011d) Japanese Government wants a voluntary ban on the use and sales of compost and humus, July 26, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1311736194P.pdf
JAIF (2011e): Cesium beyond limit found in Chiba, Saitama tea, September 4, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1315108656P.pdf
JAIF (2011f): Earthquake-report 215: Safety limit radioactive cesium in Fukushima rice, September 25, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1316921446P.pdf
JAIF (2011h) Earthquake-report 256: Cesium contaminated mushrooms served in food, November 5, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1320469975P.pdf
JAIF (2011j): Earthquake report 202: Radiation checks on wild plants, animals urged, September 12, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1315808560P.pdf
JAIF (2011k): Earthquake-report 235: Radioactive cesium found in plankton off the nuclear plant, October 15, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1318651768P.pdf
JAIF (2011m): Natto makers to seek damages from TEPCO, August 13, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1313211529P.pdf
JAIF (2012): Earthquake report 412: Cesium contaminated fish found in Tone river, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1335433576P.pdf
JANIC (2013): Stories & Facts from Fukushima, Vol.1, March 25.
Johnson R. (2011): Japan's 2011 Earthquake and Tsunami: Food and Agriculture Implications, Congressional Research Service, http://fpc.state.gov/documents/organization/161583.pdf
Kaltofen, M (2011): Radiation Exposure to the Population of Japan after the Earthquake, APHA, https://apha.confex.com/apha/139am/webprogram/Paper254015.html
Kim, V. (2011). Japan damage could reach $235 billion, World Bank estimates, Los Angelis Times, March 21.
Koyama, R. (2012):Farmland Radiation Dose Distribution Map and Food Safety Inspection Systematization, 商学論集 第81 巻第2.
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.

Kyodo News (2011): Spinach with radiation 27 times higher than limit found in Japan, March 21.

Landline (2013): Nuclear Farming, May 25.
http://www.abc.net.au/landline/content/2013/s3767536.htm

Liou Y., H. Sha, T. Chen, T.Wang, Y. Li, Y. Lai, M.Chiang, and L.Lu (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, Vol. 20, No. 6, 618-623.

Møller, A., A. Hagiwara, S. Matsui, S. Kasahara, K. Kawatsu, I. Nishiumi, H. Suzuki, K. Ueda, T. Mousseau (2012): Abundance of birds in Fukushima as judged from Chernobyl, Environmental Pollution, 164: 36–39.

MAFF (2012): FY2011 Annual Report on Food, Agriculture and Rural Areas in Japan.

MEXT (2011): Readings of environmental monitoring samples, March 24.

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, 27 May- 1 June 2012, Porto, Portugal.

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. and K.Tanoi (editors) (2013): Agricultural Implications of the Fukushima Nuclear Accident, Springer.

NISA (2011): Seismic Damage Information, the 110th Release, 23 April, Nuclear and Industrial Safely Agency of Japan.

NHK World (2011a): Radioactive cesium detected in Tokyo grade school, December, 13.

NHK World (2011b): High level of cesium detected in sand lances, April 5.

NHK World (2011c): Fukushima Prefecture probes cesium-tainted rice, November 17.

NHK World (2011d): High level of radioactivity in Tochigi mushrooms, November 11.

NHK (2011a): Radioactive element detected in grass, vegetables, May 13.

NHK (2011b): High radiation levels detected 20 km. from plant, March 16.

NHK Wold [2013a]: NHK Headline News, July 24.

NHK Wold [2013b]: NHK Headline News, August 20.

NHK World [2013c]: NHK Headline News, September 2.

NII (2013): WHO report: cancer risk from Fukushima is low, Nuclear Engineering International. March 1,
http://www.neimagazine.com/news/newswho-report-cancer-risk-from-fukushima-is-low
http://newsonjapan.com/html/newsdesk/article/89987.php

Oka, T. (2012): Application of cost-benefit analysis to the regulation of foodstuffs contaminated with radioactive substances, Japanese Journal of Health Physics, Vol. 47, No. 3, 181-188.

Osawa, J. (2011): Radiation Detected in Tea Leaves in Japan, Wall Street Journal. 11 May.

Saito, M (2011): Radiation found in seaweed near crippled Japan plant, Reuthers, May 13,
http://www.reuters.com/article/2011/05/13/us-japan-nuclear-radiation-idUSTRE74C2RB20110513

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.

Takeuchi, T. and Emiko Fujioka (2013): The agony of Fukushima farmers, in Stories & Facts from Fukushima, Vol.1, JANIC.

TEPCO (2013): Tokyo Electric Power Company, http://www.tepco.co.jp/en/index-e.html

The Japan Times (2011): Tokyo tap water has trace level of radiation, March 20.

The Japan Times (2013): Exposure data wrong for 1600 in Fukushima, June 27.

The Japan News (2013): Many evacuees have yet to return home, June 15.

The Mainichi Daily News (2011a): Gov't releases map of radioactive tellurium 129m contamination around nuke plant, November 1.

The Mainichi Daily News (2011b): Strontium-90 found in the city of Yokohama, October 12.

The Mainichi Daily News (2011c): High dosage of cesium found in soil outside Fukushima no-go zone, October 5.

The Mainichi Daily News (2011d): Gov't updates radiation maps with data on six new prefectures, November, 12.

The Mainichi Daily News (2011e): Farm households in 2 Fukushima cities to suspend rice shipments, November 29.

The Mainichi Daily News (2011f): Excessive cesium detected in greenhouse-grown mushrooms in Fukushima, October 30.

The Mainichi Daily News (2011h): Meiji ignored info on cesium-tainted baby food for two weeks, December 10.

The Mainichi Shimbun (2012a): Highest level of radioactive cesium to date found in freshwater fish in Fukushima village, March 30.

The Mainichi Shimbun (2012b): Cesium in excess of new gov't limit detected in smelt from Gunma lake, April 4.

The Mainichi Daily News (2012c): High level of radioactive cesium found in Okinawa noodles, February 13.

The Mainichi Shimbun (2012d): Foods with excessive radiation under new rule found in 8 prefectures, April 1.

The Mainichi Daily News (2012e): Fukushima city says radiation dose level unlikely to harm health, January 13.

The New York Times (2011a): Levels of Radioactive Materials Rise Near Japanese Plant, April 16.

The New York Times (2011b): Japan Nuclear Crisis Erodes Farmers' Livelihoods, March 29.

Ujiie, K. (2011): An analysis of willingness to accept for radioactive contamination on agricultural products, http://www.u.tsukuba.ac.jp/~ujiie.kiyokazu.gf/files/CP_JT.pdf

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, http://uncannyterrain.com/blog/

Yasunaria, T., A. Stohlb, R. Hayanoc, J. Burkhartb, S. Eckhardtb, and T.Yasunarie (2011): Cesium-137 deposition and contamination of Japanese soils due to the Fukushima nuclear accident, PNAS, http://www.pnas.org/content/early/2011/11/11/1112058108

Yomiuri Shimbun (2011): May 18, http://www.yomiuri.co.jp
Wikipedia (2013): Radiation effects from Fukushima Daiichi nuclear disaster, http://en.wikipedia.org/wiki/Radiation_effects_from_Fukushima_Daiichi_nuclear_disaster
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.

Appendix 1: List of products subject to government or voluntary restrictions as of August 12, 2013 (updates available at http://www.maff.go.jp/e/quake/press_110312-1.html)

I. Vegetables

1. Products subject to request of shipment/intake restraint

Designated Areas		Designated Products	
		shipment	intake
Aomori Prefecture	Towada city, Hashikami town and Aomori city	Wild mushrooms (voluntary restraint of shipment)	
Iwate Prefecture	Ofunato city, Rikuzentakata city, Ichinoseki city, Kamaishi city, Oshu city, Hanamaki city, Kitakami city, Tono city, Kanegasaki town, Yamada town, Hiraizumi town, Otsuchi town, and Sumita town	Shiitake mushrooms grown on Raw Log (Open Fields)	
	Kamaishi city, Ofunato city, Rikuzentakata city and Ichinoseki city and Oshu city	Nameko mushrooms grown on Raw Log (Open Field)	
	Ichinoseki city and Oshu city	Kuritake mushrooms grown on Raw Log (Open Field)	
	Morioka city, Hanamaki city, Oshu city, Kamaishi city, Kitakami city, Tono city, and Sumita town	Koshiabura (Eleutherococcus sciadophylloides)	
	Ichinoseki city, Oshu city, and Sumita town	Fiddlehead fern (Osmunda japonica)	
	Rikuzentakata city, Oshu city, Ichinoseki city, and Hiraizumi town	Wild Bracken (Pteridium aquilinum)	
	Ichinoseki city and Oshu city	Wild Japanese parsley (Oenanthe javanica)	
	Ichinoseki city, Oshu city, and Rikuzentakata city	Bamboo shoots	
	Ichinoseki city, Rikuzentakata city Hiraizumi town, Kamaishi city, Oshu city, Ofunato city, Kanegasaki town and Tono city	Wild mushrooms	
Miyagi Prefecture	Sendai city, Natori city, Ishinomaki city, Shiroishi city, Kakuda city, Kesennuma city, Kurihara city, Osaki city, Tome city, Higashimatsushima city, Kami town, Minamisannriku town,	Shiitake mushrooms grown on Raw Log (Open Fields)	

	Zao town, Marumori town, Murata town, Taiwa town, Tomiya town, Kawasaki town, Shikima town, Shichikashuku town, and Ohira village		
	Kesennuma city, Kurihara city, Osaki city, and Kami town	Kusasotetsu (Matteuccia struthiopteris) (Kogomi : Young bud of kusasotetsu)	
	Shiroishi city, Kurihara city, and Marumori town	Bamboo shoots	
	Kesennuma city, Kurihara city, Tome city, Osaki city, Minamisanriku town, Shichikashuku town and Taiwa town	Koshiabura (Eleutherococcus sciadophylloides)	
	Kesennuma city, Osaki city, and Marumori town	Fiddlehead fern (Osmunda japonica)	
	Kurihara city and Osaki city	Wild mushrooms	
Fukushima Prefecture	Minamisoma city (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station and the following districts: Haramachi-ku Takanokura-ji Suketsune, Fukiyatouge, Nanakyoku, Mori and Garekimori; Haramachi-ku Baba-ji Godaisan, Yokogawa and Yakushidake; Haramachi-ku Katakura-ji Namedzu; and Haramachi-ku Ohara-ji Wadajo); Kawamata town (limited to the Yamakiya district); Naraha town; Tomioka Town; Okuma town; Futaba town; Namie town; Kawauchi village (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station); Katsurao village; and Iitate village	Non-heading leafy vegetables (Spinach, Komatsuna , Kakina, Colza, Chijirena, Kousaitai, Kukitachina, Kaburena, Shinobufuyuna, Santousai, Bekana, Non-heading leafy Hakusai(non-heading leafy Chinese cabbage), Chingensai, Pakuchoi, Taasai, Takana, Katsuona, Mustard greens, Mizuna, Taisai, Saradana, Lollo rosso (Sunny lettuce), Shungiku, Swiss chard, Nabana, Saishin, Autumn Poem, Kai-lan (Chinese Kale), Tsubomina, Mizukakena, Kale, Shirona, Sendai-yukina, Senpousai, Nozawana, Benrina, Yamagata-midorina, Wasabina, Sanchu, Petit veil , Urui, Hatake-Wasabi, Hana-Wasabi, Watercress, Arugula, Shephard's purse, Iceplant, Hadaikon, Japanese butterbur, etc.)	Non-heading leafy vegetables (Spinach, Komatsuna , Kakina, Colza, Chijirena, Kousaitai, Kukitachina, Kaburena, Shinobufuyuna, Santousai, Bekana, Non-heading leafy Hakusai(non-heading leafy Chinese cabbage), Chingensai, Pakuchoi, Taasai, Takana, Katsuona, Mustard greens, Mizuna, Taisai, Saradana, Lollo rosso (Sunny lettuce), Shungiku, Swiss chard, Nabana, Saishin, Autumn Poem, Kai-lan (Chinese Kale), Tsubomina, Mizukakena, Kale, Shirona, Sendai-yukina, Senpousai, Nozawana, Benrina, Yamagata-midorina, Wasabina, Sanchu, Petit veil , Urui, Hatake-Wasabi, Hana-Wasabi, Watercress, Arugula, Shephard's purse, Iceplant, Hadaikon, Japanese butterbur, etc.)
		Heading leafy vegetables (Cabbage, Hakusai (Chinese cabbage), Heading lettuce, Brussels sprout etc.)	Heading leafy vegetables (Cabbage, Hakusai (Chinese cabbage), Heading lettuce, Brussels sprout etc.)
		Bud vegetables belonging to brassicaceae (Broccoli, Cauliflower, Stick Broccoli etc.)	Bud vegetables belonging to brassicaceae (Broccoli, Cauliflower, Stick Broccoli etc.)
		Kabu (turnip) (Ko-Kabu, Aka-Kabu, Shogoin-Kabu etc)	
	Fukushima city, Date city, Minamisoma city, Koori town	Japanese plum (Prunus mume)	

	and Kunimi town		
	Fukushima city, Date city, Minamisoma city, and Koori town	Yuzu	
	Date city, Minamisoma city, Nihonmatsu city and Iwaki city	Japanese chestnut	
	Soma city and Minamisoma city	Kiwi fruits	
	Fukushima city, Nihonmatsu city, Date city, Motomiya city, Soma city, Minamisoma city, Tamura city (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station), Kawamata town, Namie town, Futaba town, Ookuma town, Tomioka town, Naraha town, Hirono town, Iitate village, Katsurao village, and Kawauchi village (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station)	Shiitake mushrooms grown on Raw Log (Open Field)	Shiitake mushrooms grown on Raw Log (Open Field) (only those produced in Iitate village)
	Date city, Kawamata town and Shinchi town	Shiitake mushrooms grown on Raw Log (Mushroom growing facilities)	
	Soma city and Iwaki city	Nameko mushrooms grown on Raw Log (Open Field)	
	Fukushima city, Nihonmatsu city, Date city, Motomiya city, Koriyama city, Sukagawa city, Tamura city, Shirakawa city, Kitakata city, Soma city, Minamisoma city, Iwaki city, Koori town, Kunimi town, Kawamata town, Kagamiishi town, Ishikawa town, Asakawa town, Furudono town, Miharu town, Ono town, Yabuki town, Tanagura town, Yamatsuri town, Hanawa town, Inawashiro town, Hirono town, Naraha town, Tomioka Town, Okuma town, Futaba town, Namie town, Shinchi town, Otama village, Tenei village, Tamakawa village, Hirata village, Nishigo village, Izumizaki village, Nakajima village, Samegawa village, Showa village, Kawauchi village, Katsurao village, Iitate	Wild mushrooms	Wild mushrooms (only those picked at Minamisoma city, Iwaki city and Tanagura town)

	village, Bandai town, Aizubange town and Kitashiobara villeage		
	Fukushima city, Koriyama city, Date city, Soma city, Minamisoma city, Iwaki city, Motomiya city, Nihonmatsu city, Sukagawa city, Shirakawa city, Tamura city, Koori town, Kawamata town, Miharu town, Hirono town, Shinchi town, Naraha town, Nishigo village, Otama village, Kawauchi village, and Katsurao village	Bamboo shoots	
	Fukushima city, Koriyama city, Nihonmatsu city, Soma city, Date city, Tamura city, Kunimi city, Miharu town, Kawaamta town, Koori town, Furudono town, Naraha town, Otama village, and Katsurao village	Kusasotetsu (Matteuccia struthiopteris) (Kogomi : Young bud of kusasotetsu) (Open Field)	
	Fukushima city, Iwaki city, Soma city, Date city, Koriyama city, Minamisoma city, Shirakawa city, Nihonmatsu city, Motomiya city, Sukagawa city, Tamura city, Hanawa town, Shinchi town, Koori town, Kawamata town, Hirono town, Furudono town, Kagamiishi town, Otama village, Nishigo village, Samegawa village, Katsurao village, Izumizaki village, and Kawauchi village	Wild Taranome (Young bud of Aralia elata)	
	Fukushima city, Date city, Tamura city, Soma city, Kawamata town, Koori town, Kunimi town, and Hirono town	Wild butterbur sprout	
	Date city and Kawamata town	Wasabi (Japanese Horseradish) (only grown in agricultural fields)	
	Fukushima city, Nihonmatsu city, Koriyama city, Shirakawa city, Kitakata city, Date city, Sukagawa city, Iwaki city, Soma city, Minamisoma city, Motomiya city, Tamura city, Aizuwakamatsu city, Tanagura town, Hanawa town,	Koshiabura (Eleutherococcus sciadophylloides)	

	Aizumisato town, Kunimi town, Bandai town, Yamatsuri town, Kawamata town, Ishikawa town, Yanaizu town, Minamiaizu town, Furudono town, Shinchi town, Mishima town, Asakawa town, Hirono town, Ono town, Yabuki town, Aizubange town, Miharu town, Shimogo town, Kagamiishi town, Kaneyama town, Nishigo village, Samegawa village, Tenei village, Kitashiobara villeage, Katsurao village, Izumizaki village, Kawauchi village, Otama village, Tamakawa village, Hirata village, Nakajima village, and Showa village		
	Iwaki city, Nihonmatsu city, Soma city, Minamisoma city, Sukagawa city, Koriyama city, Kawamata town, Naraha town, Katsurao village, and Kawauchi village	Fiddlehead fern (Osmunda japonica)	
	Fukushima city, Kitakata city, Iwaki city, Minamisoma city, Date city, Kawamata town, and Samegawa village	Bracken (Pteridium aquilinum)	
	Nihonmatsu city	Wild Bracken (Pteridium aquilinum)	
	Naraha town and Koori town	Wild butterbur	
	Sukagawa city and Kunimi town	Wild Uwabamisou (Mizu) (Elatostema umbellatum)	
Ibaraki Prefecture	Tsuchiura city, Namegata city, Hokota city, Omitama city, Hitachiomiya city, Tsukubamirai city, Moriya city, Hitachinaka city, Naka city, Ibaraki town, and Ami town	Shiitake mushrooms grown on Raw Log (Open Fields)	
	Tsuchiura city, Hokota city and Ibaraki town	Shiitake mushrooms grown on Raw Log (Mushroom growing facilities)	
	Omitama city, Hitachinaka city, Itako city, and Tsukubamirai city, Ishioka city, Ryugasaki city, Toride city, Moriya city, Hokota city, Kitaibaraki city, Oarai town, Ibaraki town, Tone town, and Tokai village	Bamboo shoots	

	Hitachi city, Hitachiomiya city and Hitachiota city	Wild koshiabura (Eleutherococcus sciadophylloides)	
Tochigi Prefecture	Yaita city, Nasushiobara city, Ohtawara city, Sakura city, Kanuma city, Haga town, Nasu town, Mibu town, and Nikko city	Shiitake mushrooms grown on Raw Log (Open Fields / Mushroom growing facilities)	
	Utsunomiya city, Nikko city, Ashikaga city, Moka city, Nasukarasuyama city, Tochigi city, Yaita city, Nasushiobara city, Sakura city, Ohtawara city, Kanuma city, Haga town, Nasu town, Mibu town, Kaminokawa town, Motegi town, Ichikai town, Nakagawa town, Mashiko town, Shioya town, and Takanezawa town	Shiitake mushrooms grown on Raw Log (Open Fields)	
	Yaita city, Nikko city, Nasushiobara city, Nasu town, Sano city, Kanuma city, Mibu town, Nakagawa town, Nasukarasuyama city and Ohtawara city	Nameko mushrooms grown on Raw Log (Open Field)	
	Utsunomiya city, Ashikaga city, Sano city, Kanuma city, Moka city, Ohtawara city, Yaita city, Nasushiobara city, Sakura city, Nasukarasuyama city, Kaminokawa town, Motegi town, Ichikai town, Haga town, Takanezawa town, Shioya town and Mibu town	Kuritake mushrooms (Hypholoma sublateritium (Fr.) Quél.) grown on Raw Log (Open Field)	
	Utsunomiya city, Ohtawara city, Yaita city, Nasu town, Ichikai town and Shioya town	Wild Taranome (Young bud of Aralia elata)	
	Nasushiobara city, Nikko city, Ohtawara city, Nasu town, and Yaita city	Bamboo shoots	
	Nasushiobara city, Ohtawara city and Nasu town	Wild Kusasotetsu (Matteuccia struthiopteris) (Wild Kogomi (Young bud of kusasotetsu))	
	Utsunomiya city, Nasukarasuyama city, Ohtawara city, Nikko city, Kanuma city, Nasushiobara city, Yaita city, Sakura city, Nakagawa town, Shioya town, Motegi town and Nasu town	Wild Koshiabura (Eleutherococcus sciadophylloides)	
	Utsunomiya city, Nikko city, Nasushiobara city, and	Wild Sanshou (Zanthoxylum piperitum)	

	Ohtawara city		
	Nikko city and Nasu town	Wild fiddlehead fern (Osmunda japonica)	
	Utsunomiya city, Kanuma city, Nikko city, Ohtawara city, and Yaita city	Wild bracken (pteridium aquilinum)	
	Nikko city, Moka city, Ohtawara city, Nasushiobara city, Masuko town, Nasu town, Nakagawa town, Kanuma city, Yaita city and Shioya town	Wild mushrooms	
	Ohtawara city, Nasushiobara city, Nasu town and Nasukarasuyama city	Japanese chestnut	
Chiba Prefecture	Chiba city, Yachiyo city, Nagareyama city, Abiko city, Kimitsu city, Sakura city, Shiroi city, Inzai city, Sammu city and Futtsu city	Shiitake mushrooms grown on Raw Log (Open Fields)	
	Sammu city, Futtsu city and Kimitsu city	Shiitake mushrooms grown on Raw Log (Mushroom growing facilities)	
	Kisarazu city, Ichihara city, Abiko city, Kashiwa city, Yachiyo city, Shiroi city, Funabashi city, Shibayama town, and Sakae town	Bamboo shoots	
Gunma Prefecture	Numata city, Tsumagoi village Higashiagatsuma town Takayama village, Annaka city, Naganohara town and Minakami town	Wild mushrooms	
Saitama Prefecture	Yokose town, Minano town, Tokigawa town and Hatoyama town	Wild mushrooms	
Nagano Prefecture	Saku city, Miyota town, Karuizawa town, Koumi town and Minamimaki village	Wild mushrooms	
Yamanashi Prefecture	Narusawa village, Fujiyoshida town and Fujikawaguchiko town	Wild mushrooms	
Shizuoka Prefecture	Oyama town and Gotemba city	Wild mushrooms	

2. Products subject to voluntary restraint of shipment

Iwate Prefecture	Oshu city, Ichinoseki city, Ofunato city, and Hiraizumi town	Dried shiitake mushrooms (produced from those grown on Raw Log in 2011) (voluntary restraint of shipment)

	Oshu city, Hanamaki city, Ichinoseki city, Kamaishi city, Ofunato city, Kitakami city, Tono city, Rikuzentakata city, Kanegasaki town, Yamada town, Otsuchi town, and Sumita town	Dried shiitake mushrooms (produced from those grown on Raw Log in the spring of 2012) (voluntary restraint of shipment)
	Oshu city and Ichinoseki city	Shiitake mushrooms grown on Raw Log (Mushroom growing facilities) (voluntary restraint of shipment)
	Hanamaki city and Rikuzentakata city	Wild Kusasotetsu (Matteuccia struthiopteris) (Wild Kogomi : Young bud of kusasotetsu) (voluntary restraint of shipment)
	Ichinoseki city	Wild Taranome (Young bud of Aralia elata) (voluntary restraint of shipment)
	Ichinoseki city	Wild Uwabamisou (Mizu) (Elatostema umbellatum) (voluntary restraint of shipment)
	Oshu city	Wild butterbur (voluntary restraint of shipment)
	Oshu city	Wild Sanshou (Zanthoxylum piperitum) (voluntary restraint of shipment)
	Oshu city	Hiratake mushrooms grown on Raw Log (Open Field) (voluntary restraint of shipment)
	Ichinoseki city	Bunaharitake mushrooms grown on Raw Log (Open Field) (voluntary restraint of shipment)
	Ichinoseki city	Mukitake mushrooms grown on Raw Log (Open Field) (voluntary restraint of shipment)
	Hiraizumi town	Kuwai (arrowhead) (Open Field) (voluntary restraint of shipment)
Akita Prefecture	Yuzawa city	Wild Nemagaridake(Sasa kurilensis)(voluntary restraint of shipment)
Miyagi Prefecture	Kurihara city	Mukitake mushrooms (Panellus serotinus) grown on Raw Log (voluntary restraint of shipment)
	Kesennuma city	Nameko mushrooms grown on Raw Log (Open Field) (voluntary restraint of shipment)
	Osaki city and Kesennuma city	Wild Taranome (Young bud of Aralia elata) (voluntary restraint of shipment)
	Osaki city	Wild Bracken (Pteridium aquilinum) (voluntary restraint of shipment)
Yamagata Prefecture	Mogami town	Koshiabura (Eleutherococcus sciadophylloides) (voluntary restraint of shipment)
Fukushima Prefecture	Minamisoma city	Loquat (voluntary restraint of shipment)
		Japanese persimmon (voluntary restraint of shipment)
		Walnuts (voluntary restraint of shipment)
	Date city	Pomegranate (voluntary restraint of shipment)
	Sukagawa city, Kagamiishi city, Kunimi town, Tenei village, Koriyama city, Iwaki city, Kitakata city, Nishigo village, Yamatsuri town, Shirakawa city,	Dried shiitake mushrooms (voluntary restraint of shipment)

	Nihonmatsu city, Motomiya city, Tanagura city, and Hanawa city	
	Sukagawa city	Wild Udo(Aralia cordata) (voluntary restraint of shipment)
	Iwaki city	Wild Sanshou (Zanthoxylum piperitum) (voluntary restraint of shipment)
	Namie town, Futaba town, Okuma town, Tomioka Town, Naraha town, and Iitate village	Koshiabura (Eleutherococcus sciadophylloides) (voluntary restraint of shipment)
	Tamura city	Blueberry (voluntary restraint of shipment)
	Date city	Chocolate vine (voluntary restraint of shipment)
	Hirono Town	Mandarin orange (voluntary restraint of shipment)
Ibaraki Prefecture	Takahagi city	Wild mushrooms (mycorrhizal fungi) (voluntary restraint of picking and shipment)
	Ushiku city, Mito city, Tsuchiura city, Inashiki city, Kasumigaura city, and Ami town	Bamboo shoots (voluntary restraint of shipment)
	Mito city and Sakuragawa city	Shiitake mushrooms grown on Raw Log (Open Fields) (voluntary restraint of shipment)
	Hitachi city, Ishioka city, Takahagi city, Kasama City, Kasumigaura city, and Shirosato town	Shiitake mushrooms grown on Raw Log (Open Fields / Mushroom growing facilities) (voluntary restraint of shipment)
	Hitachi city, Hitachiota city, Hitachiomiya city, Kasama city, and Shirosato town	Dried shiitake mushrooms (voluntary restraint of shipment)
	Kasama city	Wild Taranome (Young bud of Aralia elata) (voluntary restraint of shipment)
Tochigi Prefecture	Yaita city, Sakura city, Takanezawa town, Shioya town, Moka city, Motegi town, Haga town, Ichikai town, Mashiko town, Sano city, Ohtawara city, Nasushiobara city, Nasu town, Nasukarasuyama city, Nakagawa town, Utsunomiya city, Nikko city, Kanuma city, Tochigi city, Mibu town, Iwafune town, Ashikaga city, and Shimotsuke city (limited to the former town of Minamikawachi)	Dried shiitake mushrooms (produced from those grown on Raw Log) (voluntary restraint of shipment)
	Sano city	Shiitake mushrooms grown on Raw Log (Open Fields) (voluntary restraint of shipment)
	Nakagawa town	Shiitake mushrooms grown on Raw Log (Mushroom growing facilities) (voluntary restraint of shipment)
	Nasushiobara city and Nikko city	Uwabamisou (Mizu) (Elatostema umbellatum) (voluntary restraint of shipment)
	Ohtawara city	Wild Myoga (Zingiber mioga) (voluntary restraint of shipment)
	Yaita city	Wild Momijigasa (Shidoke) (Parasenecio delphiniifolius)

		(voluntary restraint of shipment)
	Nikko city	Yuzu
	Yaita city	Yamaguri (Wild Chestnuts) (voluntary restraint of shipment)
	Nasushiobara city	Lotus root (Open Fields) (voluntary restraint of shipment)
Gunma Prefecture	Takasaki city, Numata city, Shibukawa city, Tomioka city, Nakanojo town, Higashiagatsuma town, Minakami town, and Takayama village	Dried shiitake mushrooms (produced from those grown on Raw Log) (voluntary restraint of shipment)
	Shibukawa city	Bamboo shoots (voluntary restraint of shipment)
	Fujioka city	Nameko mushrooms grown on Raw Log (Open Field) (voluntary restraint of shipment)
	Takasaki city(limited to within the former Kurabuchi village)	Wild Taranome (Young bud of Aralia elata) (voluntary restraint of shipment)
Chiba Prefecture	Katori city, Nagareyama city and Inzai city	Bamboo shoots (voluntary restraint of shipment)
	Matsudo city	Yuzu
	Narita city	Dried shiitake mushrooms ,Shiitake mushrooms grown on Raw Log (Open Fields) (voluntary restraint of shipment)
Kanagawa Prefecture	Manazuru town	Shiitake mushrooms grown on Raw Log (Open Fields) (voluntary restraint of shipment)
Niigata Prefecture	Yuzawa town	Wild mushrooms (voluntary restraint of shipment)
Shizuoka Prefecture	Izu city (limited to within the former town of Shuzenji and Nakaizu) and Ito city	Dried shiitake mushrooms (As for Izu city, only those picked and processed at Izu city from March 11 to September 30. As for Ito city, only those picked and processed at Ito city after March 11) (voluntary restraint of shipment)
Nagano Prefecture	Karuizawa town	Koshiabura (Eleutherococcus sciadophylloides) (voluntary restraint of shipment)
	Karuizawa town	Taranome (Young bud of Aralia elata) (voluntary restraint of shipment)

II. Fish products

1. Products subject to request of shipment/intake restraint

Designated Areas		Designated Products	
		shipment	intake
Iwate Prefecture	The marine area defined by the lines of the due east from the border between Iwate Prefecture and Miyagi Prefecture on the highest tidal shoreline, the outside border of Japan's EEZ, the due east from the border between	Japanese seaperch (Lateolabrax japonicas) and Japanese black porgy (Acanthopagrus schlegelii)	

	Miyagi Prefecture and Fukushima Prefecture on the highest tidal shoreline, and the highest tidal shoreline of Miyagi Prefecture		
	The Iwai River and its side streams; and the Satetsu River and its side streams	Iwana mountain trout (except for those cultured)	
	The Okawa (limited to within Iwate Prefecture) and its side streams; The downstream of the Kitakami River from Shijushida Dam and its side streams (excluding the upstream of the Ishibane Dam, the upstream of the Ishibuchi Dam, the upstream of the Irihata Dam, the upstream of the Gosho Dam, the upstream of the Toyama Dam, the upstream of the Tase Dam, the upstream of the Tsunatori Dam, the upstream of the Toyasawa Dam, and the upstream of the Hayachine Dam); and the Kesen River and its side streams	Japanese dace (Tribolodon hakonensis)	
Miyagi Prefecture	The marine area defined by the lines of the due east from the mountaintop of Kinkasan in Ishinomaki city of Miyagi Prefecture, the outside border of Japan's EEZ, the due east of the border between Miyagi Prefecture and Fukushima Prefecture on the highest tidal shoreline, the highest tidal shoreline of Miyagi Prefecture, and the due west from the mountaintop of Kinkasan in Ishinomaki city of Miyagi Prefecture reached to the highest tidal shoreline of Oshika Peninsula in Ishinomaki city	Takifugu pardalis (a kind of balloon fish)	
	The marine area defined by the lines of the due east from the border between Iwate prefecture and Miyagi Prefecture on the highest tidal shoreline, the outside border of Japan's EEZ, the due east from the border between Miyagi prefecture and	Japanese seaperch (Lateolabrax japonicas) and Japanese black porgy (Acanthopagrus schlegelii)	

	Fukushima prefecture on the highest tidal shoreline, and the highest tidal shoreline of Miyagi Prefecture		
	The marine area defined by the lines of the due east from the border between Iwate prefecture and Miyagi Prefecture on the highest tidal shoreline, the outside border of Japan's EEZ, the due east from the mountaintop of Kinkasan in Ishinomaki city of Miyagi Prefecture, the due west from the mountaintop of Kinkasan in Ishinomaki city of Miyagi Prefecture reached to the highest tidal shoreline of Oshika Peninsula in Ishinomaki city, and the highest tidal shoreline of Miyagi Prefecture	Bastard halibut (Paralichthys olivaceus)	
	The Abukuma River (limited to within Miyagi Prefecture) and its side streams (excluding the upstream from Shichikashuku Dam)	Yamame (a kind of trout) (except for those cultured), Sweetfish (Plecoglossus altivelis) (except for those cultured)	
	The Abukuma River (limited to within Miyagi Prefecture) and its side streams (excluding the upstream from Shichikashuku Dam); and the Okawa River and its side streams	Japanese dace (Tribolodon hakonensis)	
	The upstream of the Okura River from Okura Dam and its side streams; the upstream of the Sanhasama River from Kurikoma Dam and its side streams; the upstream of the Natori River from the Akiu Falls and its side streams; the Matsu River and its side streams (excluding River Nigori, its side streams, and the upstream from Sumikawa No.4 Dam); the upstream of the Nihasama River from Aratozawa Dam and its side streams; and the upstream of the Eai River from Naruko Dam and its side streams; the upstream of the Goishi River (the Taro River) from	Iwana mountain trout (except for those cultured)	

	Kamafusa Dam and its side streams; the upstream of the Ichihasama River from Hanayama Dam and its side streams; and Hirose River and its side streams		
Fukushima Prefecture	Lake Akimoto, Lake Inawashiro, Lake Hibara, Lake Onogawa, the rivers flowing into these lakes and the side streams (excluding the Su River); the Abukuma River limited to within Fukushima Prefecture and its side streams; the Mano River and its side streams; the Niida River and its side streams; the Ohta River and its side streams; and the upstream of the Nippashi River from Kanagawa electric generation plant and its side streams	Yamame (a kind of trout) (except for those cultured)	Yamame (a kind of trout) (except for those cultured) (only River Niida ((including side streams))
	Lake Akimoto, Lake Inawashiro, Lake Hibara, Lake Onogawa, the rivers flowing into these lakes and the side streams (excluding the Su River and its side streams); the upstream of the Nippashi from Kanagawa electric generation plant and its side streams; the Mano River and its side streams; the downstream of the Abukuma River limited to within Fukushima Prefecture from Shinobu Dam and its side streams; and the Tadami River between Tadami Dam and Taki Dam and its side streams	Japanese dace (Tribolodon hakonensis)	
	The Mano River and its side streams, the Niida River and its side streams, and the downstream of the Abukuma River limited to within Fukushima Prefecture from Shinobu Dam and its side streams	Sweetfish (Plecoglossus altivelis) (except for those cultured)	
	The Su River’s side streams; the Abukuma River limited to within Fukushima Prefecture; Lake Akimoto, Lake Onogawa, Lake Hibara, the rivers flowing into these lakes	Iwana mountain trout (except for those cultured)	

	and the side streams; the upstream of the Nagase River from the meeting point of the Su River; the downstream of the Nippashi from Kanagawa electric generation plant and its side streams (excluding the upstream from Higashiyama Dam); and the downstream of the Tadami River from Honna Dam and its side streams		
	Lake Akimoto, Lake Onogawa, Lake Hibara, the rivers flowing into these lakes and the side streams; the downstream of the Agano River from Ookawa Dam and its side streams (excluding both the upstream from Kanagawa electric generation plant and the upstream from Katakado Dam); the upstream of the Nagase River from the meeting point of the Su River; and the downstream of the Abukuma River from Shinobu Dam and its side streams	Carp (Cyprinus carpio) (except for those cultured)	
	The marine area defined by the lines of the due east from the border between Miyagi Prefecture and Fukushima Prefecture on the highest tidal shoreline, the outside border of Japan's EEZ, the due east from the border between Fukushima Prefecture and Ibaraki Prefecture on the highest tidal shoreline, and the highest tidal shoreline of Fukushima Prefecture	Fat greenling (Hexagrammos otakii), Flathead flounder (Hippoglossoides dubius), Red tongue sole (Cynoglossus joyneri), Ikanago (Ammodytes personatus) (except for fry), Stone flounder (Kareius bicoloratus), Sebastes thompsoni (a kind of rockfish), Surfperch (Embiotocidae), Brown hakeling (Physiculus maximowiczi), Fox jacopever (Sebastes vulpes), Black cow-tongue (Paraplagusia japonica), Jacopever (Sebastes schlegelii), Japanese black porgy (Acanthopagrus schlegelii), Sea raven (Hemitripterus villosus), Okamejei kenojei (a kind of Rajidae), Masu salmon (Oncorhynchus masou), Poacher (Occella iburia), Sebastes cheni (a kind of rockfish), Alaska pollock (Theragra chalcogramma), Japanese seaperch (Lateolabrax japonicas), Nibe (Nibea mitsukurii), Starry flounder (Platichthys stellatus), Slime flounder (Microstomus achne), Takifugu pardalis (a kind of balloon fish), Bastard halibut (Paralichthys olivaceus), Red gurnard (Chelidonichthys spinosus), Spotted halibut (Verasper variegatus), Common Japanese conger (Conger myriaster),	

		Yellow striped flounder (Pseudopleuronectes herzensteini), Marbled sole (Pleuronectes yokohamae), Flathead (Platycephalus sp.), Pacific cod (Gadus macrocephalus Tilesius), Roundnose flounder (Eopsetta grigorjewi), Spotbelly rockfish (Sebastes pachycephalus), Frog flounder (Pleuronichthys cornutus), Stimpson's hard clam (Marcenaria stimpsoni), Northern sea urchin (Strongylocentrotus nudus), Long shanny (Stichaeus grigorjewi), Barfin flounder (Verasper moseri), Starspotted smooth-hound (Mustelus manazo), Shosai-fugu (Takifugu snyderi) and Japanese halfbeak (Hemiramphus sajori), False kelpfish（Sebastiscus marmoratus）	
	Lake Akimoto, Lake Onogawa, Lake Hibara, the rivers flowing into these lakes and the side streams; the downstream of the Agano River from Okawa Dam and its side streams (excluding both the upstream from Kanagawa electric generation plant and the upstream from Katakado Dam); the upstream of the Nagase River from the meeting point of the Su River; the Mano River and its side streams; and the downstream of the Abukuma River limited to within Fukushima Prefecture from Shinobu Dam and its side streams	Crucian (Carassius) (except for those cultured)	
	The Abukuma River limited to within Fukushima Prefecture and its side streams	Eel (Anguilla japonica)	
Ibaraki Prefecture	The marine area defined by the lines of the due east from the border between Fukushima Prefecture and Ibaraki Prefecture on the highest tidal shoreline, the outside border of Japan's EEZ, the due east from the border between Ibaraki Prefecture and Chiba Prefecture on the highest tidal shoreline, and the highest tidal shoreline of Ibaraki Prefecture	Sebastes cheni (a kind of rockfish), Japanese seaperch (Lateolabrax japonicas), Nibe (Nibea mitsukurii), Okamejei kenojei (a kind of Rajidae), Pacific cod (Gadus macrocephalus Tilesius)	
	The marine area defined by	Bastard halibut (Paralichthys olivaceus) ,	

	the lines of the due east from the border between Fukushima Prefecture and Ibaraki Prefecture on the highest tidal shoreline, the outside border of Japan's EEZ, lat. 36°38'N, and the highest tidal shoreline of Ibaraki Prefecture	Stone flounder (Kareius bicoloratus)	
	Lake Kasumigaura, Lake Kitaura, Lake Sotonasakaura and the rivers flowing into these lakes; and the Hitachitone River	Channel catfish (Ictalurus punctatus) (except for those cultured), Carassius auratus langsdorfii (a kind of crucian carp) (except for those cultured)	
	Lake Kasumigaura, Lake Kitaura, Lake Sotonasakaura and the rivers flowing into these lakes; the Hitachitone River; and the Naka River limited to within Ibaraki Prefecture and its side streams	Eel (Anguilla japonica)	
Tochigi Prefecture	The Watarase River limited to within Ashiomachi, Nikko city and its side streams	Iwana mountain trout (except for those cultured)	
Gunma Prefecture	The Agatsuma River between the the Iwashima bridge and Agatumagawa intake structure and its side streams	Yamame (a kind of trout) (except for those cultured)	
	The Agatsuma River between the the Iwashima bridge and Agatumagawa intake structure and its side streams	Iwana mountain trout (except for those cultured)	
Chiba Prefecture	Tega swamp and the rivers flowing into this swamp and the side streams; and the Tega River and its side streams	Silver crucian carp (Carassius auratus langsdorfii) , Natural carp (Cyprinus carpio)	

2. Products subject to voluntary restraint of shipment

Iwate Prefecture	The Iwai River (Inland water common fishery right No. 36), the Koromo River (Inland water common fishery right No. 35)	Natural Yamame (a kind of trout) (voluntary restraint of catching)
Miyagi Prefecture	The Abukuma River (limited to within Miyagi Prefecture)	Natural Eel (Anguilla japonica) (voluntary restraint of shipment)
	The Natori River, The Shishido River, and The Motoisago River	Iwana mountain trout (except for those cultured) (voluntary restraint of shipment)

Fukushima Prefecture	The Mano River limited to within Fukushima Prefecture and its side streams	Mokuzugani (a kind of crab) (voluntary restraint of catching)
	Kawauchi village	Honmokoro (cultured) (voluntary restraint of shipment)
	Lake Numazawa and the rivers flowing into this lakes	Himemasu (Oncorhynchus nerka) (voluntary restraint of catching)
	Koriyama city	Weather loach (Misgurnus anguillicaudatus) (voluntary restraint of shipment)
Ibaraki Prefecture	Marine area within Ibaraki Prefecture	Ikanago (Ammodytes personatus)(Meroudo) (voluntary restraint of shipment)
	Marine area within Ibaraki Prefecture (northern and southern marine area)	Takifugu poecilonotus (a kind of balloon fish) (voluntary restraint of shipment)
	The upstream of the Hanazono river from Mizunima Dam	Natural iwana mountain trout (voluntary restraint of shipment)
	The Sakura river, the Ono River, the Shintone and the Hitachitone River	Natural Carassius cuvieri (a kind of crucian) (voluntary restraint of shipment)
	North fleet of Kasumigaura and the rivers flowing into Kasumigaura	Natural Carassius cuvieri (a kind of crucian) (voluntary restraint of shipment)
Tochigi prefecture	The whole Kinugawa riverine system (Lake Chuzenji and the rivers flowing into the lake) (Lake Chuzenji Fishery Association)	Natural fishes in mountain streams (requirement for the postponement of opening the fishing season)
Gunma Prefecture	Lake Akagioonuma	Natural Japanese smelt (Hypomesus nipponensis) (voluntary restraint of shipment)
		Natural Japanese dace (Tribolodon hakonensis) (voluntary restraint of catching)
		Natural carp (Cyprinus carpio) (voluntary restraint of catching)
		Natural iwana mountain trout (voluntary restraint of catching)
		Natural yamame (a kind of trout) (voluntary restraint of catching)
	The upstream of the Nakuta River from the meeting point of the Agatsuma River and its side streams	Natural Japanese dace (Tribolodon hakonensis) (voluntary restraint of catching)
	Lake Haruna	Japanese smelt (Hypomesus nipponensis) (voluntary restraint of shipment)
Saitama Prefecture	The Naka River and its side streams in Tone riverine system	Natural catfish (Silurus asotus) (voluntary restraint of catching)
	The Edo River	Eel (Anguilla japonica) (voluntary restraint of shipment)
Chiba Prefecture	The sea off the coast of Choshi and Kujukuri	Japanese seaperch (Lateolabrax japonicas) (voluntary restraint of shipment by fishermen)
	Tega swamp	Stone moroko (Pseudorasbora parva) (voluntary restraint of shipment)

		Crucian carp (Carassius carassius) (voluntary restraint of shipment)
		(Note) Shipment of all kinds of fish and shellfish is voluntarily restrained by Fishery Association.
	The Tone River bordering Chiba Prefecture (the upstream from estuary barrage)	Silver crucian carp (Carassius auratus langsdorfii) (voluntary restraint of shipment)
		Eel (Anguilla japonica) (voluntary restraint of shipment)
		(Note) Shipment of all species of fish and shellfish except for Freshwater prawn (Macrobrachium) is voluntarily restrained by Fishery Association.
	The Edo River（Ichikawa city）	Eel (Anguilla japonica) (voluntary restraint of shipment)
Tokyo Metropolis	The Edo River, The former Edo River(excluding ertuary), and The Shinnaka River	Eel (Anguilla japonica) (voluntary restraint of shipment)

III. Livestock products

Products subject to request of shipment/intake restraint

Designated Areas		Designated Products	
		shipment	intake
Iwate Prefecture	The whole area	Cattle (moving from other prefecture (except for those less than 12 months old) and shipping to slaughterhouses), excluding cattle controlled under the shipment and inspection policy set by the Iwate prefectural government	
Miyagi Prefecture	The whole area	Cattle (moving from other prefectures (except for those less than 12 months old) and shipping to slaughterhouses), excluding cattle controlled under the shipment and inspection policy set by the Miyagi prefectural government	
Fukushima Prefecture	Tamura city (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station); Minamisoma city (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station and the following districts: Haramachi-ku Takanokura-ji Suketsune, Fukiyatouge, Nanakyoku, Mori and Garekimori; Haramachi-ku Baba-ji Godaisan, Yokogawa and Yakushidake; Haramachi-ku Katakura-ji Namedzu; and Haramachi-ku Ohara-ji Wadajo); Kawamata town	Raw milk	

	(limited to the Yamakiya district); Naraha town (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station); Tomioka Town; Okuma town; Futaba town; Namie town; Kawauchi village (limited to within a 20-kilometer radius of Fukushima Nuclear Power Station); Katsurao village; and Iitate village		
	The whole area	Cattle (moving from other prefecture (except for those less than 12 months old) and shipping to slaughterhouses), excluding cattle controlled under the shipment and inspection policy set by the Fukushima prefectural government	
Tochigi Prefecture	The whole area	Cattle (moving from other prefecture (except for those less than 12 months old) and shipping to slaughterhouses), excluding cattle controlled under the shipment and inspection policy set by the Tochigi prefectural government	