Assessments of preparedness, agri-food impacts and implications for disaster risk management of Fukushima nuclear disaster

Bachev, Hrabrin

Institute of Agricultural Economics, Sofia

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Hrabrin BACHEV

Institute of Agricultural Economics, Sofia

Abstract. On March 11, 2011 the strongest ever recorded in Japan earthquake occurred which triggered a powerful tsunami and caused a nuclear accident in Fukushima nuclear plant. The later was a "man-made" disaster having immense impacts on people's life, health and property, infrastructure, supply chains, economy, policies, natural and institutional environment, etc. This paper assesses preparedness for and agri-food impacts of the Fukushima nuclear disaster, identifies challenges in post-disaster recovery, and withdraws lessons for improving disaster risk management. Japan was not well prepared for such huge disaster while agri-food sector and consumption have been among the worst hit areas. The triple disaster was a rare but a high impact event, therefore, it is necessary to "prepare for unexpected". Risk assessment is to include diverse hazards and multiple effects of a likely disaster, it is to be discussed with all stakeholders, and measures taken to educate and train all for complex disasters. It is necessary to modernize property rights, regulations, safety standards, and norms, enhance capability of responsible public authorities and improve coordination between divers actors. It is important to set up mechanisms for effective public resource allocation and reduction of agents' costs. Different elements of agri-food chain have dissimilar capability requiring differential public support. There is a strong "regional" interdependency of agrarian, food and rural assets (and damages), and it is important to properly locate risk and take prevention and recover measures. Disaster response demonstrated the important role of small scale farms and food organizations, and high efficiency of private, market and collective governance. Before, during and after a disaster all available information from all sources is to be immediately publicized in understandable form through all possible means. Disaster provides opportunity to discuss, introduce and implement fundamental changes in agricultural, economic, regional, energy, disaster management, etc. policies. It is important to learn from the past experiences and make sure that "lessons learned" are not forgotten.

Keywords. Fukushima, nuclear accident, agri-food impact, risk management

1. Introduction

On March 11, 2011 a mega thrust undersea earthquake with a magnitude of 9.0 Megawatt (Mw) occurred off the Pacific coast of Japan widely known as the Great East Japan Earthquake (GEJE). The earthquake was the most powerful earthquake ever recorded in or around Japan, and the fourth most powerful earthquake in the world since 1900 [Japan Meteorological Agency, 2013]. GEJE triggered powerful tsunamis and a coastal area surpassing 400 km was hit by tsunami higher than 10 m that submerged plane areas more than 5 km inland (Picture 1). The earthquake and the tsunami caused a nuclear accident in one of the world's biggest nuclear power stations - the Fukushima Daiichi Nuclear Power Plant, Fukushima prefecture (Picture 2). The tsunami arrived at the plant station around 50 minutes after the initial earthquake as the 14-meter-high tsunami overwhelmed the plant's seawalls and damaged cooling and control systems. Three out of the six reactors suffered large explosions and level 7 meltdowns occurred leading to releases of huge radioactivity into the environment [Nuclear Regulation Authority, 2014]. Radioactive contamination from the nuclear plant has spread in the region and beyond

though air, rains, dust, water circulations, wildlife, garbage disposals, transportation, and affected soils, waters, plants, animals, infrastructure, and population.

Picture 1. Tsunami caused by the Great East Japan Earthquake, March 2011

Picture 2. Nuclear Disaster at Fukushima Daiichi Nuclear Power Plant, March 2011

The Fukushima nuclear accident has been having immense impacts on people's life, health and property, social infrastructure, economy, policies, natural and institutional environment, etc. in the affected regions, Japan, and beyond [Akiyama et al., 2012; Al-Badri and Berends, 2013; Bachev, 2014; Barletta et. Al. 2016; Belyakov, 2015; Buesseler, 2014; Fujita et al., 2012; IBRD, 2012; IRSN, 2012; MHLW, 2013; Nomura and Hokugo 2013; WHO, 2013]. Japanese agriculture, food industry and agri-food consumption have been among the worst hit areas [Bachev and Ito, 2014, 2018; FAO/IAEA, 2018; Hamada and Ogino, 2012; JFC, 2011-2014; Johnson, 2011; Koyama, 2013; Kunii et al., 2018; Monma et al., 2015; Nakanishi and Tanoi, 2013; Nakanishi, 2018; Oka, 2012; Sekizawa, 2013; Todo et al., 2015; Ujiie, 2012; Watanabe, 2013]. This study tries to assess preparedness for and long-term agri-food impacts of the Fukushima nuclear disaster, identify challenges in post-disaster recovery and reconstruction, and withdraw lessons for improving disaster risk management in Japan and around the globe.

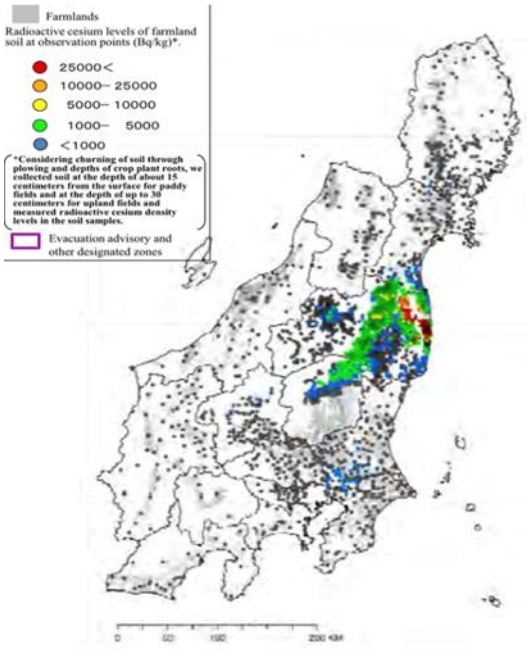
2. Preparedness and Agri-food Impacts Assessment

The agri-food sector of Japan was not well prepared for such a big disaster and it has been badly affected by the accident. The adverse long-term effects on agriculture, food industries and food consumption have been in a number of directions:

First, enormous production and income reduction due to radiation contamination, (mandatory and voluntary) shipment restrictions, increased input supply, production and marketing costs, higher costs for adaptation and implementation of new safety standards, and diminished market demands and prices of farm and agri-food products. Almost 55% of the Japanese farms reported they were affected negatively by the triple disaster [JFC, 2013]. In the worst hit Iwate, Miyagi, Fukushima, Ibaraki, Tochigi, Gunma, and Chiba prefectures almost 90% all farms suffered as "prices decline" and "harmful rumors" pointed as the main reason for the negative impact. The annual loss of income from the nuclear accident in Fukushima prefecture alone is estimated to be around 100 billion JPY [MAFF, 2013]. Damages to agriculture have been particularly big in areas around the Fukushima nuclear plant, where farming and related activity has been suspended or significantly reduced. Implemented evacuation zone comprises 8% of the total number of farmers and 9% of agricultural lands of Fukushima prefecture [MAFF, 2012]. What is more, the effective resumption of operations in mostly affected by the GEJE Iwate, Miyagi and Fukushima prefectures is deterred by the impact of nuclear accident, unavailable arable land, facilities and equipment, undecided place of settlement, and funding problems [MAFF, 2015]. What is more the importance of the nuclear crisis as a factor for "not resuming farming" has increased. Similarly, 58% of the food companies in Japan were severely affected by the Fukushima disaster due to canceled orders, reduced demands, sales and prices, and increased costs of input supply, including 82% of the companies in Northern Kanto and Eastern Tohoku, and 94% in Fukushima prefecture [JFC, 2014]. A year after the accident less than 50% of the pre-disasters operations were reported in around 48% of the affected companies.

Second, there has been radioactive contamination of farmlands, agrarian assents and important infrastructure from the nuclear accident's fallout (Map 1). Long-lived radioactive cesium has contaminated 30,000 km2 or around 8% of the land surface of Japan as almost 40% of it with radiation exceeding official allowable level [MECSST, 2011]. Heavily contaminated areas are located in 101 municipalities of 8 prefectures as farmlands contamination with cesium ranges from 16 to 56,600 Bq/kg [MAFF, 2013]. There have been huge public and private costs associated with cleaning of farmlands and other agrarian assets. In Fukushima prefectures the restoration of farming operations has been progressing slowly while some heavily contaminated areas would require a long time before farming resumes [MAFF, 2017]. Agriculture and agri-business have been a major employer for family and non-family labor in the affected regions, and after the accident a great number of workers lost temporary or permanently employment (and income) opportunities in these important sectors. Furthermore, many farms livelihood and businesses have been severely destructed as a result of loss of lives, injuries and displacement, and considerable damages on property (farmland, crops, livestock, homes, material assets, intangibles such as established brands, good reputation, etc.), related infrastructure, and community and business relations. Therefore, much of the overall damages from the Fukushima nuclear disaster on farmers' livelihood and possessions, physical and mental health, environment, lost community relations etc. can hardly be evaluated in quantitative terms [Bachev and Ito, 2013].

Map 1. Farmlands radioactive contamination in Japan, 2011



Third, up to the Fukushima nuclear plant accident there had been no adequate system for agri-food radiation regulation and inspection to guarantee food safety in the country [MAFF, 2011]. Immediately after the nuclear accident the government introduced Provisional regulatory limits for radionuclides in agri-food products, while in 2012 food safety standards were upgraded to the world's strictest. Widespread inspections on radiation contamination have been introduced, and numerous (mandatory and voluntary) production, shipment and consumption restrictions on agri-food products imposed. Regular vigorous radiation tests are carried out on a great number of agri-food products in 17 vulnerable prefectures, including all rice bags produced in Fukushima prefecture. There have also emerged many private and collective inspections systems introduced by farmers and rural associations, food processors, retailers, local authorities, consumer organizations, independent agents etc. some employing stricter than official food safety norms. There are still a number of products from contaminated areas of 17 prefectures, which are subject to mandatory or voluntary shipment restrains (outside Fukushima they mostly cover mushrooms, wild plants, and fish). As a result of undertaken measures, the number of agri-food items with level exceeding the official safety standards diminished to zero in all groups but mushrooms and wild plants, fishery products, and wild bird and animal meat (Table 1). Modernization of the food safety system in Japan has taken some time, and it has been associated with enormous public and private concerns, debates and costs.

Table 1. Ratio of inspected agricultural products in Japan exceeding official safety limit (%)

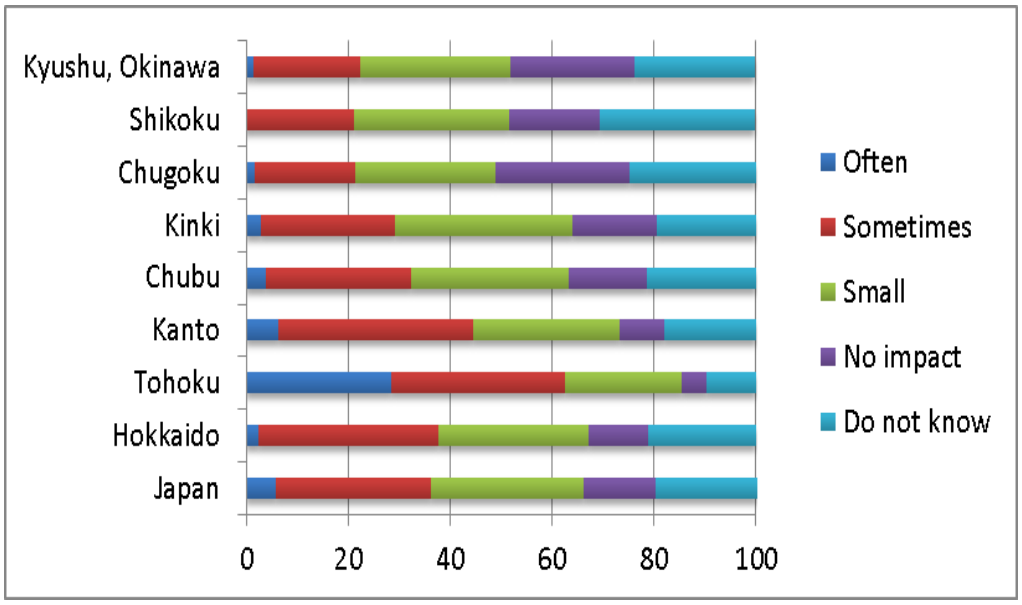
Items	FY2011	FY2016
1. Rice	2,2	0
2. Vegetables	3	0
3. Fruits	7,7	0
4. Legume	2,3	0
5. Tea	8,6	0
6. Raw milk	0,4	0
7. Beef	1,3	0
8. Pork, poultry and eggs	0,7	0
9. Mushrooms and wild plants	20,2	0,7
10. Fishery products	17,2	0,1
11. Wild bird and animal meat	62,4	22,1

Source: Ministry of Health, Labor and Welfare

Fourth, in the days after the nuclear disaster there was destruction of supply of potable water, foods and other necessities in most affected regions [MAFF, 2011]. Unprecedented for modern history of Japan food shortages was prevailing across the disaster areas and big cities like Tokyo. "Normal" food supply to all affected people was quickly restored and important infrastructure (production and storage facilities, wholesale markets, transportation network, etc.) rebuilt. Nevertheless, there have been numerous restrictions on production, sells, shipments and consumption of basic agri-food products in the affected regions which stopped, delayed or significantly reduced the effective supply of a great range of local products (Figure 1). Furthermore, due to genuine or perceived health risk many consumers stop buying agricultural, fishery and food products originated from "Northern Honshu". Even in cases when it was proven that food is safe some wholesale traders, processors and consumers restrain buying products from the contaminated areas [MAFF, 2012]. That was a result of lack of sufficient capabilities in the inspection system, inappropriate restrictions (initially covering all shipments in a prefecture rather than from contaminated localities), revealed rare incidences of contamination in commonly safe origins, low confidence in the official "safety" limits and inspections, lack of good communication, harmful rumors ("Fu-hyo"), or not authentic character of traded products [Bachev and Ito, 2018]. The "reputation damage" has been particularly important for many traditional farm produces (rice, fruits, vegetables, mushrooms, milk, butter, beef, etc.) from the worst affected regions which demand and prices significantly declined [Koyama, 2013]. Demands for Fukushima, Ibaraki and Northern Honshu purchase agri-food products have been recovering but still a good proportion of consumers select the region of agro-food products buying "rarely" or "not at all" from the affected regions because "worry about safety" [JFC, 2014]. Many concern consumers continue to disbelieve in the

existing inspection system and employ other ways to procure safe food – direct sales, sales contracts, origins, imports, etc.

Figure 1. Purchase of foodstuffs produced in areas affected by Great East Japan Earthquake (including eating out), 2014



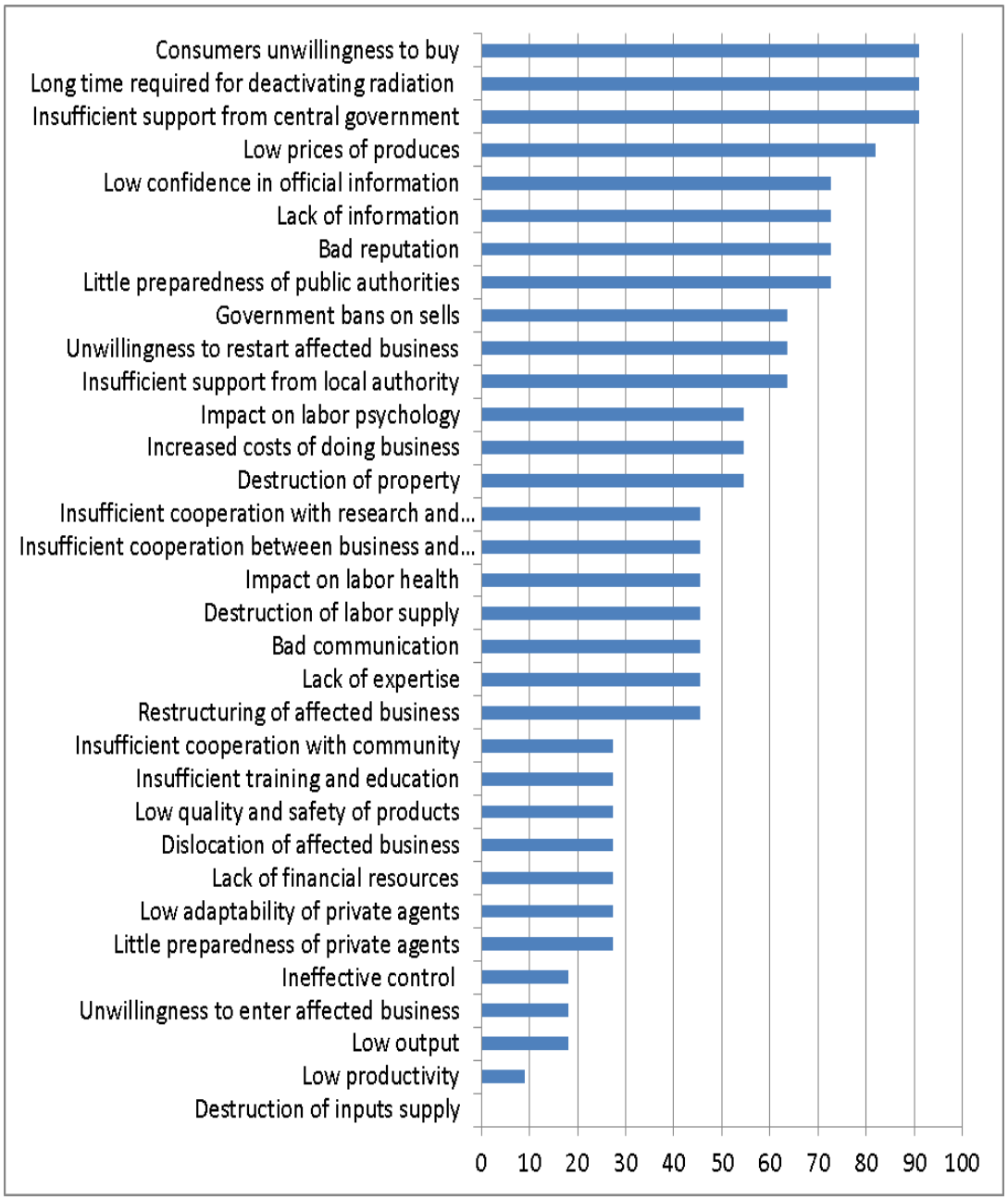
Fifth, the nuclear accident has adversely affected international trade as 40 countries imposed restrictions on agri-food import from Japan, including major importer such China, United States, Indonesia, Malaysia and South Korea. Gradually many countries eased import restrictions from Japan but still keeping restrictions for products from Fukushima prefecture as radioactive test certificates are required [MAFF, 2017].

Sixth, the 2011 disasters have some positive effects on agri-food sector as well especially for some farmers and agri-businesses from non-contaminated regions which saw their prices, demands, production and sales opportunities increased. Furthermore, there has been a boom in technological, product and organizational innovations, and growth of new sectors such as radiation testing, decontamination, energy saving, renewable (solar, wind, biofuel) energy, nuclear safety, debris cleaning, processing and disposal, research and development, robotics, ITC, no-soil and solar sharing farming etc. with huge investments of leading players and state, numerous new comers, joint ventures, etc. All they created new employment and income opportunities in the affected regions and around the country.

According to the leading experts in the area the major factors for long-term persistence of the nuclear accident's negative impacts on agriculture are: consumers' unwillingness to buy, long time required for deactivating radiation, insufficient support from the central government, low prices of produce, low confidence in official information, lack of information, bad reputation, and little preparedness of public authorities [Bachev and Ito, 2018]. The most important factors for sustaining of the negative impacts of the nuclear disaster on food industries are: lack of information, consumers' unwillingness to buy, long time required for deactivating radiation, little preparedness of public authorities, bad reputation, insufficient support from the central government, and low confidence in official information. The most important factors for the persistence of negative impacts of the nuclear disaster on food consumption are: lack of

information, low confidence in official information, insufficient support from the central government, and bad reputation.

Figure 2. Factors for persistence of agrarian negative impacts of Fukushima nuclear disaster (%)

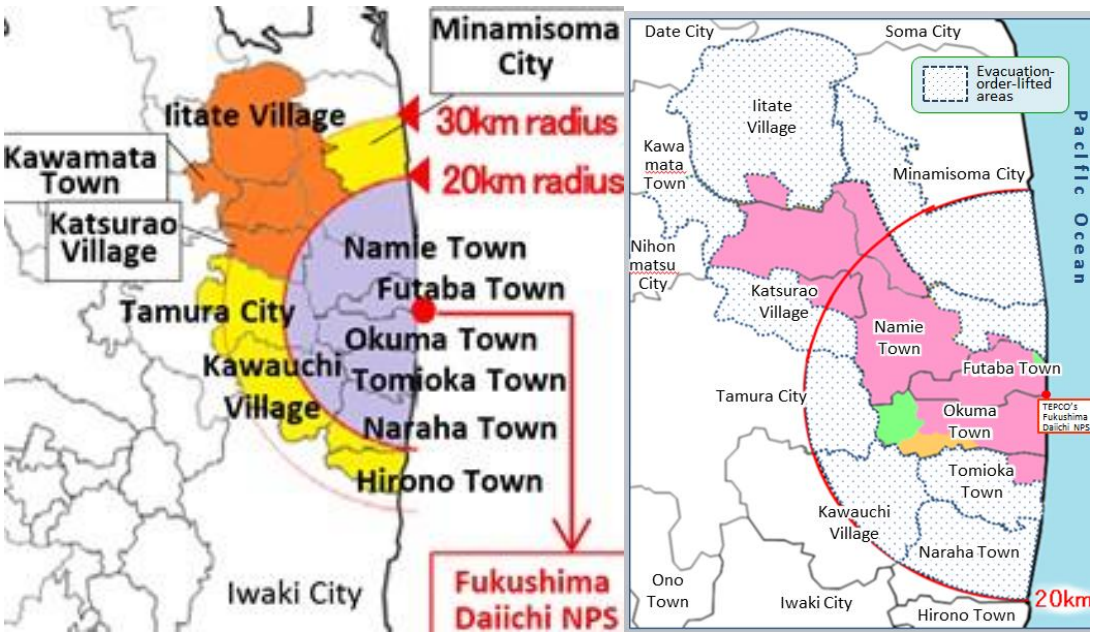


Source: Experts assessment 2017

3. Major Challenges in Disaster Recovery

After the nuclear disaster a large scale evacuation affecting almost 9% of Fukushima prefecture population was carried out. Despite that evacuation areas and number of evacuees gradually decreased (Map 2) the "evacuation designated zones" still covers 371 km2 (2,7% of territory of Fukushima prefecture) while nearly 45000 Fukushima residents (2,4% of total) continue to live as evacuees, including 75% in other prefectures [FPG, 2018].

Map 2. Evacuation zones in 2011 and 2018



Source: Fukushima Prefectural Government

Evacuation and reconstruction have been associated with number of challenges: failure for timely evacuation from certain highly contaminated areas, slow response of authorities, lack of sufficient public information in the first stages of the disaster, mistrust to public and private institutions, multiple displacements of many evacuees, divided communities and families, bad communication between different organizations, lack of financial resources, insufficient manpower and building materials, ineffective use of public funds, discrimination toward some evacuees, emotional conflicts between evacuees (about "self-evacuation", compensations, rebuilding modes), insufficient and unequal compensation, unequal decontamination and economic recovery of individual sectors (fast of construction industry, slow for farming, services, food processing and fishery) and regions (much slower for Fukushima), workers moving away from agriculture and fishery, unequal payment for work in traditional local industries and government's emergency employment program, substandard labor conditions for decontamination workers, increased number of individual and organized criminal cases, population decline due to out-migration, long-time to obtain local consent for reconstruction plans, problems for attracting contractors, difficulties of land acquisition for building cities, spikes in construction material prices and manpower shortages, and lack of contractors, numerous lawsuits against TEPCO and authorities, delay in establishing the Reconstruction Agency (February 2012) for coordinating multiple recovery efforts in affected areas, lack of clear government guidelines for the nuclear disaster recovery, revisions in national energy, disaster prevention etc. policies, lack of detailed contamination map for all affected agricultural lands, using extension officers in affected areas for obtaining samples for monitoring tests while suppressing their ability of consulting, introducing technology, and educating in areas of production badly needed, etc. [Bachev and Ito, 2018]. By end 2014 about 70% of monitored 58 municipalities in 7 prefectures completed or almost completed decontamination, remaining

failed to meet deadline as 12 towns sought extensions up to 3 years while certain heavily contaminated areas stayed untouched.

Many evacuees, especially younger generation, refuse to return back even after decontamination is completed because of the persisting high radiation in forests around houses and existing hot spots, health risk, destructed business and community infrastructure (shops, schools, medical facilities), established life and business in other areas, etc. Major reasons for the slow progress are: delayed reconstruction, a slow pace of lands decontamination, existing hotspots, restricted mobility in evacuated areas, calls for more decontamination, difficulties in safe disposal of contaminated soil and debris, population fears regarding radiation hazards, concern about safety of intermediate nuclear waste storage facility, lack of job opportunities, destructed business, unrestored critical services and infrastructure, absence of communities consensus for certain projects, uncertainty for future developments, etc.

Insufficient decontamination of farmland and irrigation canals, decreased motivation among farmers, and local anxiety over rumors about contaminated produce are major reasons for low resumption rate of farming in the evacuation zone. It has been also difficult to farm efficiently (e.g. water control in paddy fields) since farmers were not allowed to stay permanently, there has been uncertainty associated with marketing of output (high contamination, consumer unwillingness to buy), and radioactive water runoff from mountains to reservoirs and paddy fields.

Improved food safety measures have let the Fukushima agri-food products to become one of "most secure in the world". Nevertheless, enormous public and private actions to increase safety and transparency measures, and huge promotion campaigns, have not recover consumer trust. Demand for agri-food products from the affected region in Japan and internationally stays low. "Reputation damage" persists due to the lack of sufficient capabilities in inspection system, inappropriate restrictions (initially covering all shipments in a prefecture rather than from contaminated localities), revealed rare incidences of contamination in commonly safe origins, low confidence in official "safety" limits and inspections, lack of good communication, harmful rumors, not authentic character of traded products, etc. Demands for Fukushima, Ibaraki and Northern Honshu agricultural products has been recovering fast while the farm-gate and wholesale prices lower than in the other parts of the country. That is a consequence of the increased number of inspections, reduction of radioactive contaminations, improving consumer confidence on inspection and safety, "forgetting" contamination issue by some part of population, preferences to lower prices regardless quality by some consumers, changing marketing strategies of processors and smaller shops (not promoting/labeling anymore some products as "Fukushima origin"), increasing procurement by restaurants and processors from the region, etc.

There have a number of challenges with the present safety inspection system. Due to the lack of personnel, expertise, and high-precision equipment, the water, food and soil tests have not always been accurate, consistent and comprehensive. Very expensive high-precision instruments are not available everywhere to measure lower radiation levels set up by the new regulation (detecting single-digit levels in water, food). Food safety inspections are basically carried out at distribution stage (output for shipment or export), and do not (completely) cover produces for farmers' markets, direct sells, food exchanges and self-consumption. Capability for radiation safety control in Fukushima prefecture is high while in other prefectures strict

tests are not carried out at all and contamination has “no administrative borders”. Many of privately and collective testing equipment are not with high precision, and/or samples are properly prepared for analysis by inexperienced farmers. There are considerable discrepancies in measurements of radiation levels (air, food) done by different entities in a specific location. Consequently, certain sold and consumed products are labeled as safe despite contamination. Some tested agricultural products are further cooked or dried reaching higher levels of radiation during consumption.

Agri-food inspections, regulations and countermeasures are conducted in vertically segmented administrations with “own” policies and not (well)coordinated procedures - soil contamination surveys and inspection of agricultural produce by MAFF, monitoring of air radiation levels by MECSST, regulations on food safety standards and value determination by MHLW, decontamination and waste disposal by ME, training associated with food safety by CAA, and restoration and decontamination by RA. 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). Neither there is a common framework for centralizing and sharing all related information and making it available to interested parties and public.

Officially applied “area based” system for shipment restrictions is harming many farmers producing safe commodities, instead of area-wide blanket lifting a permit shipment by selected farmers would be more appropriate. System extending random sampling tests of circulating produce (shipment level) with management/control at production “planning” stage is suggested. According to most agents the biggest hurdle is the lack of a clear radiation risk standard that can be universally accepted. There have been on-going discussions among experts about “safety limits” and lack of agreement confuses producers and consumers.

Another challenge of inspection system is the costs for local authorities, farmers, food industry, etc. Fukushima prefectural government maintains the number of tested items, funding is expected to deplete while the central government decreases screened items number. Much of testing inspection costs of cooperatives, farmers, food processors etc. are not compensated.

There a challenges with emerging new technologies and organizational modes – for plant factories they are high building and running costs, difficulties in cultivation technique, human development, food certification system (fertilizers are used to water), needs for stable marketing through integration, etc. New organization forms usually require entrepreneurship, collective actions (lands consolidation, cooperation), big investment, taking over by non-agrarian capital/entities, which are not always available, well-accepted or legitimate.

Another challenge is the health risk for population caused by radiation exposure. Thanks to the timely undertaken measures (warnings, protection, evacuation, monitoring, decontamination, food inspections, treatment), radiation levels for the general population have been well below the norms required to damage health. Latest air dose rates around the country and within critical places in Fukushima prefecture is higher than before disaster but comparable with major cities overseas [FPG, 2018]. Surveys in most affected regions indicate that the annual radiation intakes from foods have been less than 1% of the maximum allowed and decreasing over time [MHLW, 2018].

In 2011 the official "safe" radiation exposure levels were drastically increased from 1 mSv to 20 mSv per year. There have been debates and great concerns about the health effects from cumulative exposure above and within official limit. That worries are enforced by the controversial opinions of experts, slow process of decontamination in some areas and ecosystems, unresolved issue with safe disposal of contaminated debris in certain areas, deficiency of the food safety control systems, continuing radiation leakages in the nuclear plant. Since the accident complains and hospitalization has been increasing in Fukushima prefecture [Bachev and Ito, 2018]. It is believed that health effects of the radiation release are "primarily psychological rather than physical". Many consumers and producers "lose peace of mind" having food with (lower than official safety limit but nevertheless) radiation contamination. Uptake of radioactive materials with food by local residents increases during summer season when mostly fresh vegetables and fruits are consumed. Despite "safe" level cooking and drying of some ingredients also increases radiation concentration. Besides, there are untested wild plants or home produced food widely consumed by locals. Long periods of evacuee life, lost property and employment have caused many people to grow isolated or develop physical or mental (stress, anxiety) problems. "Disaster related deaths" are also growing reaching several thousands, majority being from Fukushima prefecture. Nevertheless, it is becoming increasingly difficult to identify relationships between health problems/deaths and nuclear accident due to the long period of time.

Since October 2011 by end of March 2018, TEPCO paid more than ¥8 trillion in compensation related to Fukushima accident, half to individuals and another one to businesses [Brasor and Tsubuku, 2018]. Payouts officially ended but there are thousands individual and collective claimants seeking or disputing compensations from TEPCO or authorities through court or other ways. Estimated amount of compensation has been growing up each time the governmental panel issues new guidelines. Number of false claims and swindling compensation funds for millions of yens are also reported.

Progress in compensation payments has been slow and uneven due to delays in TEPCO's review process, demands for further documentation, lack of sufficient funds, multiple disputes, etc. Major problems related to compensation in agri-food sectors are: great paper works; lengthily negotiation; delays in payments; not paying full amount claimed; disputing accident origin of damages; denying claims when production and distribution are restrained voluntarily; farmland, farming property and discontinuation of business damage uncompensated; disagreements over compensation "closing date; insufficient amount to restart farming or sustain consumption; inspection, administrative, radiation map preparation, etc. costs of organizations not compensated; support for damages not clearly specified in guidelines; negotiation asymmetry for farmers who did not market through cooperatives; high lawyers costs; "safety tests" costs of farmers and consumer associations not compensated; lack of clarity how certain claims will be compensated; cash-flow difficulties and interest payments; uniform compensation "per 10 are" while differences in amount of products, discrepancies in method (organic, conventional), unlike value added of produce, etc.

Furthermore, there is still uncertainty about the full costs related to the nuclear accident since their level has been expanding constantly. Initial government estimates (2014) were that it would take ¥11.16 trillion and 40 years to clean up the Fukushima site, including 2,5 trillion for decontamination, 1,1 trillion for interim storage facilities, 2 trillion for reactor decommissioning and contaminated water treatment, and 5 trillion for compensation from

TEPCO. In 2018 compensation payments are already more than ¥8 trillion while budget for decontamination ¥2.9 trillion [ME, 2018]. Process of decommissioning the nuclear reactors is at the beginning stage and associated with many challenges - lack of experiences, available technologies, uncertainties and risks, failures, public concerns, lack of disposal site, etc.

For a long-period generated during decontamination soil, leafs, mud, and other radioactive waste amounting 16-22 mil.m3 has been stored in thousands "temporary" storage sites across Fukushima and 12 other prefectures [ME, 2018]. "Designated waste" containing radioactive substances measuring more than 8000 Bq/kg is 143,689 tons. New temporary (up to 30 years) storage facilities for radioactive waste near the nuclear plant operates since 2017 where merely 513 m3 are transported. A site for the final disposal of radioactive waste outside of Fukushima prefecture has not been chosen yet since local residents strongly oppose to construction of facilities - fears about radiation, environmental threat, risk that agro-products will become unsellable.

After the nuclear accident all 54 nuclear reactors in Japan were shut down for stress tests and complying to new (2013) world's strictest safety standards. Until 2018 only 5 nuclear plants (9 reactors) resumed operations due to lack of readiness, uncompleted formal procedures and strong opposition by local governments and communities. Consequently, experts find official estimates "over-optimistic" predicting that nuclear disaster costs will increase further and become as high as national annual tax - ¥43 trillion [Okuyama, 2014].

Government report points out that the release of radioactive materials following the Fukushima nuclear accident remains Japan's biggest environmental problem. According to some experts undertaken large-scale decontamination creates new environmental problems such as: huge amounts of radioactive waste, removal of top soil, damage to wildlife habitat and soil fertility, increased erosion on scraped bare hillsides and forests, and intrusion by people and machinery into every ecosystem scheduled for remediation. All these difficulties and uncertainties make it difficult to access the full environmental impact nuclear disaster, and require a long-term monitoring and actions [ME, 2018].

4. Lessons from Japanese experiences

There are a number of lessons that can be learned from the assessment of agri-food sector readiness, impacts and recovery from the nuclear disaster in Japan:

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

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

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

- It is necessary to modernize the specific and overall formal institutional environment (property rights, regulations, safety standards, norms) according to the needs of contemporary disaster risk management. A particular attention is to be put on updating agri-food safety, labor, health, and animal welfare standards, and ensure adequate mechanisms, qualified agents, and technical instruments for effective implementation and enforcement. Agri-food inspection system is to be improved by creating uniform inspection manuals and standards, enhancing coordination and avoiding duplication between different organizations, establishing inspection framework prefectural borders, and management system extending random sampling tests of marketed produce with management and control at production "planning" stage.

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

- Different agents and elements of agri-food chain are affected unlikely from a disaster and have dissimilar capability to recover. Most farming assets (multiannual crops, irrigation facilities, building, brands, biodiversity, landscape) are interlinked with land, and if land is

damaged a rapid recovery (rebuilding, relocation, alternative supply) is very costly or impossible. Smaller-scale and highly specialized enterprises, small-member communities and organizations, visitors and tourists to disaster regions, are more vulnerable and have less ability to protect, bear consequences and recover. All that require differential public support (intervention, compensation, funding, assistance) to various types of agents it order to provide emergency relief, accelerate recovery and diminish negative long-term consequences.

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

- Establishment of accessible cooperative, quasi-public or public agricultural (crop, livestock, machineries, building, life and health) insurance system, including assurance against big natural, nuclear etc. disasters is very important for rapid recovery of affected agents and sectors. Modernization of the out of dated (often informal) lands, material, biological and intellectual property registration and valorization system is important for effective post disaster compensation, recovery and reconstruction. That is particularly true for great number of subsistent and "semi-market" holdings dominating the agro-food sector around the globe, which usually suffer significantly from disasters (often losing all possessions) but get no market valuation, insurance and/or public support.

- Specific responses to 2011 disasters have highlighted the comparative advantages of traditional communities and non-governmental organizations, and certain less "efficient" but more resilient structures (small operators, partnerships) and sectors (one season crops, poultry, pig, processing). Important role of small scale farm and food organizations, informal networks and leadership has been proven immediately after accident now in rapid agri-food supply, securing food safety and transparency, effective (self)recovery, reconstruction, technological and organizational innovations, networking, decentralized actions, etc. These governing modes have to be included in the disaster management system, relevant actors properly trained and appropriate responsibilities assigned.

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

systematized way (updates, diverse aspects, unified measurement, time series, alternative sources), which make many foreigners and local skeptical about accuracy.

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

- Importance of international cooperation in all areas has been repeatedly proven in post disaster recovery, decontamination and reconstruction, etc. through sharing information, knowledge, expertise, know-how, specialized equipment, etc. It is particularly crucial to share internationally advance Japanese experience through media, visits, studies, conferences, etc. and turn Fukushima (Tohoku) in a disaster risk management hub for other regions and countries. It is essential not to copy but adapt the positive Japanese experiences to the specific (institutional, cultural, natural) environment and risks structure of each community, subsector, region, and country.

- It is important to learn from the past experiences and make sure that "lessons learned" are not forgotten. Impacts and factors of a disaster, disaster management, and post disaster reconstruction are to be continuously studied, knowledge communicated to public, and "transferred" to next generation. It is critical to share "good" and "bad" experiences with disaster prevention, management and recovery with other regions and countries, in order to prevent that happening again.

5. Conclusion

Almost eight years after Fukushima nuclear disaster there are still a number of challenges associated with the recovery and reconstruction in the region and elsewhere. They are mostly related with a big number of evacuees with destructed life and businesses, continuing outmigration from the badly affected areas, slow pace of rebuilding of devastated infrastructure, housings and businesses, prolong decontamination process, on-going crises in Fukushima nuclear plant, consumer reluctance to visit and buy products of affected regions, etc. Speed and extent of disaster recovery and post-disaster reconstruction differ quite substantially among individual agents, (sub)sectors, and (sub)regions. Besides, there are great uncertainties associated with the long-term social, health, economic, environmental, policy etc. consequences of the nuclear disaster.

Agriculture, food industry and food consumption have been among the worst hit by the disasters areas. Agri-food sectors of Fukushima, Miyagi and Iwate prefectures have been particularly severely affected in the short and longer term. There are also significant adverse consequences on other (neighboring) regions and entire food chains at a larger (regional, national, international) scale.

There is a great variation of the specific impacts of the nuclear disaster on different type of farming and business enterprises (small-big scale, specialized, diversified, integrated), particular agents (producers, processors, distributors, consumers, community and public

organizations), individual sub-sectors (rice, vegetables, beef), and specific locations (evacuation zone, seaside). Moreover, there have been enormous damages and long-term consequences on farming and rural households, important properties (farmland, livestock, orchards), personal ties, established brands, informal organizations and traditional communities. Many of all these negative effects can hardly be adequately expressed in quantitative (e.g. monetary) terms. In addition, 2011 disasters have considerably aggravated some already existing problems of the agrarian and rural regions such as: aging and shrinking population, lack of labor and young entrepreneurs, low competitiveness and efficiency, income and services disparities, etc.

The specific responses to the 2011 disasters have highlighted the comparative advantages of traditional communities and non-governmental organizations, and certain less "efficient" but more resilient structures, and had positive impacts on development of certain (more resilient, adaptive) sectors in most affected regions and some (traditional, prospective) sectors in other parts of the country.

The post disaster recovery and reconstruction have given opportunities and induced considerable policies and institutional modernization in agrarian and other (e.g. energy, security) sectors, and improve disaster prevention and management, food safety information and inspection, technological and product innovation, jobs creation and investment (including in "new" areas such as research and innovation, ICT, renewable energy, robotization), farmlands consolidation and enhancement, infrastructural amelioration, organizational restructuring, etc.

This study is just a new attempt to assess disaster management readiness, impacts of nuclear accident, and lessons for agriculture and food chains. Understandably research is incomplete due to the "short" period of time after the disaster, insufficient and controversial data, difficulties to adequately assess longer term implications, etc. Therefore, more in depth and interdisciplinary studies are necessary to evaluate overall impacts and improve disaster risk management system.

References

A. Belyakov, From Chernobyl to Fukushima: an interdisciplinary framework for managing and communicating food security risks after nuclear plant accidents, Journal of Environmental Studies and Sciences, Vol. 5, Issue 3 (2015), 404-417.

D. Al-Badri and G. Berends (eds.), After the Great East Japan Earthquake: Political and Policy Change in Post- Fukushima Japan, Nordic Institute of Asian Studies Press, Copenhagen, 2013.

H. Bachev, Socio-economic and environmental impacts of March 2011 earthquake, tsunami and Fukushima nuclear accident in Japan, Journal of Environmental Management and Tourism, 5 (2014), 127-222.

Bachev H. (2014): Environmental Management in Agriculture, Mechanisms, Forms and Efficiency, LAP LAMBERT Academic Publishing.

Bachev H. and F.Ito (2013): Impact of Fukushima Nuclear Disaster on Agrifood Chains in Japan, The IUP Journal of Supply Chain Management, Vol.X, 4, 7-52.

Bachev H. and F.Ito (2013): Impacts of Fukushima Nuclear Disaster on Japanese Agriculture and Food Chains, P. Gorawala and S.i Mandhatri (editors), Agricultural Research Updates, Vol. 6, 1-75, New York: Nova Science Publisher, 1-76.

Bachev H. and F. Ito (2015): Agri-food sector impact of March 2011 earthquake and tsunami in Northeastern Japan, Trends Journal of Sciences Research, 1 (1), 21-38.

Bachev H. and F. Ito (2015): March 2011 earthquake, tsunami and nuclear accident impacts on Japanese agri-food chains, IUP Journal of Supply Chain Management, Vol. XII, No. 1, 1-40.

Bachev H. and F. Ito (2015): March 2011 Earthquake, Tsunami, and Fukushima Nuclear Disaster. Impacts on Japanese Agriculture and Food Sector. LAP LAMBERT Academic Publishing.

Bachev H. and F. Ito (2016): Socio-economic impacts of the march 2011 earthquake, tsunami and nuclear accident on agri-food chains in Japan, Economic Tought, 3, 67-90.

Hrabrin Bachev and Fusao Ito (2018): Agricultural Impact of the Great East Japan Earthquake - Six Years Later, KSP Books.

H. Bachev and F.Ito, Implications of Fukushima Nuclear Disaster for Japanese Agri-food Chains, International Journal of Food and Agricultural Economics, 2 (2014), 95-120.

H. Bachev and F. Ito, Agricultural Impact of the Great East Japan Earthquake - Six Years Later, KSP Books, Istanbul, 2018.

FAO/IAEA, Joint Division Questions & Answers - Nuclear Emergency Response for Food and Agriculture, Joint FAO/IAEA Program, http://www-naweb.iaea.org/nafa/faqs-food-agriculture.html

FPG, Fukushima Prefectural Government, 2018 http://www.pref.fukushima.lg.jp/site/portal-english/

J. Sekizawa, Appropriate Risk Governance on Radionuclide Contamination in Food in Japan, in S. Ikeda and Y. Maeda (eds), 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, 2013.

JFC, Findings on the impact of the earthquake on food industry, 2011- 2013 surveys, Japan Finance Corporation, Tokyo, 2011, 2012, 2013.

JFC, Findings of the impact of the Great East Japan Earthquake has given to farm management, 2011-2012 surveys, Japan Finance Corporation, Tokyo, 2011, 2012.

JFC, Consumer Survey results on changes in purchasing behavior of consumers after Earthquake, 2011-2014 surveys, Japan Finance Corporation, Tokyo, 2011, 2012, 203, 2014.

JFC, Findings on renewable energy in agriculture, 2014 Survey, Japan Finance Corporation, 2014.

Japan Meteorological Agency, Earthquakes and Tsunamis, Meteorological Agency, Tokyo, 2013.

IBRD, The Great East Japan Earthquake. Learning from Megadisasters, Knowledge Notes, International Bank for Reconstruction and Development/The World Bank, Washington DC, 2012.

IRSN, Summary of the Fukushima accident's impact on the environment in Japan, one year after the accident, Institute for Radiological Protection and Nuclear Safety, Fontenay-aux-Roses, 2012.

K. Buesseler, Fukushima and Ocean Radioactivity, Oceanography, 25 (2014), 93-105.

[17] Consumer's evaluation on radioactive contamination of agricultural products in Japan: decomposition of WTA into a part due to radioactive contamination and a part due to area of origin

K. Ujiie, Consumer's evaluation on radioactive contamination of agricultural products in Japan, Food Syst Res, 19 (2012), 142-155.

M. Fujita, H. Nobuaki, J. Sagara, B. Adam, The economics of disaster risk, risk management, and risk financing. Economic Impacts, IBRD-World Bank, Washington DC, 2012.

MAFF, Annual report, Ministry of Agriculture, Forestry and Fisheries, Tokyo, 2012-2018.

MECSST, Land contamination, Ministry of Education, Culture, Sports, Science and Technology, 2011.

ME, Environmental Remediation in Japan, Ministry of Environment, Tokyo, March 2018.

MHLW, Survey of Dietary Intake of Radionuclides (September to October 2012), Ministry of Health, Labor and Welfare, Tokyo, Press Release June 21, 2013.

N. Akiyama, H. Sato, K. Naito, Y. Naoi, T. Katsuta, The Fukushima Nuclear Accident and Crisis Management - Lessons for Japan-U.S. Alliance Cooperation, The Sasakawa Peace Foundation, 2012.

N. Hamada and H.Ogino, Earthquake Food safety regulations: what we learned from the Fukushima nuclear accident, Journal of Environmental Radioactivity, 111 (2013), 83–99.

N. Kunii, M. Fujimura, Y. Komasa, A. Kitamura, H.Sato, T. Takatsuji, M. Jimba and S. Kimura, The Knowledge and Awareness for Radiocesium Food Monitoring after the Fukushima Daiichi Nuclear Accident in Nihonmatsu City, Fukushima Prefecture, Int. J. Environ. Res. Public Health, 15, 2018, 2289.

N. Watanabe, Current State of Losses from the Nuclear Accident and Support Measures by JA-Affiliated Organizations, Norinchikin Research Institute, Tokyo, 2013.

Nuclear Regulation Authority, Monitoring information of environmental radioactivity level, Nuclear Regulation Authority, Tokyo, 2014.

Nippon.com, Japan's Nuclear Power Plants, July 19, 2018 https://www.nippon.com/en/features/h00238/

P. Brasor and M.Tsubuku, Tepco's compensation for 3/11 victims has made matters worse for many, National, April 13, 2018.

R. Johnson, Japan's 2011 Earthquake and Tsunami: Food and Agriculture Implications, Congressional Research Service, Washington DC, 2011.

R. Koyama The Influence and Damage caused by the Nuclear Disaster on Fukushima's Agriculture, Nuclear Disaster on Fukushima's Agriculture, Commercial Studies, Vol. 81, No. 4 (2013).

RA, Progress to date, Reconstruction Agency, Tokyo, 2018.

S. Okuyama, Three Years After the Nuclear Accident, The Japan News, April 22, 2014.

T. Monma, Goto, I., Hayashi, T., Tachiya, H., Ohsawa, K. (Eds.), Agricultural and Forestry Reconstruction After the Great East Japan Earthquake Tsunami, Radioactive, and Reputational Damages, Springer, 2015.

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

T.Nakanishi, Agricultural aspects of radiocontamination induced by the Fukushima nuclear accident—A survey of studies by the Univ. of Tokyo Agricultural Dept., Proc. Jpn. Acad., Ser. B 94 (2018), 20-34.

T. Nomura and T. Hokugo, Situation of Compensation in Japan, presentation at the NEA Workshop on "Nuclear damages, liability issues and compensation schemes", OECD NEA, 2013.

T. Oka, Application of cost-benefit analysis to the regulation of foodstuffs contaminated with radioactive substances, Japan J. Health Physics, 47 (2012), 181-188.

Y. Todo, K. Nakajima, and P. Matous, How Do Supply Chain Networks Affect the Resilience of Firms to Natural Disasters? Evidence from the GEJE, Journal of Regional Science, 55 (2015), 209–229.

W. Barletta, J. Stoop, C. O'Hara, I.Bailiff, N. Hermanspahn, R. Hugtenburg, R. Alcock, A.Covaci, D. Barceló, J. Gan, A. Karlsson, 5 years after Fukushima — insights from current research, Posted on 10 March 2016 https://www.elsevier.com/connect/5-years-after-fukushima-insights-from-current-research

WHO, Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation, World Health Organization, Genève, 2013.