Eight Years after Fukushima Nuclear Accident -Community Recovery and Reconstruction from Nuclear and Radiological Disasters –A Case of Kawauchi Village and Tomioka Town in Fukushima

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Abstract

On 11 March 2011, the Great East Japan Earthquake and Tsunami severely damaged the Fukushima Daiichi Nuclear Power Plant (FDNPP). Large radioactivity released induced multi-hazard disasters on human livelihood and ecosystem in the Fukushima Prefecture. In December 2018, some 43,000 residents of Fukushima were yet to return to their hometowns, with 33,000 of them living outside the prefecture. This is due to: Persistent uncertainty of long-term radiation impacts on the thyroid as well as whole body; Radiation fear and anxiety having impacted some 165,000 precipitately displaced in the absence of sound risk information and communication during the initial stage of the nuclear disaster; Psychosocial and mental stresses; and Delayed recovery of employment opportunities and environmental livelihood.

Acute or chronic, and direct or indirect impacts of nuclear disasters required intensive science-policy interface to promote a national multi-hazard disaster risk management as evidenced in the case of the affected communities of Fukushima such as Kawauchi-Village and Tomioka Town.

Kawauchi Village has achieved return of the evacuees to the radiation-affected homeland for the first time ever in the world. In March 2012; after tedious decontamination work in the village, radiation doses were found to be safe for its residents to return home, and schools and public offices were reopened. In 2013, the public authorities of the village and Nagasaki University concluded a comprehensive agreement to assist the village in sustaining its recovery efforts through a local satellite of the University known as the “Nagasaki University–Kawauchi Village Reconstruction Promotion Base”. The University dispatched a full time public health nurse to

stay permanently in the village and provided health radiation consultation services and monitors radiation levels in food and soil samples. Regular meetings are held in the village to foster greater dialogue between the radiation experts, physicians, radiation nurses, and community leaders of Kawauchi village and its population. Building on this experience, Nagasaki University also concluded with Tomioka Town a comprehensive agreement to support the town's recovery and established a local satellite office to start helping recovery of the its community soon after lifting of evacuation order in April 2017.

The village/town-university collaboration provides the Sendai Framework for Disaster Risk Reduction with a model for developing a multi-disciplinary and multi-hazard approach to public DRR policy during the recovery phase of a nuclear accident.

Introduction

1.This subchapter will indicate how ISDR can implement its mandate for nuclear and radiological disasters with reference to the four Sendai Framework Priorities for Action drawing upon the empirical lessons from the experience in the recovery and reconstruction of the affected communities in Fukushima.

A) ISDR's mandate for nuclear radiation disasters

Background

2. In 2004, UNISDR recognized in its definition of hazard its flagship report that any hazards of "different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation, technological and man-made hazards)" are within its purview[1]. It also defined technological hazards as: "Danger originating from technological or industrial accidents, dangerous procedures, infrastructure failures or certain human activities, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Some examples: industrial

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[1] Hazard is defined as: "A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards)". See UNISDR, 2004. Geneva *Living with Risk A global review of disaster reduction initiatives* (2004 Version - Volume II, Annex 1), P.4 at: https://www.unisdr.org/files/657_lwr21.pdf.

pollution, ***nuclear activities and radioactivity***, toxic wastes, dam failures; transport, industrial or technological accidents (explosions, fires, spills)"[2] (Emphasis is made by the authors).

3. In Fukushima, Chernobyl, Semipalatinsk of the Northeast Kazakhstan as well as Three Mile Island, the nuclear power plant (NPP) accidents and the repetitive nuclear weapon tests generated deep and long-lasting human and environmental consequences in the affected regions and communities: the devastation and radio-contamination of land, forests and water led to long-term mass population displacements[3].

4. In view of such radiation risk assessment, the Joint Inspection Unit of the UN System identified multilateral concerns as follows[4].

5. The nuclear accident at the Fukushima Daiichi nuclear plant in March 2011 once again has given rise to concerns about:

- the adequacy of the international governance framework to ensure appropriate safety standards and conventions;
- the transparency and stakeholder involvement for establishment of trust and smooth risk communication;

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[2] UNISDR, ibid., P.7.

[3] Inomata, T. and Cazeau, J. W. 2014. *Post-Rio+20 Review of Environmental Governance Within the United Nations System (*JIU/REP/2014/4*)* Para.63 *available* at: https://www.unjiu.org/sites/www.unjiu.org/files/jiu_document_files/products/en/reports-notes/JIU%20Products/JIU_REP_2014_4_English.pdf

[4] *Ibid.,* Para.62.

- the global emergency preparedness and response system; and
- sustainable development prospects in areas with a nuclear legacy.

6. These concerns energized discussion in various United Nations forums[5] in the fields of disaster response and reduction and of health and human rights on the effectiveness of national regulatory bodies and as well the role of relevant international institutions emitting various guidelines and recommendations on nuclear and radiation safety: these include OCHA, UNISDR, IAEA, WHO, UNEP, UNCEAR and WHO in addition to Non-governmental expert bodies such as the International Commission on Radiological Protection (ICRP), the SHAMISEN Consortium for Nuclear Emergency Situations[6] and IARC Expert Group on Thyroid Health Monitoring After Nuclear Accidents[7]

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[5] For example, UNDP which inherited the role of lead agency for United Nations activities on Chernobyl from OCHA; IAEA's Inter-Agency Committee on Radiological and Nuclear Emergencies; Inter-Agency Standing Committee(serviced by OCHA); United Nations Scientific Committee on the Effects of Atomic Radiation; Human Rights Council; Environment and Security Initiative(serviced by UNEP) and; Joint UNEP/OCHA Environment Unit (For detail, see Ibid., Box III) as well as WHO, ILO, FAO, UNU and International Commission on Radiological Protection.

[6] See its Improvement of Medical and Health Surveillance Project (2015-2017 SHAMISEN). It produced: *Recommendations and procedures for preparedness and health surveillance of populations affected by a radiation accident* available at: https://www.isglobal.org/documents/10179/5808947/SHAMISEN+Recommendations+and+procedures+for+preparedness+and+health+surveillance+of+populations+affected+by+a+radiation+accident+EN/f3df29c3-1c00-4004-91fc-3b0750d5458e

[7] International Agency for Research on Cancer IARC Expert Group on Thyroid Health Monitoring after Nuclear Accidents 2018. Lyon, France. *Thyroid health monitoring after nuclear accidents (IARC Technical Publications; 46) available at: http://publications.iarc.fr/Book-And-Report-Series/Iarc-Technical-Publications/Thyroid-Health-Monitoring-After-Nuclear-Accidents-2018*

7. During the UN high-level meeting on Nuclear Safety and Security on 22 September 2011, the Secretary-General of the United Nations undertook an initiative for developing, through the Inter-Agency Standing Committee, an international emergency response framework in case of nuclear accidents fostering preparedness for nuclear disasters and enabling humanitarian assistance by the United Nations system organizations[8]. But the United Nations made no headway[9] until the Third United Nations World Conference on Disaster Risk Reduction on Disaster Risk Reduction at Sendai, Japan, in March 2015.

8. The World Conference on Disaster Risk Reduction in one of the working sessions discussed lessons learned from Fukushima and Chernobyl under the them entitled "Technological Hazards: From Risk Reduction to Recovery". The Sendai Framework confirmed ISDR's mandate to deal with nuclear and radiological hazards under its paragraphs 15[10] and 17[11].

[8] Secretary-General's closing statement on 22 September 2011 to High-Level Meeting on Nuclear Safety and Security available at: https://www.un.org/sg/en/content/sg/statement/2011-09-22/secretary-generals-closing-statement-high-level-meeting-nuclear

[9] *Ibid.,* Box III, Para. 3.

[10] Para. 15 reads "The present Framework will apply to the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters caused by natural or man-made hazards, as well as related environmental, technological and biological hazards and risks. It aims to guide the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors."

[11] Para.17 reads "To attain the expected outcome, the following goal must be pursued:
Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience." (Emphasis place by the authors)

9.To promote a multi-hazard approach to build resilient health systems, “The Bangkok Principles[12] for the Implementation of the Health Aspects of the Sendai Framework” addresses radiation hazards among others.

10. Upon recommendations of the Intergovernmental Expert Working Group on Indicators relating to DDR (A/71/644, P.20), the General Assembly in its resolutions 69/283 of 3 June 2015 and 71/276 of 2 February 2017 set forth the terminology of hazards as well as 38 indicators of the seven global targets[13] of the Sendai Framework to measure progress in the implementation of the Framework as part of attainment of SDGs. The approved recommendations of the Working Group defined that these indicators apply to nuclear radiation along with other technological hazards.

B) Multilateral monitoring and surveillance of findings and policy development relevant for nuclear radiation

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[12] Adopted at the International Conference on the Implementation of the Health Aspects of the Sendai Framework for Disaster Risk Reduction 2015–2030, held in Bangkok on 10 and 11 March 2016, viewed on 20 October 2018 at https://www.preventionweb.net/files/47606_bangkokprinciplesfortheimplementati.pdf

[13] (a) Substantially reduce global disaster mortality by 2030;
(b) Substantially reduce the number of affected people globally by 2030;
(c) Reduce direct disaster economic loss in relation to GDP by 2030;
(d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;
(e) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;
(f) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;
(g) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

DRR

11. Effective use of the above-mentioned indicators (i) enables measurement of progress in the implementation of the Sendai Framework and the 2030 Agenda along with its set of 38 indicators and the Sendai Framework Monitoring System (SFM) and (ii) facilitates the take-stock of findings from the field and check their relevance for research and policy development on nuclear radiation DRR.

12. Identification and formulation of feasible practices thus achieved would enable the UN system entities to better understand the global risk landscape and the systemic nature of nuclear-related man-made hazards within the Global Risk Assessment Framework (GRAF), and achieve system-wide governance avoiding and eliminating duplication and fragmentation of initiatives and frameworks.

Words into action

13. In response to Paragraph 48 (c) of the Sendai Framework, UNISDR has issued evidence-based and practical guidance entitled “Words into action” consisting of a series of targeted Sendai Framework implementation guides”. This exercise complements the above-mentioned multilateral monitoring and surveillance process. It builds on the precedent “Words into action- A Guide for Implementing the Hyogo Framework” that UNISDR formulated in close collaboration with States and through the mobilization of expertise available among multi-stakeholders.

14. The Implementation Guide for Man-made and Technological Hazards [14], is based on the recognition that the number and magnitude of Man-made disasters worldwide has risen since 1970s and continues to grow in both frequency and impact on human wellbeing and economic costs. It contains far in-depth a variety of practice and considerations as well as networks and frameworks at multiple levels of governance to address technological hazards within and across sectors including nuclear and radiological hazards with respect for each of the four Priority Areas for Action for the Sendai Framework. The Guide contains cases of the experience and lessons learned from emergency response, recovery and reconstruction from the nuclear accidents at the Three Mile Island NPP (Nuclear Power Plant) in the USA, the Chernobyl NPP and the Fukushima Daiichi NPP as well as nuclear legacy waste mapping in Central Asia.

Development of SFM.

15. However, more efforts and global cooperation are required to mainstream DRR within and across all sectors dealing with technological and man-made hazards, particularly, nuclear hazards. It should be borne in mind that to these hazards, the 38 indicators of the seven global targets of the Sendai Framework equally apply through the SFM. For example, despite an imperative need for substantially increasing the number of countries with national and local disaster risk reduction strategies by 2020, little progress has been made to address and integrate radiation technological risk management plans within such strategies not only at the global, but also local community levels.

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[14] UNISDR, *Words into Action, Implementation Guide for Man-made and Technological Hazards*, December 2017 available at: https://www.unisdr.org/files/54012_manmadetechhazards.pdf

16. At present, the SFM is at the development stage and has scarce data and information on national regulatory plans and strategies specific to nuclear hazard management, although the SFM is applicable throughout the entire process of emergency response, post-crisis and post-recovery phases in the event of nuclear accident. There is an obvious need to learn about cases of national experience in building post-accident management intended to improve protection for human beings and the environment in case of nuclear hazard. Elaboration of such effective risk management would only be feasible if it could involve in a more transparent way both relevant professional stakeholders and the affected population as well as public authorities. Search for such best practices would also be intensified through the active use of the SFM.

17. It should be recalled that in the implementation of the Sendai Framework for Disaster Risk Reduction, Member States agreed to define disaster as "[a] serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" and confirmed that nuclear radiation along with other technical hazards is within the scope of disaster defined in paragraph 15 of the Sendai Framework[15]. They also accepted that it applies to small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters caused by natural or man-made hazards, as well as related environmental, technological and biological hazards and risk.

18. The UNIDR has not yet defined the scope of nuclear activities and radioactivity hazards that it should address. In this respect, an attention is drawn to the International Nuclear and Radiological Event Scale (INES) which was developed by an international group of experts convened jointly by the IAEA and the OECD Nuclear Energy Agency (OECD/NEA).

19. The INES scale can be applied to any event associated with the transport, storage and use of radioactive

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[15] Recommendations of the Intergovernmental Expert Working Group on Indicators relating to DDR (A/71/644, P.20) endorsed by the General Assembly in its resolution 71/276 of 2 February 2017 approving the terminology of hazards and 38 indicators of the seven global targets of the Sendai Framework to measure progress in the implementation of the Framework as part of attainment of SDGs.

material and radiation sources. It applies whether or not the event occurs at a facility. It includes the loss or theft of radioactive sources or packages and the discovery of orphan sources, such as sources inadvertently transferred into the scrap metal trade. The scale can also be used for events involving the unplanned exposure of individuals in other regulated practices (e.g. processing of minerals)[16]. The total number of international nuclear and radiological events reported to IAEA amounted to 2,507[17] from 2005 to 2017 or 192 events average per annum.

20. If UNISDR follows INES and addresses those events which involve long-lasting impact and mass displacement of population, relevant INES accidents at levels 4 to 7[18] may be chosen. Some example are as follows: Level 7: Accidents at Chernobyl (ex-S.U., 26.04.85) and Fukushima, Japan (11.03.2011); Level 6: Significant release of radioactive material by explosion of a high activity waste tank at Kyshtym, Russia, 1957; and Level 5: Windscale Pile, UK, 1957 — Release of radioactive material to the environment following a fire in a reactor, Three Mile Island, USA, 1979 — Severe damage to the reactor core.

21. We note the importance of its methodology to compile relevant data. However, we do not entirely follow its approach. Because the Sendai Framework is more concerned with tackling multi-hazard risk management to reduce large-scale, frequent and infrequent, sudden and slow-onset disasters caused by natural or man-made hazards, as well as related environmental, technological and biological hazards and risk. INES is only intended for use in civilian (non-military) applications and only relates to the safety aspects of

[16] IAEA, Ibid., P.4.

[17] IAEA, *Annual Report 2017*, P.68 in https://www.iaea.org/sites/default/files/publications/reports/2017/gc62-3-incident-and-emergency.pdf.

[18] INES classifies nuclear and radiological accidents and incidents by considering three areas of impact on: People and the Environment by the radiation doses; Radiological Barriers and Control of radiation containing radiation inside facilities; Defence-in-Depth for sustaining accident preventive measures. The events are rated among seven Levels: 7 Major Accident, 6 Serious Accident, 6 Accident with Wider Consequences, 5 Accident with Local Consequences, 4 Serious Incident, 3 Incident, 2 Anomaly and 1 No Safety Significance (Below Scale/Level 0).

events and INES rating is not recommended to use as a means of deciding on an emergency response[19].

Towards better monitoring radiation protection and post disaster recovery

22. One of the far-reaching best practices is the protection approach developed by the French Steering committee for the management of the post-accident phase of a nuclear accident or a radiological emergency (ORDIPRA)[20]. In early 2018, CODIRPA revised the post-accident management policy published in 2012[21], considering the lessons learned from the Fukushima accident. Experience shows that these post-accident measures can have a major human, economic and financial impact and need to be defined and implemented in advance.

23. It is the first national policy document in Europe containing a national DRR plan to deal with nuclear accidents. It was prepared in full agreement with multi-stakeholders and has three strongly connected fundamental objectives:

• protecting the population against the dangers of ionising radiations;

• providing support for members of the population who have suffered the consequences of an accident; and

• preparing the social and economic recovery of the affected areas.

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[19] IAEA, *INES International Nuclear and Radiological Event Scale User's Manual*, 2013, P. 4 available at https://www-pub.iaea.org/MTCD/Publications/PDF/INES2013web.pdf

[20] CORDIPRA: Comité directeur pour la gestion de la phase post-accidentelle d'un accident nucléaire ou d'une situation d'urgence radiologique

[21] CORDIPRA, Policy elements for post-accident management in the event of nuclear accident available at: http://www.french-nuclear-safety.fr/Information/News-releases/National-doctrine-for-nuclear-post-accident-management

I. Impact and cost of damages by the Great East Japan Earthquake and Tsunami of 2011

24. On 11 March 2011, the Great East Japan Earthquake and Tsunami of 2011, a magnitude 9.0 earthquake occurred with a resulting 14-m or more tsunami. This event has been classified as Level 7 on the International Nuclear and Radiological Event Scale ('Severe Accident'), which was also applied in the case of the 1986 Chernobyl power plant accident.

25. This disaster left nearly 19,700 people dead and more than 2,500 people missing[22]. On 13 March 2011, about 470,000 people[23] including 165,000 inhabitants of Fukushima were evacuated. As of 10 January 2019, 53,000 evacuees still have no choice but to live at temporary locations[24].

26. In Fukushima, there were 4,088 deaths (including 2259 disaster-related deaths) and 2 persons were missing as of 5 December 2018[25].

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[22] Fire and Disaster Management Agency, 158th *Situation report of the 2011 Great East Japan Earthquake* dated 7 October 2016, available at http://www.fdma.go.jp/bn/higaihou/pdf/jishin/158.pdf

[23] Ministry of Land, Infrastructure, Transport, and Tourism (MLIT), White Paper on Land, Infrastructure, Transport, and Tourism In Japan, 2010 available at http://www.mlit.go.jp/english/white-paper/2010.pdf

[24] Reconstruction Agency, *Numbers of evacuees following the Great East Japan Earthquake and Tsunami of 2011 as of 29 January 2019* in Japanese, available at http://www.reconstruction.go.jp/topics/main-cat2/sub-cat2-1/20190129_hinansha.pdf.

[25] Fukushima Prefecture, *Steps for Revitalization in Fukushima* (December 25,2018 Edition) available at: http://www.pref.fukushima.lg.jp/uploaded/attachment/307870.pdf.

27. The population in the Fukushima prefecture decreased from 2,024,401 in 1 March 2011 to 1,861,839 in November 2018.

A) Financial Impact

Total cost of damages by the Great East Japan Earthquake and Tsunami of 2011

28. The estimates of combined costs of damages by the natural events (i.e. Earthquake and Tsunami of the Great East Japan Earthquake and Tsunami of 2011) and the Fukushima Daiichi Nuclear reactors' accident are compiled in Table 1 together with reference projections by the World bank and a PSR Senior Scientist. They would eventually amount to JPY54 trillion or US$ 490.9 billion.

Table 1. Estimates of cost of damages by the Great East Japan Earthquake and Tsunami of 2011 (In trillion yen unless otherwise indicated)

Damages	Original estimates	Current estimates	Projected estimates (December 2016)
(1) Damages caused by natural events i.e. earthquake and tsunami	16.9[1]	32[2]	32[2]
(2) Assessment of damages caused by the Fukushima Daiichi Nuclear reactors' disaster	9.0[3*]	13.3[3*]	22[3*]
Total of (1) and (2)	25.9.	45.3	54
Memorandum: Total economic loss caused by 2011 Fukushima Daiichi Nuclear reactors' disaster	N.A.	N.A.	$250-$500 billion US or JPY 27.5 trillion-55 trillion[4]
	N.A.	N.A.	$122-235 billion or JPY13.4 to JPY25.9 trillion[5]

Sources:
1. Board of Audit of Japan, June 2011.
2. Reconstruction Agency, March 2016.
3. TEPCO, January 2014 and May 2017. The asterisk refers to para. 32 of the text.
4. Steven Starr, MT (ASCP), PSR Senior Scientist, October 2012. "Costs and Consequences of the Fukushima Daiichi Disaster" by Steven Starr, posted on October 31, 2012 at https://www.psr.org/blog/resource/costs-and-consequences-of-the-fukushima-daiichi-disaster/
5. World Bank, *The recent earthquake and tsunami in Japan: implications for East Asia* available at http://siteresources.worldbank.org/INTEAPHALFYEARLYUPDATE/Resources/550192-1300567391916/EAP_Update_March2011_japan.pdf

29. In June 24, 2011, the Cabinet Office of Japan estimated the economic damage caused by the Great East Japan

Earthquake at JPY 16.9 trillion[26]

30. It is broken down as follows:

- Structures (Homes/housing sites, stores/offices, factories, machines, etc.) JPY 10.4 trillion
- Lifeline facilities (Water, gas, electricity, communications/broadcasting facilities) JPY 1.3 trillion
- Infrastructure facilities (Rivers, roads, ports, sewers, airports, etc.) JPY 2.2 trillion
- Agriculture, forest, and fisheries-related facilities (Farmland/agricultural facilities, forests and fields, fisheries-related facilities, etc.) JPY 1.9 trillion
- Other (Educational facilities, healthcare/social welfare facilities, waste treatment facilities, other public facilities) JPY 1.1 trillion

31. These estimates relate to damages caused by natural events i.e. earthquake and tsunami of the Great East Japan Earthquake and Tsunami of 2011, but not to the Fukushima nuclear accident. As of August 2017, the government estimated that the current Process for Reconstruction from 2011 to 2020 would require some JPY27.2 trillion net of the gross costs for recovery and reconstruction cost at JPY32 trillion[27] inclusive of some JPY4.8 trillion defraying a portion of nuclear disaster recovery work to be borne by TEPCO.

32. The Great East Japan Earthquake and Tsunami severely damaged the Fukushima Daiichi Nuclear Power Plant 1 owned and operated by the Tokyo Electric Power Company (TEPCO), resulting in a large release of radioactivity into the environment. Due to the complexity of compensation issues involved in man-made radiation incident inducing multi-hazards on human livelihood and ecosystem in the affected area, TEPCO in consultation with the government entities estimated a separate cost assessment of damages caused by the Fukushima Daiichi Nuclear reactors' disaster initially at JPY9.0 trillion in January 2014 and mooted an amount of JPY13.3 trillion. But it seems to rise to a level of JPY22 trillion in the end[28] as discussed in Box 1.

33. The total cost at JPY22 trillion of damages caused by the nuclear reactors' accident is significantly high, compared with the rest of cost of damages caused by natural events which is originally estimated at JPY16.9 yen. It would be significant to note that the cost of damage caused by a single man-made hazard may either surpass individual costs of sectoral damages caused by the natural hazards or eventually equate to the total cost of them.

Over all disaster impacts on Fukushima prefecture

34. The precise value of the abandoned cities, towns, agricultural lands, businesses, homes and property located within the roughly 310 sq. miles (800 sq. km) of the exclusion zones has not been established. However, the Fukushima Prefectural Government provided an estimate of total cost of damage of the earthquake and tsunami at JPY 1,198.8 billion as of 23 March 2012(See Box 2)[29].

[26]Cabinet Office, Japan "White Paper on Disaster Management in Japan 2016" accessed on 5 March 2017, Fig A-19, on Page A-34 available at:
http://www.bousai.go.jp/kyoiku/panf/pdf/WP2016_DM_Full_Version.pdf

[27] Reconstruction Agency "Current Status of Reconstruction and Challenges" (Page on Budget for reconstruction) available at http://www.reconstruction.go.jp/english/topics/Progress_to_date/pdf/201708_Current_Status_of_Reconstruction_and_Challenges.pdf

[28]Tokyo Electric Power Company Holdings, Inc.(TEPCO) *Press Release (May 18, 2017): Outline of the 'Revised Comprehensive Special Business Plan (The Third Plan)* available at https://www4.tepco.co.jp/en/press/corp-com/release/betu17_e/images/170518e0101.pdf

[29]Fukushima Prefecture, *Steps for Revitalization in Japanese Fukushima (December 25,2018 Edition, P.2 in* https://www.pref.fukushima.lg.jp/uploaded/attachment/307870.pdf.

Box 1

Estimates of the total economic loss caused by 2011 Fukushima Daiichi Nuclear reactors' disaster

The precise value of the abandoned cities, towns, agricultural lands, businesses, homes and property located within the roughly 310 sq. miles (800 sq. km) of the exclusion zones has not been established. Estimates of the total economic loss range from $250-$500 billion US[30].

More precisely, based on the information from TEPCO[31] and the Board of Audit of Japan[32], Mycle Schneider et al.[33], estimated in their World Nuclear Industry Status Report 2016 that the total cost of damages caused by the Fukushima nuclear power disaster was JPY13.3 trillion (US$ 133 billion), based on the following items:

(1) Decommissioning and contaminated water treatment costs of JPY2 trillion (US$ 20 billion.)
(2) Compensation costs of about JPY7.1 trillion (US$ 71 billion).
(3) Decontamination costs of JPY3.6 trillion (US$ 36 billion): decontamination cost at about JPY2.5 trillion (US$ 25 billion) and the interim storage facilities cost at about JPY1.1 trillion (US$ 11 billion).

Furthermore, TEPCO submitted to the Government in its "New Second Comprehensive Special Business Plan"[34] an up-dated JPY22 trillion (US$220billion) estimates of cost that reflect delay in removal of melt-downed debris and lifting of evacuation orders in the contaminated zones. The break-down of the amount is as follows:

(1) Decommissioning and contaminated water treatment costs of 8 trillion yen (US$80 billion).
(2) Compensation costs of about 8 trillion yen (US$80 billion).
(3) Decontamination costs of 6 trillion yen (US$ 60 billion) including the interim storage facilities cost.

[30]Steven Starr, *Costs and Consequences of the Fukushima Daiichi Disaster* 31 October 2012 at http://www.psr.org/environment-and-health/environmental-health-policy-institute/responses/costs-and-consequences-of-fukushima.html

[31]TEPCO, "New Comprehensive Special Business Plan", 31 March 2016, in http://www.tepco.co.jp/en/press/corp-com/release/betu16_e/images/160331e0201.pdf

[32] Board of Audit of Japan, "Report on the results of the accounting audit regarding the implementation status of government's assistance provided to TEPCO for compensation for nuclear damage", March 2015, (in Japanese), accessed 12 April 2016.

[33]Issued on 27 July 2016 at https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2016-HTML.html#_Toc455844015.

[34]Committee for Reforming TEPCO and Overcoming 1F Challenges (TEPCO Committee), "TEPCO's Reform Plan" of 14 December 2016 (in Japanese) accessed on 7 February 2017 at: http://www.meti.go.jp/committee/kenkyukai/energy_environment/touden_1f/pdf/007_01_00.pdf

Box 2

<Cost of damage in Fukushima Prefecture> As of 2012.3.23

- ◆Reported cost of damage for **public works facilities**: **About JPY 316.2 billion**
- ◆Reported amount of damage on **agricultural, forestry and fishery facilities: About JPY 245.3 billion**
- ◆Reported amount of damage on **educational facilities**: **About JPY 37.9 billion**
- ◆**Total of reported amount of damage on public facilities: About JPY 599.4 billion**

※Areas under the jurisdiction of the prefectural government: for the 30km radius surrounding the Fukushima Daiichi Nuclear Power Station (F1NPS), damage costs were estimated based on aerial photographs.

※Areas under the jurisdiction of municipalities: Excludes approximate cost of damage for a part of Minamisoma City and 8 municipalities located in the Futaba area.

[Data] Land Rehabilitation & Development Group, Fukushima Restoration & Revitalization Headquarters for Great East Japan Earthquake

B) Health and Environmental Impact

35. The 2011 Fukushima nuclear power plant disaster reminds that even contemporary systems are vulnerable to natural hazards, e.g. earthquakes and tsunami, and are subject to interdependent complexity between natural and human factors. According to international researchers of the United Nations University Institute for the Advanced Study of Sustainability, "[The] consensus within the DRR community is that technological hazards such as nuclear accidents must be addressed through a multi-hazard approach, considering sequences of risks that can trigger such hazards and their impacts on the surrounding communities and environment.[35]" They also considered it necessary to "open up the safety culture in the nuclear industry so that it accommodates the concerns of the surrounding communities"[36].

36. The ISDR secretariat considers that the 2011 triple disaster of earthquake, tsunami and nuclear power plant disaster in East Japan, accelerated an ongoing global shift to a multi-hazard approach to disasters, in which risks are not viewed in isolation but as interlocking parts of a whole.[37]

[35] United Nations University Institute for the Advanced Study of Sustainability "Fukushima Global Communication Programme Final Report", August 2016 , P.7 at https://collections.unu.edu/eserv/UNU:5758/FGC_Final_Report_EN.pdf

[36]Ibid.

[37]Statement by Mr. Robert Glasser, the UN Secretary-General's Special Representative for Disaster Risk Reduction, Geneva ,15 August 2016 accessed at http://www.unisdr.org/archive/49885

37. The following paragraphs contain relevant data for public health and environmental risk management[38].

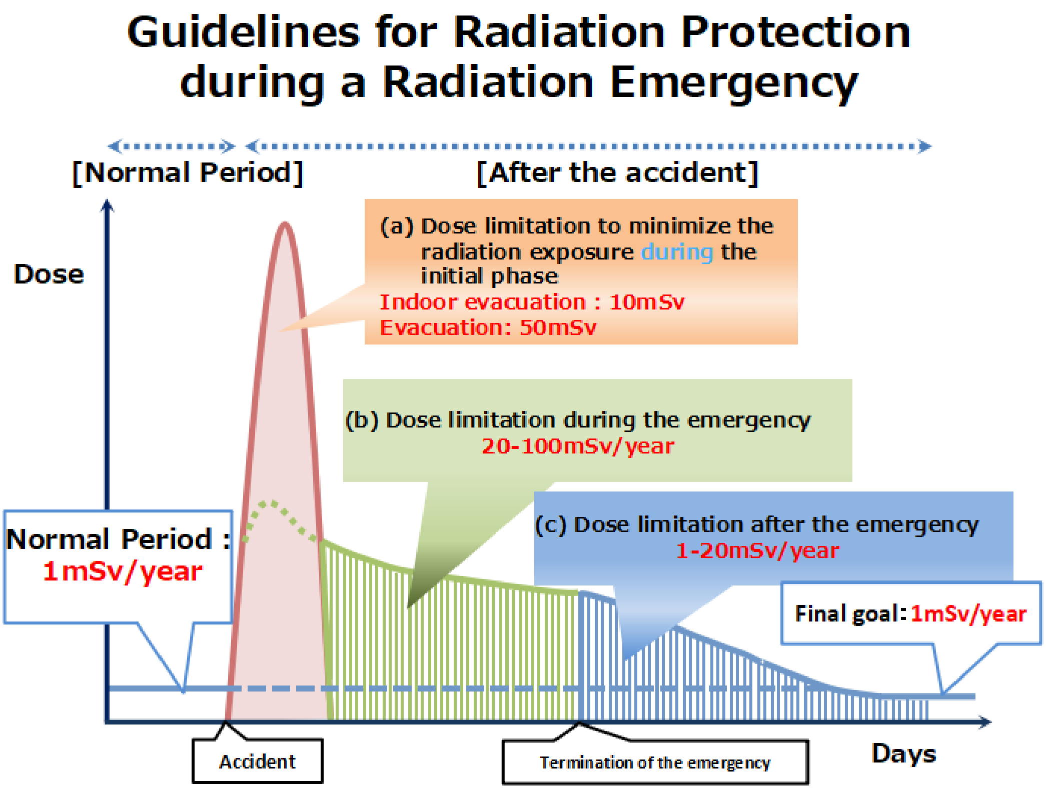
38. The Tokyo Electric Power Company (TEPCO) released large quantity of radioactivity into the environment. Radionuclides were released into the atmosphere by hydrogen gas explosions from the damaged reactors. The Nuclear and Industrial Safety Agency of Japan (NISA) reported that 1.6×1017 Bq of ^{131} Iodine (^{131}I) and 1.5×10^{16} Bq of ^{137}Cesium (^{137}Cs) were released into the environment during the Fukushima event. In comparison, 1.8×10^{18} Bq of ^{131}I and 8.5×10^{16} Bq of ^{137}Cs were released into the environment in the Chernobyl accident. Japan declared a nuclear emergency after the failure of the cooling system at the damaged reactors.

39. The International Commission on Radiological Protection (ICRP) recommends that the public be exposed to no more than 1 mSv of radiation per year under normal conditions. The Commission in its Publication 109 that a reference levels should be set in the band of 20–100 mSv effective dose (acute or per year).

40. Even the ICRP recommends that annual exposure to radiation be limited, to the range of 20 to 100 mSv per year. After the accident was over, the ICRP recommended that the dose level to optimize protection from radiation for people should be in the lower range of 1 to 20 mSv per year. Based on these statement, central government enforced such policy (see the Government's guidelines in Graphic A).

[38] Their input is based on "Public health activities for mitigation of radiation exposures and risk communication challenges after the Fukushima nuclear accident" by Shimura T, Yamaguchi I, Terada H, Robert Svendsen E, Kunugita N in Journal of radiation Research (May 2015) Vol.56, No.3, 2015, pp.422-429 available at: https://www.ncbi.nlm.nih.gov/pubmed/25862700

Graphic A.



Source: ICRP, 2007. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann. ICRP 37 (2-4).

41. There are early, intermediate and late disaster response and recovery phases, which have distinctive public health characteristics and parameters. The early phase is dealing with the atmospheric transport of the initial radioactive plumes, which involved the radionuclides of ^{131}I and ^{134}Cs/^{137}Cs in the Fukushima prefecture for at least 2 weeks after the accident.

42. There are two main ways that radiation exposure occurs with humans: external exposure from radionuclides deposited on the ground and in the radioactive cloud, and internal exposure from inhalation and ingestion of radionuclides in the radioactive cloud and in contaminated food and water, respectively. It is important to avoid the acute exposure from inhalation and ingestion (^{131}I for exposure

to the thyroid), and from external exposure ($^{134}Cs/^{137}Cs$, whole body) by evacuating the affected populations and so it is urgently needed to administer stable iodine (KI) for target population to block and mitigate the radioactive ^{131}I intake into thyroid glands.

43. 41. In the intermediate phase, the primary concerns are regarding sheltering, relocation, control of the radioactively contaminated environment, and foods or drinking water intake controls. In the late response and early recovery phases, long term management and monitoring are necessary to lay the foundation for the long recovery process. Since, the long-term health of exposed populations requires continued public health tracking, therefore, public health emergency should be more carefully discussed, and guide lined at the level of local and central government in coordination with local communities affected.

Thyroid Health Monitoring in the framework of the Fukushima Health Management Survey

44. The Fukushima prefecture government has implemented the Fukushima Health Management Survey to monitor the physical and mental health of citizens and maintain and improve health in Fukushima into the future. The survey also provides the assessment of citizens' external radiation exposure dose for the first four months, and thyroid examination.

46. The large-scale ultrasound thyroid screening in Fukushima Prefecture of Japan demonstrated a high detection rate of thyroid cancer in young individuals, revealing 116 and 71 cases in the first and second rounds, respectively, among the same cohort of approximately 300,000 subjects. These findings raised concerns among residents and the public that it might be due to putative exposure to radiation from the accident at Fukushima Daiichi Nuclear Power Plant[39]. However, we should simultaneously consider the screening effect and possibility of overdiagnosis.

47. The increase in risk for late-onset thyroid cancer due to radiation exposure is a potential health effect after a nuclear power plant accident mainly due to the release of radioiodine in fallout. The risk is particularly elevated in those exposed during infancy and adolescence. To estimate the possibility and extent of thyroid cancer occurrence after exposure, it is of utmost importance to collect and analyze epidemiological information providing the basis for evaluation of radiation risk, and to consider

[39]Shunichi Yamashita, Shinichi Suzuki, Satoru Suzuki,1 Hiroki Shimura, and Vladimir Saenko. 2018. *Lessons from Fukushima: Latest Findings of Thyroid Cancer After the Fukushima Nuclear Power Plant Accident* in THYROID Volume 28, Number 1, 2018 Mary Ann Liebert, Inc. DOI: 10.1089/thy.2017.0283

radiobiology and molecular genetics. At present, there is no direct evidence of radiation-associated thyroid cancer, however, it is difficult or impossible to distinguish radiation-induced thyroid cancer from spontaneous/sporadic thyroid cancer because molecular radiation signatures, biomarkers of radiation exposure, or genetic factors specific to radiation-induced cancer have not yet been identified. Therefore, sound epidemiological study is essentially needed in Fukushima.

48. Recently some of the studies made by the US Environmental Protection Agency (USEPA) imply that adverse effects from low dose, low-dose rate (LDDR) exposures are not detectable although there is no safe dose of ionizing radiation. They warn against continuing the use of the linear no-threshold (LNT) model in LDDR radiation environments in view of unnecessary burdens of costly cleanups of highly sensitive equipment as well as perception gap between the public and medical experts on the real effects of LDDR radiation exposures.[40]

49. To better understand the potential impact of radiation exposure, we should note a large difference in radionuclides released by the accidents at Chernobyl and Fukushima. The following table shows the significant extent at which they differ to each with other.

Table 2

Radionuclides released by the accident at Chernobyl and Fukushima

Chernobyl		Fukushima
5,200 (x6.8)	Total	770 (thousands tBq)
1,800 (x11.3)	^{131}I [8.0d]	160
44 (x2.4)	^{134}Cs [2.0y]	18
85 (x5.7)	^{137}Cs [30y]	15
8.0 (x57)	^{90}Sr [29y]	0.14
0.03 (x10,000)	^{239}Pu [24,000y]	0.000003

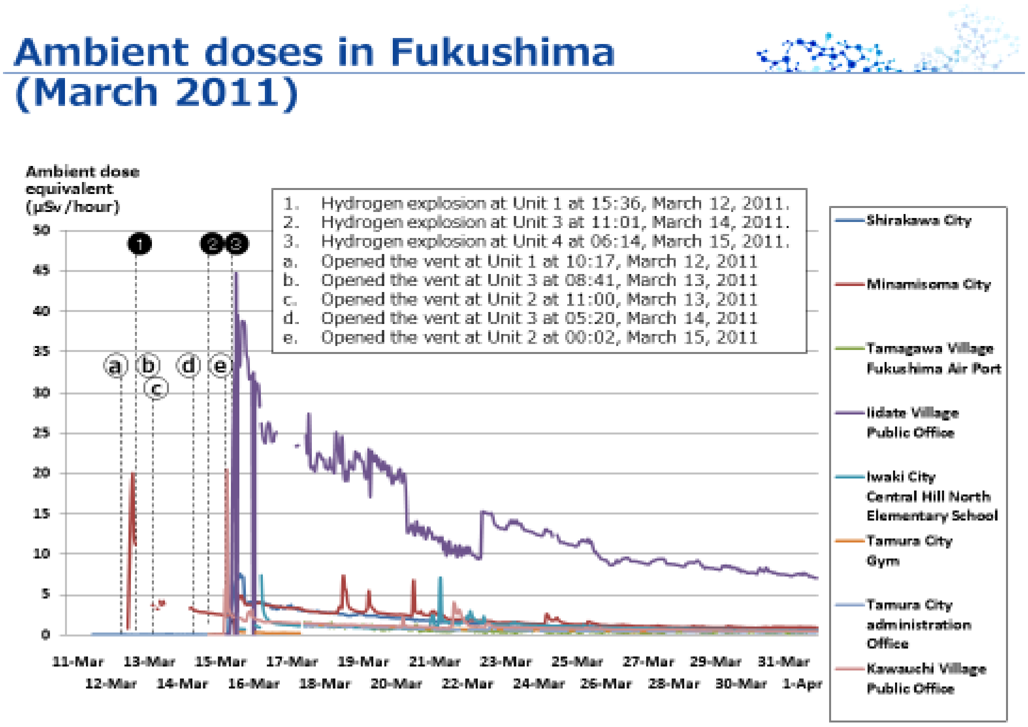
Source: UNSCEAR 2008 Report to the General Assembly, with scientific annexes

[40] John J. Cardarelli II and Brant A. Ulsh. 2018. *It Is Time to Move Beyond the Linear No-Threshold Theory for Low-Dose Radiation Protection* Dose-Response: An International Journal April-June 2018:1-24 available at: sagepub.com/journalsPermissions.nav
DOI: 10.1177/1559325818779651 journals.sagepub.com/home/dos

Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety - The Accident at TEPCO's Fukushima Nuclear Power Stations (https://japan.kantei.go.jp/kan/topics/201106/iaea_houkokusho_e.html)

50. Ambient doses experienced by various location in Fukushima in March 2011 were modest compared with Chernobyl.

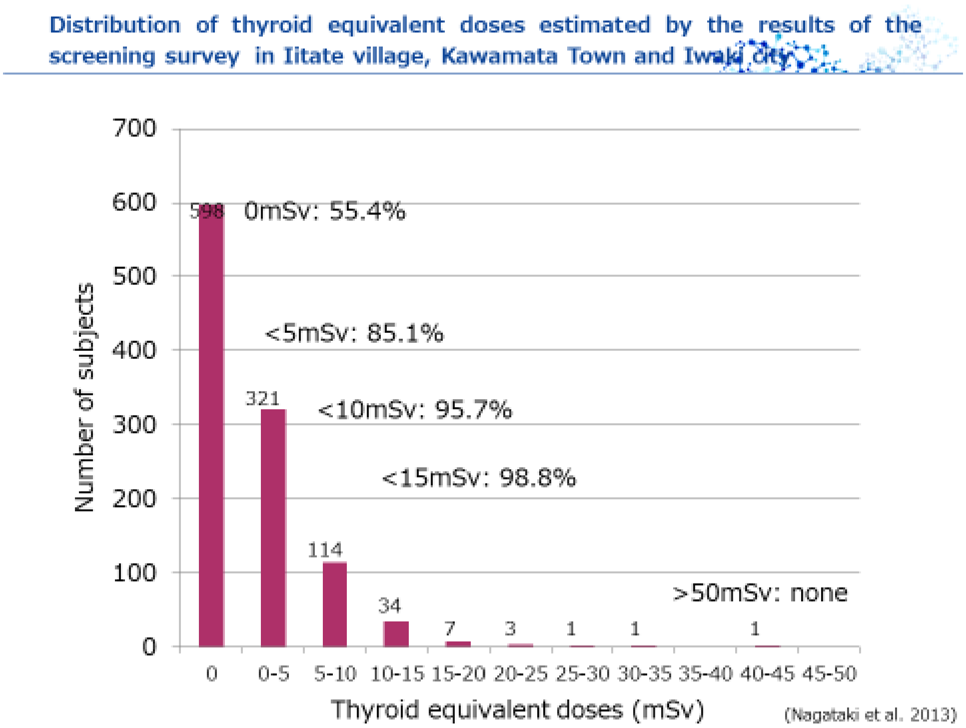
Graphic B



Source: Nagataki S, Takamura N, Kamiya K, Akashi M. Measurements of individual radiation doses in residents living around the Fukushima Nuclear Power Plant. Radiat Res. 2013 Nov;180(5):439-47.

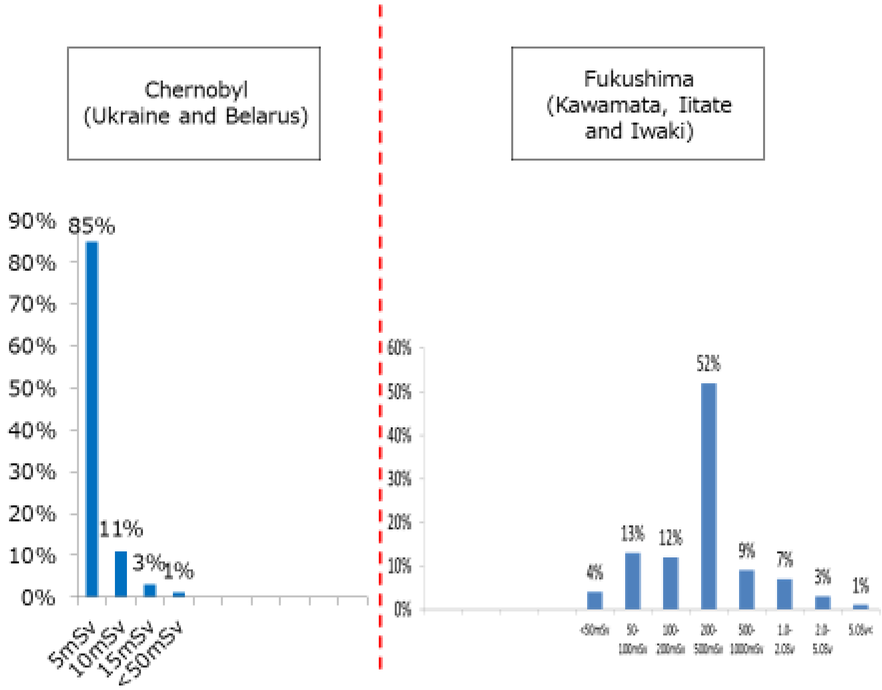
51. Thyroid equivalent doses estimated by the results of the screening survey in Iitate village, Kawamata Town and Iwaki city were considerably lower than in Chernobyl.

Gaphic C



Source: Nagataki S, Takamura N. A review of the Fukushima nuclear reactor accident: radiation effects on the thyroid and strategies for prevention. Curr Opin Endocrinol Diabetes Obes. 2014 Oct;21(5):384-93.

Graphic D: Thyroid equivalent doses compared between Chernobyl and Fukushima.



Source: UNSCEAR 2008 Report to the General Assembly, with scientific annexes

Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety - The Accident at TEPCO's Fukushima Nuclear Power Stations (https://japan.kantei.go.jp/kan/topics/201106/iaea_houkokusho_e.html)

52. The lessons from Fukushima show the necessity of correct understanding of the issues on radiation and the thyroid. Epidemiological studies conducted thus far demonstrate that the dose-dependent risk of radiation-induced thyroid cancer can be assessed and used for projections in the population once significant exposure has taken place in comparison with those of Chernobyl.

53. These predictions are not indeed applicable, at the individual level or in situations with a very

low exposure dose. Radiation risk assessment, radiation safety, and protection are very different problems, which are not always easy to comprehend.

54. The accident at the Fukushima Nuclear Power Plant caused a biased risk perception. The association between radiation and the thyroid has reminded people of the reiteration of Chernobyl and brought about a simplistic way to assume that the high incidence of thyroid cancers has been caused by radiation exposure. This, in turn, has further augmented excessive anxiety, worries, and wrong interpretations of the results of elaborate large-scale ultrasound thyroid screening, having a psychological and mental impact as well as stigmatization on those exposed to radiation.

55. It is thus necessary to deepen the understanding of radiation and the thyroid, both among healthcare professionals and the public, and to develop appropriate radiation risk communication by examining in detail the data of long-term epidemiological surveys and by studying the relation with the exposure dose and other factors, and to rely on the insights provided by cancer biology and genetics. The lessons from Fukushima stimulates the global alliance of radiation protection projects such as "Shamisen" and "IARC 2018 report on nuclear disaster and thyroid health monitoring" (Re2), both of which emphasize the importance of smooth communication and trust among the stakeholders before, during and after the accident.

C. Social Impact

Evacuation of the local population

56. The large release of radioactivity from the Fukushima Daiichi Nuclear Power Plant 1 induced multi-hazard disasters on human livelihood and ecosystem in the affected area in the Fukushima Prefecture. Approximately 154,000 people in the prefecture were evacuated following the radiological incident[41]. Evacuation of hospitalized patients within 20–30 km of the damaged reactor was commenced on 15 March 2011 and completed on 18 March 2011. Some elderly hospital patients, nearly 60, died during their transportation.

57. There were some 2,227 disaster-related deaths in Fukushima accounting for 61 per cent of such 3,676 deaths in all prefectures affected by the Great East Japan Earthquake and Tsunami, which are

[41]The total number of the evacuees due to earthquake, tsunami and the nuclear power station accident peaked in May 2011 at 164, 865.

defined deaths not directly caused by the earthquake and tsunami but are attributable due to indirect causes such as deterioration of physical conditions because of evacuation. The number of those deaths was particularly high among people who evacuated from cities and towns within evacuation zones.

58. Still more than 44,800 evacuees stay at temporary locations and are not able to decide whether to return or not to their home regions due to delay in recovery of economic and environmental livelihood, and lack of employment opportunities as well as fear of radiation risks to health. In October 2012, about 31,000 evacuees were children less than 18 years old reflecting their relative vulnerability to radiation exposure. In April some 18,000 of them were still at temporary locations.

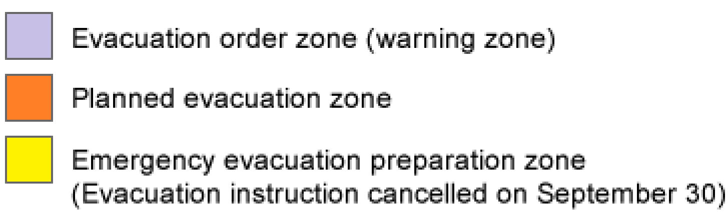
Evacuation zone designation

59. Although some people in the prefectures neighboring Fukushima were voluntary evacuated, mandatory evacuation due to radiological exposure risk was ordered by the Japanese government only in regions of the Fukushima prefecture. As mentioned above, approximately 154,000 people in the Fukushima prefecture were evacuated in response to the 2011 Fukushima radiological incident. Evacuation from the 3-km zone was ordered at 21:23 on the evening of 11 March. The evacuation zone was extended to 10 km away from the damaged reactor at 5:44 on 12 March. Finally, the evacuation zone was extended to 20 km within 24 h of the initial release from the damaged reactor.

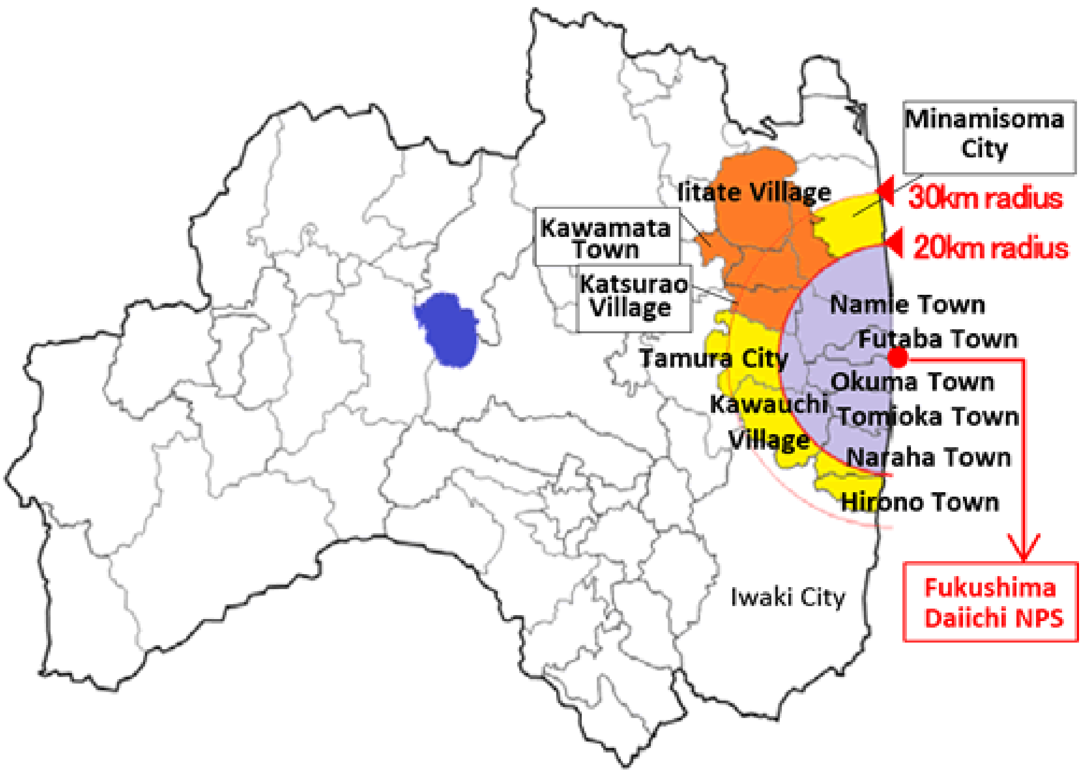
60. From April 22, 2011 until April 1, 2017, the government maintained three evacuation zones: Evacuation Order Zone (Warning Zone); Planned Evacuation Zone; and Emergency Evacuation Preparation Zone (Evacuation Instruction cancelled on September 30, 2011).

61. Transition of evacuation designated zones is summarized as follows (See Figures below[42])

- **As of April 22, 2011**

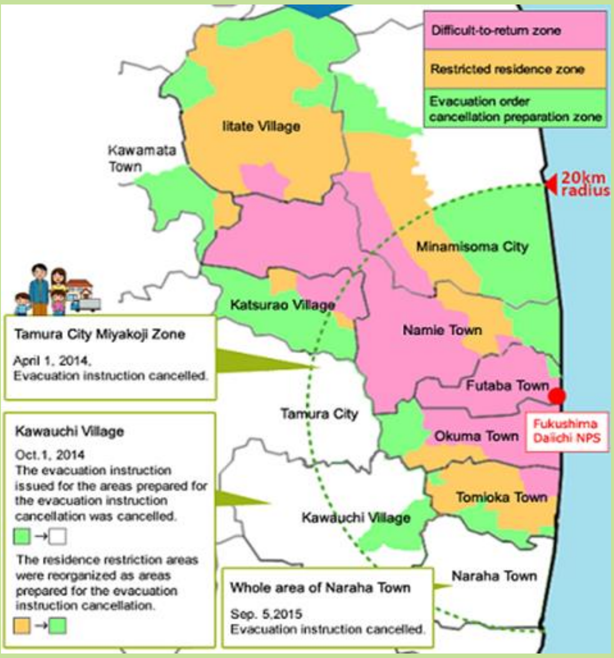
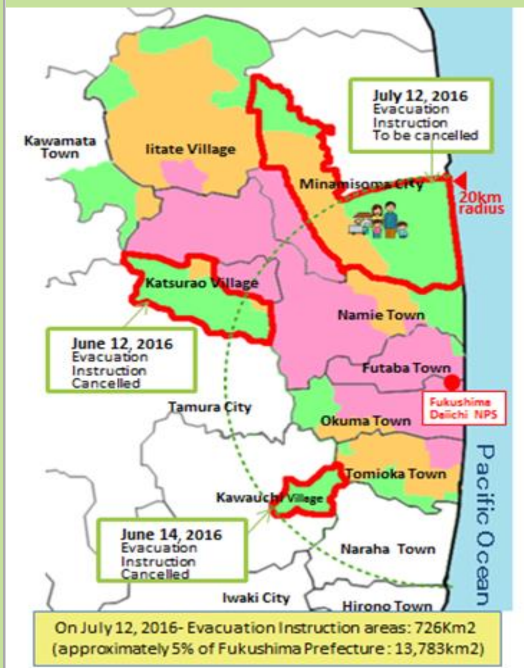


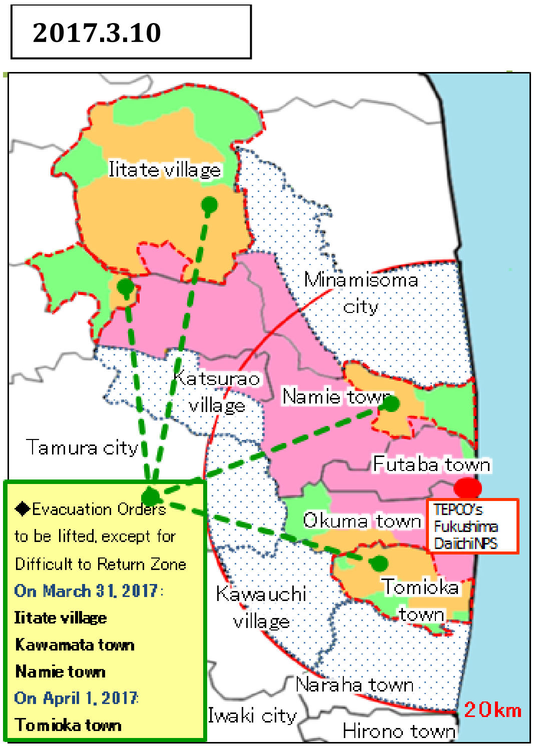
[42] Compiled by Fukushima Prefectural Government on 12 November 2018 at: https://www.pref.fukushima.lg.jp/site/portal-english/en03-08.html



- **Current Instructions**

Evacuation-Designated zones : About 2.7% of the whole Fukushima Prefecture area (Apr 1 2017)	
Difficult-to-Return zone	・Annual integrated doses are over 50mSv. ・Entry is prohibited with some exceptions. ・Lodging is prohibited.
Restricted residence zone	・Annual integrated doses are between 20 and 50 mSv. ・Entry is permitted, and business operation is partially permitted. ・Lodging is prohibited with some exceptions.
Evacuation order cancellation preparation zone	・Annual integrated doses are below 20 mSv. ・Entry is permitted, and business operation is permitted. ・Lodging is prohibited with some exceptions.

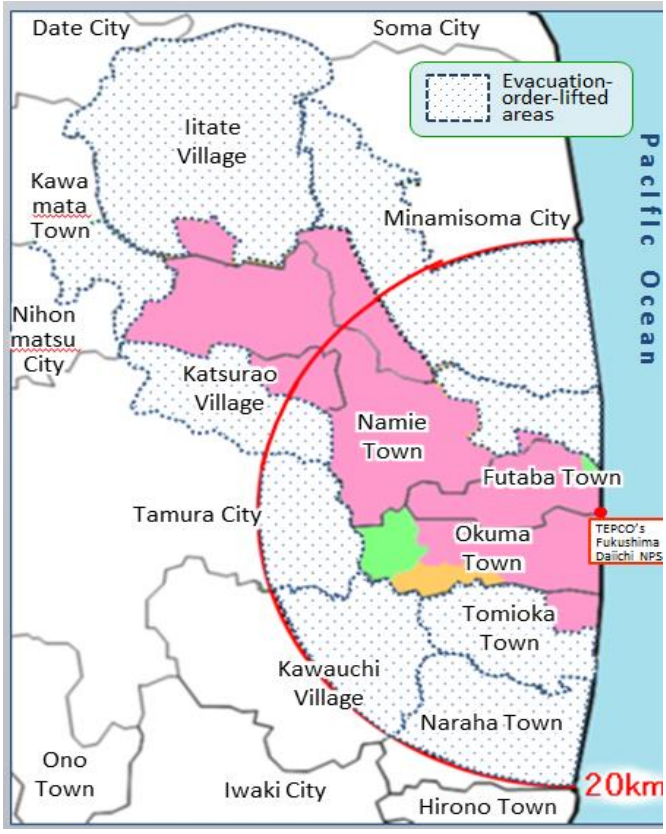
2015.9.05		2016.6.12	
			

2017.4.01

The Evacuation designated zones are approx. 2.7% occupation (371km2) of the entire area of Fukushima Prefecture (13,783km2).

- **Difficult-to-return zone/ SZRR**



62. In the difficult-to-return zone, following the revision of the Act for Special Measures for the Reconstruction and Revitalization of Fukushima (May 2017), the national government designated special zones for reconstruction and revitalization (SZRR).

63. The government recognized the Plans for Reconstruction and Revitalization for Special Zones proposed by the following municipalities:

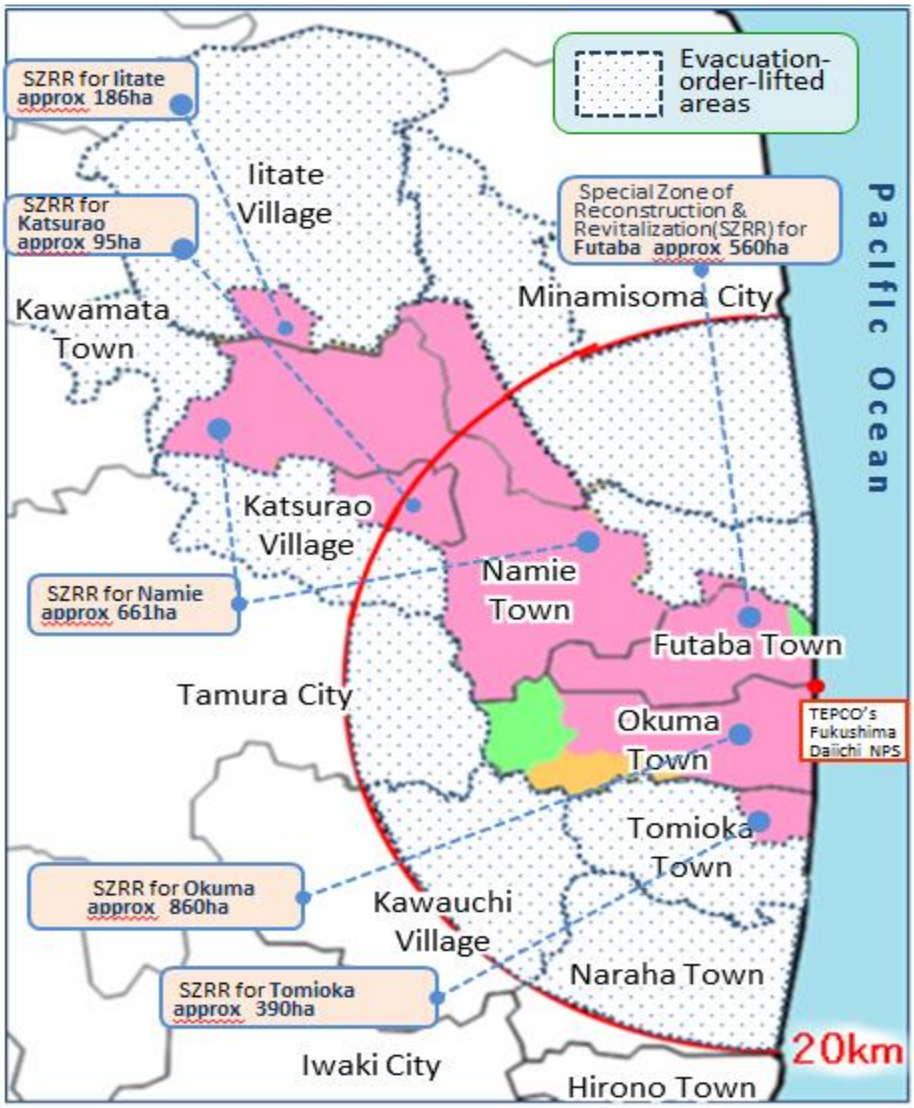
Futaba Town [Sep 15, 2017] Okuma Town [Nov 10, 2017]

Namie Town [Dec 22, 2017] Tomioka Town [Mar 9, 2018]

Iitate Village [Apr. 20 2018] Katsurao Village [May 11 2018]

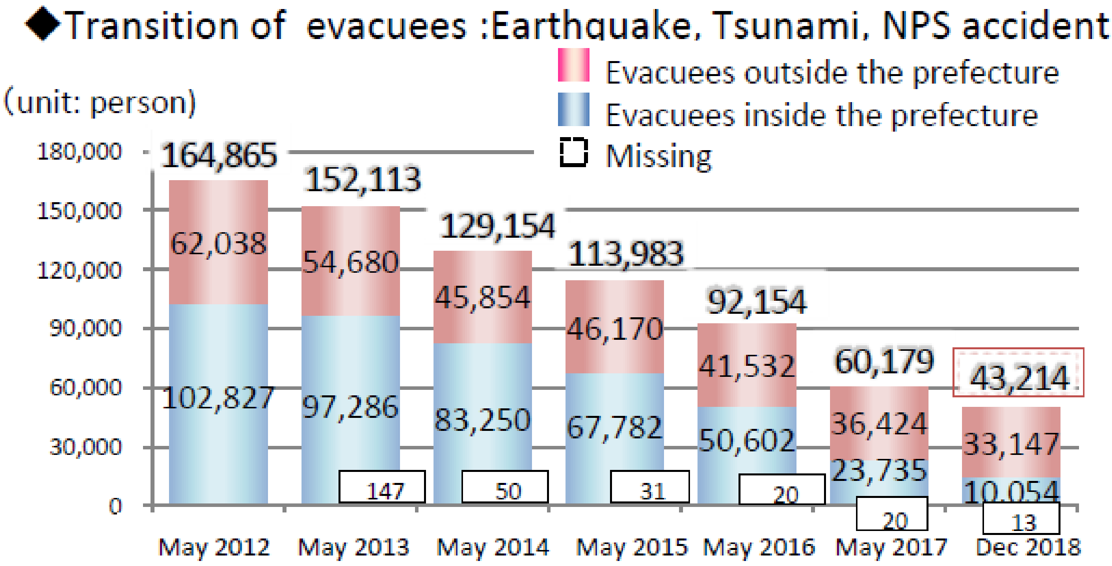
64. The revised act will concentrate on carrying out decontamination and infrastructure development of the designated zones to create an environment which people can return to.

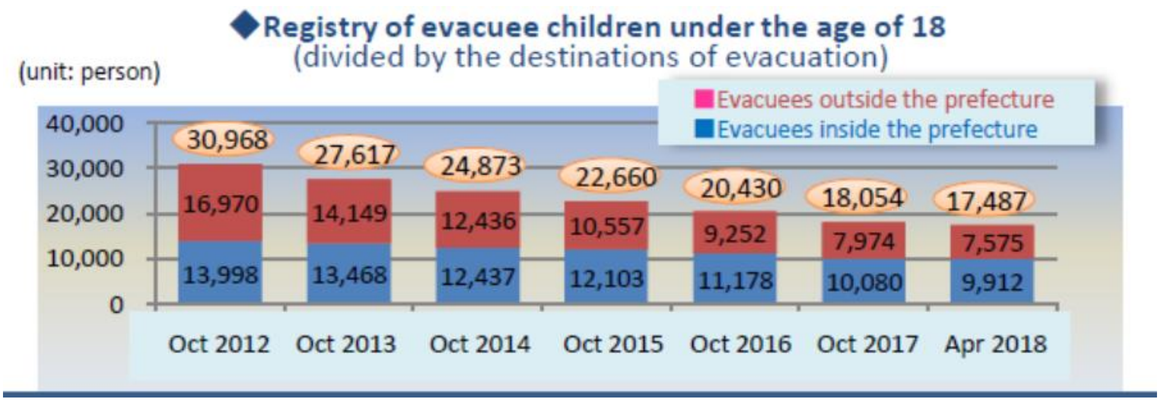
Special zones for reconstruction and revitalization (SZRR)

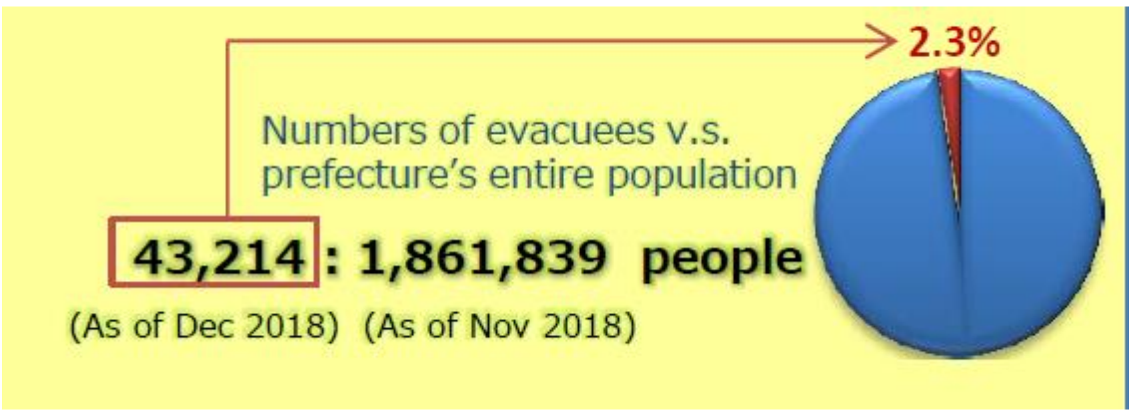


65. As of December, 2018, roughly 43 thousand people inclusive of 33 thousand outside the prefecture is still under evacuation. Most of the evacuation orders issued to the evacuation-designated zones (excluding the Difficult-to Return Zones) have been lifted. Accordingly, reconstruction and revitalization in the former evacuation-designated zones got under way towards remediation and reconstruction (see the graphics and the figure below[43]).

[43]Fukushima Prefecture. *Steps for Revitalization in Japanese Fukushima* (December 25,2018 Edition) available at: http://www.pref.fukushima.lg.jp/uploaded/attachment/307870.pdf.







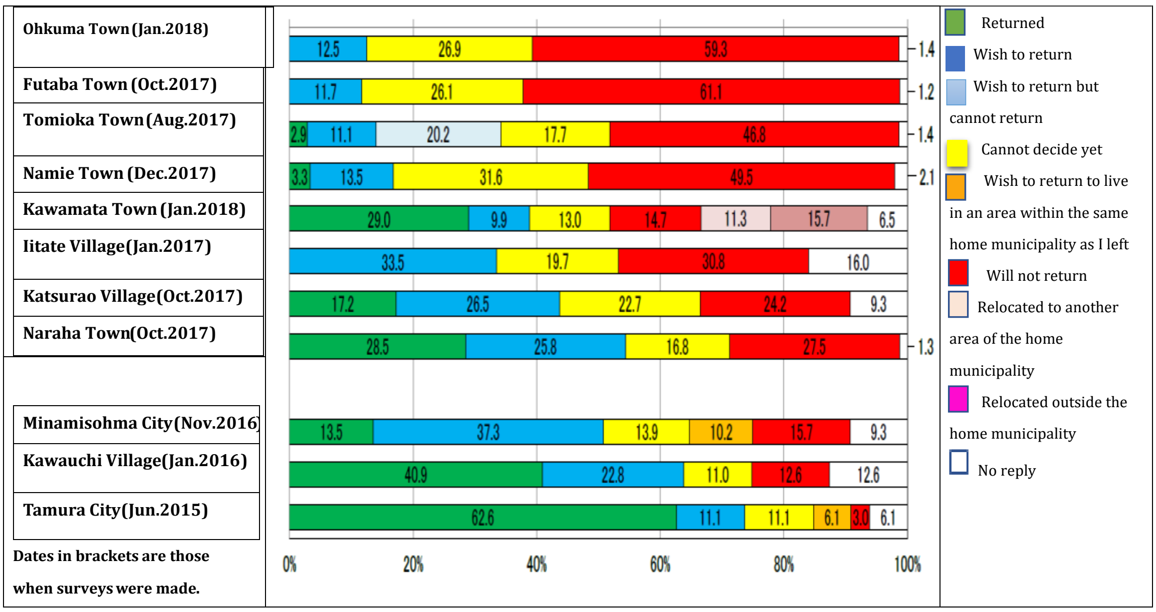
Return of Evacuees from evacuation designated zones

66. Eleven municipalities of Fukushima affected by the FDNPS accidents made surveys (published on 6 March 2018) on the intention of their evacuated residents on the return to their home

communities in the zones where evacuation designation was lifted. According to the results, only in four municipalities the number of residents who have expressed will to return or have already returned exceeded the half of the respective total evacuees. And the shares of the returnees in the evacuated residents ranged from 11.1 % to 37.3 % (See the next graphic translated from the original Japanese latest version "Tackling accelerated reconstruction of Fukushima" by the Reconstruction Agency is found at:

http://www.reconstruction.go.jp/portal/chiiki/hukkoukyoku/fukusima/material/20181030_fukkokasoku.pdf

Surveys on the intention of the evacuated residents on the return to their home communities in the zones where evacuation designation was lifted (published on 6 March 2018 by the Reconstruction Agency).



II. Community Recovery and Reconstruction from Nuclear and Radiological Disasters -Case of Kawauchi Village and Tomioka Town

A) Developing national and local multi-hazard risk reduction strategies

67. Based on lessons learned from the Great East Japan Earthquake and Tsunami in 2011, the Government and local authorities in Fukushima have developed multi-hazard risk reduction strategies and implemented a series of inter-disciplinary support measures during Intensive Reconstruction Period (2011-2015). Although progress was achieved in (i) Providing Health and Living Support; (ii) Restoring Towns and Housings; (iii) Reviving Industry and Livelihoods; and (iv) Revitalizing and Reconstructing Fukushima under the Act on Special Measures adopted to this effect in 2011, it has been recognized that the recovery and reconstruction of Fukushima was considerably delayed due to disruption of life-line infrastructure as well as industry and business chains. Long-term evacuation and relocation of the residents affected by the nuclear power station accident requires comprehensive measures of physical and mental health care and community development including "Mental Recovery" projects during the Reconstruction and Revitalization Period (2016-2020) the Government's Cabinet launched in March 2018 by its Guidelines for Reconstruction[44] for that period.

68. The government also launched a new National Resilience Plan on 14 December 2018 to construct robust national capacity to prevent future large-scale disasters based on assessment of vulnerability to all hazards. The plan requires all local authorities to adopt its own Resilience plan in which should (i) maximize protection of human life; (ii) Maintain vital functions of the State and society without catastrophic obstacles; (iii) Minimize the damage on the property of the people and public facilities; and (iv) Ensure quick restoration.

69. In view of these guidelines, the local plan in Fukushima Prefecture[45] and that of Kawauchi Village include comprehensive support measures for return and life rebuilding of people evacuated from outside the evacuation instructing area, which comprise provision of radiation risk information and school radiation education, and health care and socio-psychological support as well as decontamination of

[44] Reconstruction Agency, *Basic Guidelines for Reconstruction in Response to the Great East Japan Earthquake in the "Reconstruction and Revitalization Period (11 March 2018) in http://www.reconstruction.go.jp/english/topics/Laws_etc/20160527_basic-guidelines.pdf.*

[45] Fukushima Prefectural Government, *Fukushima's Resilience Plan* (in Japanese) in https://www.pref.fukushima.lg.jp/uploaded/attachment/249726.pdf

radiated soil, monitoring of radionuclide doses, restauration of farming ecosystem, and employment assistance of damaged job seekers, evacuees, returnees[46].

B) Evidence-based community recovery and reconstruction from Nuclear and Radiological Disasters

70. As the Sendai Framework (para.17) pointed out, Nagasaki University maintains its goal to "Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience".

71. There is a pressing need for the Prefectural Government and local communities in Fukushima to understand how nuclear radiation risk has increased and manifested causing critical-infrastructure disruptions, economic and social losses with health impact on the affected population. However, there is no overarching framework for managing such risks especially as they have been handled by specific and technical communities often in isolation from broader risk-reduction efforts. Moreover, lessons learned from the impacts of the FDNPS accident require intensive evidence-based science-policy interface to promote multi-hazard risk management on nuclear disasters characterized by acute, chronical, and direct and indirect impacts.

72. Thus, Nagasaki University is deeply convinced of the need for providing technological support and interacting with the local communities of Fukushima in their response and recovery of health and livelihood including. We report hereafter a case of developing a public and academic collaboration model based on the experience of such as Kawauch-Village, the first community which achieved return of the evacuees.

73. Since 2011, Nagasaki University has been assisting the reconstruction efforts of Kawauchi Village in the Fukushima Prefecture, which was the first village to declare it safe for residents to return to their homes. In April 2013, Nagasaki University and the Kawauchi government office concluded an agreement concerning comprehensive cooperation toward reconstruction of the village.

74. The present study evaluates the internal and external exposure doses of residents and conducted

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[46] Kawauchi Village Office, *Reconstruction, Reconstruction and Maintenance Plan of 28 March 2018* (in Japanese) in http://www.kawauchimura.jp/data/doc/1522220887_doc_10_0.pdf.

a risk communication based on each resident's radiation dose. Furthermore, researchers began a comprehensive support of Tomioka residents who have returned to their hometown in 2017. Based on the experiences in Kawauchi village, the cooperation of residents, local authorities and specialists is essential for the recovery of areas affected by the nuclear disaster. Accumulated experiences and practices should be carefully evaluated and recorded to prepare for future unexpected nuclear disasters.

Establishment of a Satellite Office of Nagasaki University in Kawauchi Village

75. Immediately after the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS) in March 2011, an evacuation order was issued, to minimize residents' external radiation exposure. On 11 March 2001, the Governor of the Fukushima Prefecture issued instructions for the evacuation of all settlements within 2 km of the FDNPS (1). That same day, the Director-General of the Nuclear Emergency Response Headquarters (Prime Minister) ordered the evacuation of all individuals within 3 km of the FDNPS, and then the evacuation radius was expanded to 20 km later that day. On 15 March 2011, instructions were issued ordering all people living between 20 and 30 km from the FDNPS to shelter in place (1–3).

76. Kawauchi village, in the Fukushima Prefecture, is located within 30 km of the FDNPS (Figure II-1). After the sheltering instructions were issued, almost all residents of the village evacuated, with 75% relocating to the city of Koriyama, where the Kawauchi government office had relocated its offices (4). After the declaration of the termination of the accident by the Prime Minister in December 2011, the mayor of Kawauchi village decided to return to the town.

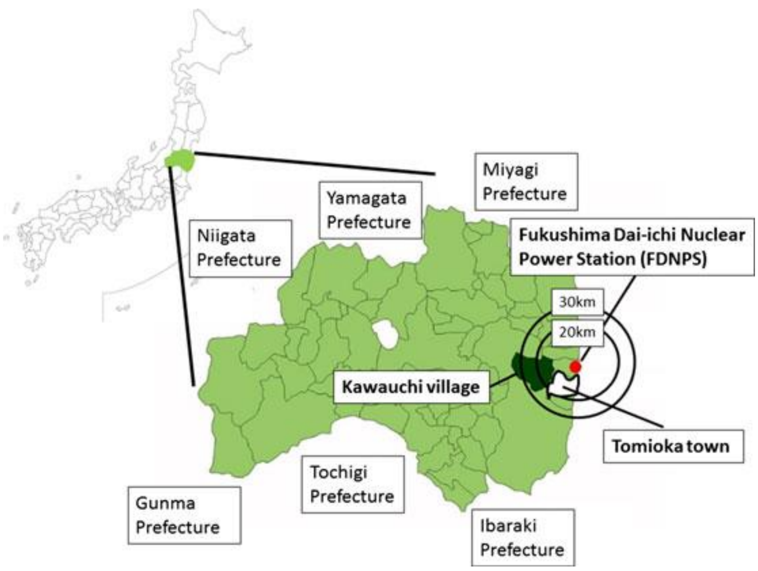

Figure II- 1. Kawauchi village and Tomioka town.

77. Since the inception of crisis, Nagasaki University has been assisting in Kawauchi village's recovery efforts through the evaluation of internal and external exposure doses and risk communication with residents based on their individual doses.

78. In December 2011, we estimated the external radiation exposure doses of residents of Kawauchi through the measurement of radiocesium concentrations in the soil samples collected from the residential areas of the village. The estimated external effective doses from soil samples were 0.0011–0.38 µSv/h (0.010–3.3mSv/y) within the 20–30 km radius from FDNPS. The risk of external radiation exposure of residents revealed sufficiently low in Kawauchi Village[47]

79. In March 2012, the village office of Kawauchi relocated its function in the village, and the residents started returning. In May 2012, a public health nurse from Nagasaki University stayed for an extended period to conduct individual consulting on radiation exposure and health.

80. In April 2013, a comprehensive agreement was concluded between Nagasaki University and the Kawauchi village office to assist the village in sustaining its recovery efforts through:

i. Evaluation of effectiveness of decontamination based on the measurement of radionuclides in soils;
ii. Evaluation of risk of internal exposure through the measurement of food and water;
iii. Health consultations with residents according to the results of the above-mentioned measurements; and
iv. Health promotion of residents.

81. And a satellite office of Nagasaki University was established in the village. From this satellite office, researchers have been working with residents and village office. AS regards the satellite office in Tomioka town, please see paragraph 104 below onwards.

Process of risk communication with the affected population

82. In Kawachi village, we carried out risk communication with residents through various channels:

[47]Taira, Y., Hayashida, N., Yamaguchi, H., Yamashita, S., Endo, Y. and Takamura, N. *Evaluation of environmental contamination and estimated radiation doses for the return to residents' homes in Kawauchi Village, Fukushima prefecture.* PLoS One 7, e45816 (2012).

e.g. (i) Public village lectures on the radiation situation of the village; (ii) Briefing meetings for village leaders, staff and experts specialized in municipal public management (such as health care, life support for elderly displaced people in temporary housing, long-term care prevention, farming recovery, food safety, etc.); (iii) Elderly people salons such as fall prevention classroom, lecture meetings for the elderly on physical strength and awareness improvement; and (iv) child rehabilitation classes at least five times a year in elementary schools working with the village board of education and elementary schools so that children can learn, in an active learning format, what is necessary for recovery, such as knowledge on radiation and health effects as well as village's efforts towards recovery.

83. These events are targeted towards those villagers who have returned from temporary locations seeking advice on the prospect of village’s livelihood recovery including health environment. The events are also used as an effective means of disseminating specialized knowledge on health guidance and counseling, medical checkup and capacity building of health supports to municipal leaders and staff, local professionals, civilian committee members, such as chairpersons of the Women's Council, autonomous groups etc.

84. In the same vein, the dialogue meeting with residents in Tomioka Town takes place once a month. Apart from that, we do weekly home visits to individuals. Those residents are persons who returned to Tomioka Town (about 900 people). Since the people who returned home are mainly elderly, often the audience targeted in our events. But we also offer classes for school children and students. Especially at the dialogue meeting, we share the task with the staff of the local government in responding to inquiries about those matters closely related to the residents' lives, while explaining and discussing their concerns on radiation.

Follow-Up of Radiocesium Concentrations in Wild Mushrooms and Edible Wild Plants

85. Based on the experiences of the Chernobyl accident, it is well known that radiocesium concentrates in wild mushrooms. Kawauchi village was known for wild mushrooms even before the accident as its residents have enjoyed collecting and eating various mushroom varieties. After the accident, many residents had concerns about recovering their ‘mushroom culture’. The researchers discussed this with residents of the village and began a collaboration, known as the ‘mushroom map’ project, in 2013, aiming to clarify the situation of radiocesium contamination of mushrooms in the village.

86. Residents were asked to bring in the mushrooms they collected in the village and the concentrations of radiocesium were measured[48](7, 8). Researchers also calculated the committed effective doses and reported the results to residents. Recently, data on the results of the mushroom map project between 2014 and 2015 have been reported. They show that, in more than 90% of mushrooms, concentrations of radiocesium were still detectable (Figure II-2).

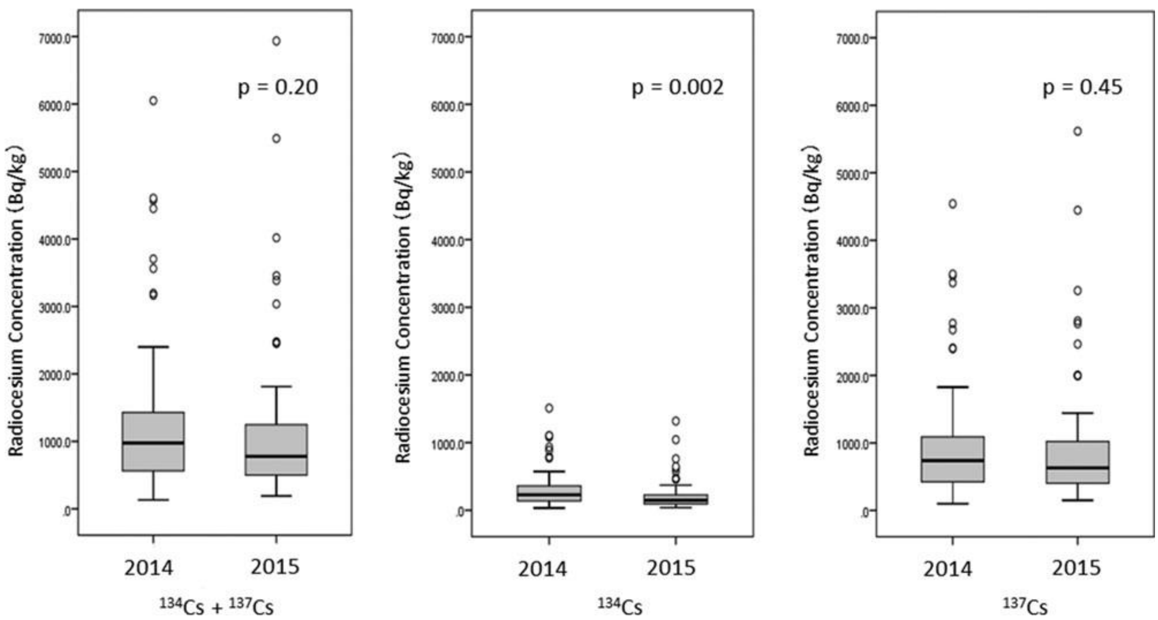

Figure II- 2. Comparison of concentration of radiocesium of Sarcodon aspratus collected in 2014 and 2015[49].

87. We noticed that most species showed relatively higher concentrations of radiocesium and that several species showed relatively lower concentrations. This suggests that the concentration of radiocesium might depend on the species of mushroom. Usually, habitat varies depending on species. Yoshida and Muramatsu (9) found that the habitat of the mycelium seemed to be one of the most important factors controlling radiocesium concentration in mushrooms. Since habitat is closely associated with each species, it is suspected that species type is also associated with radiocesium

[48]Nakashima, K., Orita, M., Fukuda, N., Taira, Y., Hayashida, N., Matsuda, N. and Takamura, N. Radiocesium concentrations in wild mushrooms collected in Kawauchi Village after the accident at the Fukushima Daiichi Nuclear Power Plant. Peer 3, e1427 (2015) and Orita, M., Nakashima, K., Taira, Y., Fukuda, T., Fukushima, Y., Kudo, T., Endo, Y., Yamashita, S. and Takamura, N. Radiocesium *concentrations in wild mushrooms after the accident at the Fukushima Daiichi Nuclear Power Station: follow-up study in Kawauchi Village*. Sci. Rep. 7, 6744 (2017).
[49]Orita, M., Nakashima, K., Taira, Y., Fukuda, T., Fukushima, Y., Kudo, T., Endo, Y., Yamashita, S. and Takamura, N. *Radiocesium concentrations in wild mushrooms after the accident at the Fukushima Daiichi Nuclear Power Station: follow-up study in Kawauchi village*. Sci. Rep. 7, 6744 (2017).

concentrations in mushrooms. In addition to wild mushrooms, it has been clarified that radiocesium is also frequently observed in edible wild plants. The researchers also evaluated the concentrations of edible wild plants collected in Kawauchi village by residents and found that 10% of them showed concentrations of radiocesium at a level of 100 Bq/kg.

88. Regular meetings were held with residents to report these results and to discuss the future direction of the projects aiming for the recovery of the village. We emphasized that although radiocesium was detected in most mushrooms collected in the village, committed effective doses are limited even if residents consumed them several times.

89. Such communications, based on collaboration between residents and specialists, have become one of the leading models for recovery from the nuclear disaster. We noticed that 'face to face discussion' based on own 'dose' of each resident is very important during the recovery phase after the nuclear disaster.

Assessment of Individual Doses for the Lifting of Evacuation Zones in Kawauchi Village

90. Although the residents of Kawauchi village began returning to their homes in March 2012, residents who had been living within 20 km of the village could not return until the evacuation order was lifted.

91. In collaboration with the village office, the external doses of residents who were living in the evacuation zone and temporarily returned to their homes were measured using personal dosimeters. This allowed for the prediction of residents' exposure doses after the evacuation order was lifted and showed that these additional external exposure doses were relatively limited in the area within 20 km of the village. Our study[50]confirmed that individual doses are at low level even in the evacuation order area in Kawauchi village, and external effective dose levels are certainly decreasing due to the decay of artificial radionuclides and the decontamination of contaminated soil. Long-term follow-up of individual doses as well as internal-exposure doses, environmental monitoring and reconstruction of infrastructure are needed so that residents may return to their hometowns after a nuclear disaster.

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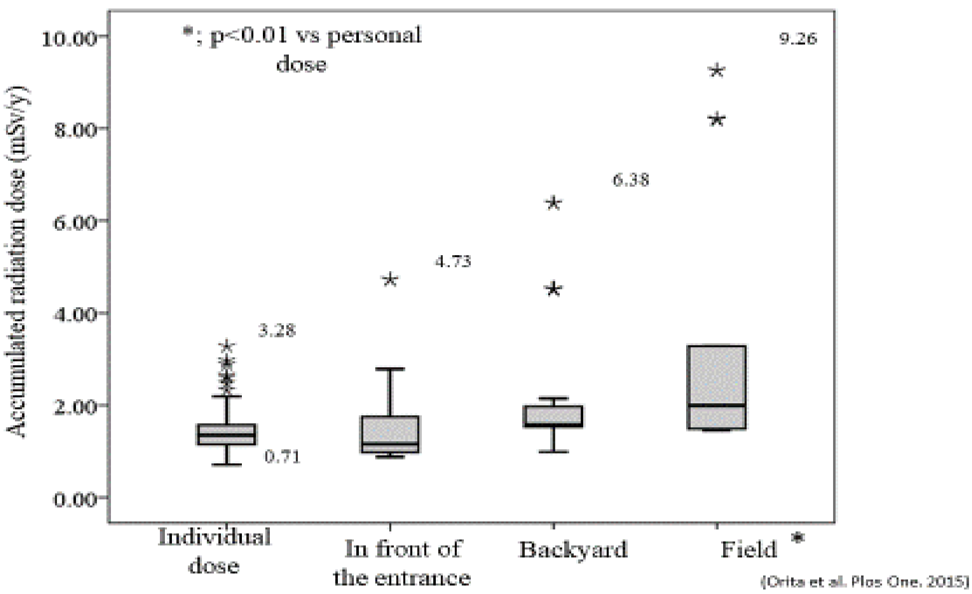
[50]Orita M, Hayashida N, Taira Y, Fukushima Y, Ide J, Endo Y, Kudo T, Yamashita S, Takamura N. *Measurement of individual doses of radiation by personal dosimeter is important for the return of residents from evacuation order areas after nuclear disaster*. PLoS One 10(3): e0121990, 2015.

Figure II-3

Figure 3.
Cumulative individual doses, cumulative ambient doses in front of the entrance, in the backyard, and field.



92. Based on these results, residents, the Kawauchi village office, and the Japanese government discussed and decided to lift the evacuation order. In April 2013, 1 year after people began returning to the village, rate of returned residents was almost 50% of the pre-accident total population. By May 2017, the rate of returned residents had increased to 80%.

Paradigm shift in risk communications with inhabitants

93. During assistance, we noticed from our participatory survey that fear of radiation risk was not a

dominant factor affecting the return of evacuees. Concern with job opportunity, livelihood, education and environment is of equal or greater importance compared with radiation risk (see the result of survey below).

Box 3.

Factors not to return to hometown (February, 2012)

1. Scary damage caused by radiation:	161 persons (15.50%)
2. Access to medical facilities:	201 persons (19.35%)
3. Anxiety in the living environment:	135 persons (12.99%)
4. Working environment in the village:	125 persons (12.03%)
5. Anxiety in the education:	110 persons (10.59%)
Total number	1,039

(Kawauchi village office)

94. We also conducted a survey[51] in Kawauchi Village on the hesitation of the registered residents to decide to return to their hometowns for various reasons including employment mismatch for themselves, education for their children, and, particularly, anxiety regarding the health effects of radiation exposure.

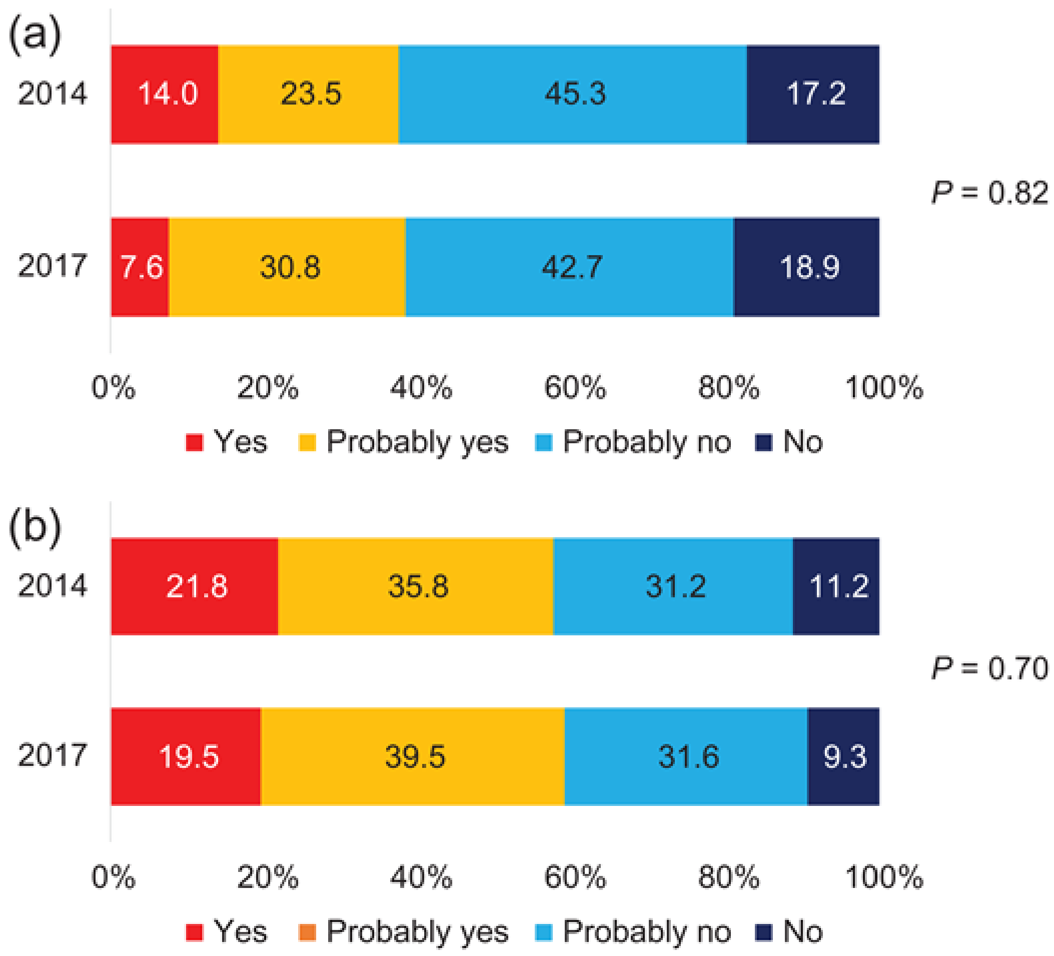
95. Although it is known that the exposure doses of residents are very limited due to the prompt evacuation and food regulation policy[52], we found that the percentage of residents who considered that adverse health effects would occur from 1 mSv per year of radiation exposure [the protection level for the public recommended by the International Commission of Radiological Protection (ICRP)] was 37.5% (38.4% in 2014)]. Also, the percentage of residents who stated that adverse effects would occur via their annual intake of mushrooms, including 100 Bq/kg of radiocesium (the current standard value of food

[51] Nana Sato, Makiko Orita, Yasuyuki Taira, Noboru Takamura. *Seven years post-Fukushima: overcoming the resident–specialist gap*
Journal of Radiation Research, Volume 59, Issue 4, 1 July 2018, Pages 526–527, https://doi.org/10.1093/jrr/rry037
Published: 30 April 2018

[52] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). *Developments since the 2013 UNSCEAR report on the levels and effects of radiation exposure due to the nuclear accident following the Great East-Japan Earthquake and Tsunami.* Available at: http://www.unscear.org/docs/publications/2016/UNSCEAR_WP_2016.pdf (7 December 2017, date last accessed).

regulation in Japan), was 59.0% (57.6% in 2014) (see Figure II.-4.).

Figure II-4.



Source: Nana Sato et al., *Seven years post-Fukushima: overcoming the resident–specialist gap (see footnote 41 above)*

NB: (a) The percentage of residents who responded that adverse health effects would occur from 1 mSv per year of radiation exposure in 2014 and 2017; (b) the percentage of residents who answered that adverse effects would occur via their annual intake of mushrooms, including 100 Bq/kg of radiocesium, in 2014 and 2017.

96. These results suggest that residents do not fully understand the difference between radiation protection policy, which is as low as reasonably achievable (ALARA), and the actual health effects of radiation based on the results of epidemiological studies. Significantly, this gap has not changed, even 7 years after the accident.

97. Underlying this gap are high levels of psychological distress and decline in subjective well-being were observed among Fukushima residents, especially those who expressed great concern over radiation or distrust of government. Post-accident medical studies have also revealed the exacerbation of physical illnesses such as diabetes and hyperlipidemia, especially in evacuees[53].

98. To fill the cleavage between the public and professionals, we promote through group-based discussions or face-to-face communications to address comprehensive health risks to individuals and well-being. The activities were intended to support residents' decisions and to promote public health in a participatory manner[54].

99. Individual consultations on radiation exposure and health effects, frequently asked questions were as follows:

1) 【Regarding internal radiation exposure】

Are water and rice safe?

What is the level of concentration of radiocesium in locally produced foods?

2) 【Regarding external radiation exposure】

What is the level of radiation exposure in the evacuation order area of the village?

What does a "baseline of 1 mSv/year" mean?

What is the purpose of the decontamination?

3) 【Regarding Children】

Is it safe for children to play outside?

We are worried about the health effects of radiation on our children.

4) 【Other questions】

What is the difference between radioactive material and radiation?

100. Individuals are not willing to leave the affected areas if adequate conditions are built up. Therefore, a long-term goal should be to rehabilitate areas to allow people to return to their normal habits.

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[53]Satoh H, Ohira T, Hosoya M, et al. *Evacuation after the Fukushima Daiichi Nuclear Power Plant accident is a cause of diabetes: results from the Fukushima Health Management Survey.* J Diabetes Res.2015; 2015:627390 and Nomura S, Blangiardo M, Tsubokura M, Ozaki A, Morita T, Hodgson S. *Postnuclear disaster evacuation and chronic health in adults in Fukushima, Japan: a long-term retrospective analysis.* BMJ Open. 2016;6: e010080.

[54]

Michio Murakami, PhD, Akiko Sato, MPH, PhD, Shiro Matsui, BL1, Aya Goto, MD, PhD, Atsushi Kumagai, MD, PhD, Masaharu Tsubokura, MD, PhD, Makiko Orita, PhD, Noboru Takamura, MD, PhD,
Yujiro Kuroda, PhD, and Sae Ochi, MPH, PhD. *Communicating with Residents About Risks Following the Fukushima Nuclear Accident.* Asia Pacific Journal of Public Health 2017, Vol. 29(2S) 74S–89S available at https://doi.org/10.1177/1010539516681841

101. This represents complex situations that cannot be managed with radiation protection considerations alone. All relevant dimensions, such as health, environmental, economic, social, psychological, cultural, ethical, political, etc. should be addressed.

102. There shall be a paradigm shift from radiation safety principle based on radioactive doses, to tackling with societal factors that are determinants of public health. Public health not only of evacuees, but also the general population is very much affected by social, environmental and psychological impacts of both the nuclear accident and countermeasures, e.g. evacuation, relocation, decontamination and constraints on freedom of residence and movement as well as limited use of ecosystem for livelihood.

103. The accident at the Fukushima Daiichi Nuclear Power Plant caused extensive human suffering and revealed the need for more effective means of communicating health risks to the public.

Establishment of Satellite Office of Nagasaki University in Tomioka Town

104. The town of Tomioka is located within 20 km of the FDNPS (Figure 1). After the accident, its residents evacuated to Kawauchi village, and the town office finally relocated to Koriyama city. Before the accident, the total population was almost 160 000, and the town of Tomioka played a central role in the Futaba region, including Kawauchi village, where the FDNPS is located.

105. In 2017, the evacuation order for Tomioka was partially lifted. Although decontamination efforts were complete, it had been clarified that most residents did not plan to return to Tomioka, since many had established their new lives in the places to which they evacuated. However, the recovery of Tomioka was still deemed essential for the recovery of the Futaba region.

106. To support this recovery, a comprehensive agreement was concluded between Nagasaki University and the town itself in September 2016. Since April 2017, when the Tomioka town office reopened in the town, the researchers established a satellite office there and began to support the town's recovery. Although the number of residents who have returned remains limited, it is believed that the provision of continuous support for Tomioka, based on the similar experiences in Kawauchi village, is important for the recovery of the Futaba area (For risk communication process with Tomioka inhabitants, see para. 84).

Conclusion of the section

107. As the Chernobyl accident made clear, the direct involvement of local stakeholders in the day-to-day management of a radiological situation is feasible. There is also an evidence of the potential for its residents to implement many protective actions for their day-to-day lives, in addition to the collective actions taken by the authorities. However, in Chernobyl, no local authorities have ever returned to their homes after the evacuation. This means that Kawauchi village is the first local authority to have returned to its hometown after evacuation following a nuclear disaster. As this work has made clear, cooperation among residents, specialists and local authorities is essential for the recovery of areas affected by nuclear disasters. Our experience in Kawauchi village has shown a potential for successful recovery. Accumulated experiences and practices of the sort should be carefully evaluated and recorded not only to accelerate the recovery of Fukushima's other local communities as and when evacuation orders are lifted therefrom, but also to prepare for future unexpected nuclear disasters elsewhere in Japan and the world.

III. Overall Conclusions

Need for universal health coverage on radiation exposure

108. Concerning the public health radiation emergency issue, people-based universal health coverage, under the basic principal of trust and smooth communication among the stakeholders, should be applied so that "no one be left behind".

109. Especially health consequences of low dose and low dose-rate radiation exposure are always unclear and uncertain because of its stochastic effect. Therefore, careful and long-term health monitoring programs including care and treatment should be transparently planned and implemented after the nuclear and radiological disaster.

Lessons learned from community recovery in Fukushima

110. Experience of Kawauchi Village provides the following lessons:

- There is a pressing need for understanding how nuclear radiation risk manifested with health impact on the affected population at the community level such as fear and anxiety about cancer risk, precipitated evacuation in the absence of adequate risk communication, consequential psychosocial and mental stresses, and delayed recovery of employment opportunities and environmental livelihood.

- The comprehensive and continuing health check-up of all Individuals is indispensable for evaluating dose–responsive relationship and achieving resilience and a countermeasure against public fear and anxiety about radiation.
- There shall be a paradigm shift from radiation safety principle based on radioactive doses, to tackling with societal factors that are determinants of public health. Public health not only of evacuees, but also the general population is very much affected by social, environmental and psychological impacts of both the nuclear accident and countermeasures, e.g. evacuation, relocation, decontamination and constraints on freedom of residence and movement as well as limited use of ecosystem for livelihood.
- Comprehensive risk management is required during crisis and post-crisis period after the NPP accident. There, the reliability and creditability of crisis communication are of primordial importance together with post-crisis risk communication with the affected inhabitants to directly address face to face their individual concerns.
- It is important to develop professional human resources and build up capacity in the field of disaster and radiation exposure medical science within national DRR plans.

Strengthening Sendai Framework's multi-hazard approach

111. The Sendai Framework provides for its goal to prevent new and reduce existing disaster risk. Much more should be done for its full implementation as follows:

- Mainstream DRR within and across all sectors dealing with man-made hazards and particularly nuclear hazards applying to them the 38 indicators of the seven global targets of the Sendai Framework through the SFM and with respect for each of the four Priority Areas for Action for the Sendai Framework.
- Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020 mainstreaming radiation risk management plans.
- Promote a multi-hazard approach should in view of the multi-facetted nature of nuclear and radiological disasters having acute and chronical, and direct and indirect impacts and damages requiring intensive evidence-based science-policy interface implemented within a national disaster risk management plan.
- Ensure coherent governance framework and eliminating duplication of fragmented

programmes and projects through UNISDR's take-stock of research and policy development on nuclear radiation DRR in such multilateral sources as:

(i) Relevant global and regional thematic mechanisms[55] to address nuclear risk reduction in UN, WHO and d IAEA; and

(ii) SDG-related mechanisms such as the High-Level Political Forum on Sustainable Development and the work of UNISDR, UNEP, Habitat, UNOCHA, UNCEAR, WHO, IAEA, CTBTO, IFRC and ICRP relevant for the implementation and review of DRR-related SDG1, SDG11 and SDG13.

- Identify feasible practices that can serve for *better monitoring radiation protection and post disaster recovery* in the Global Risk Assessment Framework (GRAF) and the SFM and measuring relevant progress in the implementation of the Sendai Framework;
- Develop through UNISDR networking and exchange of information among governments and multi-stakeholders to unleash a global momentum for developing guidelines on nuclear hazard risk-communication with the population at the community level; and
- Establish an International Recovery Platform for nuclear disaster risk reduction drawing upon the lessons learned by the Fukushima affected-communities together with the relevant findings from IAEA, ICRP, IFRC, UNSCEAR, WHO and CTBTO on the model of the IRP advocated in the Hyogo Framework for Action.

[55] For example, SHAMISEN Consortium for Nuclear Emergency Situations: Improvement of Medical and Health Surveillance Project (2015-2017 SHAMISEN) to implement “Recommendations and procedures for preparedness and health surveillance of populations affected by a radiation accident (18 July 2017)”.