ATTACHMENT A-11

EVACUATION SCENARIOS AND NUMBER OF EVACUEES

UNSCEAR 2020/2021 Report, Annex B, Levels and effects of radiation exposure due to the accident at the Fukushima Daiichi Nuclear Power Station: implications of information published since the UNSCEAR 2013 Report

Content

This attachment describes the methodology used for assessing public exposure to the evacuees from the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS) in March 2011.

Notes

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MODELLING OF EVACUATION SCENARIOS

1. The Japanese authorities took extensive measures to reduce radiation exposure. There was widespread evacuation at different times following the accident and there were also restrictions on food supplies (for an overview of the evacuation see UNSCEAR 2013 Report [UNSCEAR, 2014]). Information on the number of people residing in the evacuated and adjacent areas before the accident and the number of people evacuated is presented in table A-11.1 from attachment C-12 of the UNSCEAR 2013 Report.

Table A-11.1. Populations of the evacuated areas and some adjacent territories and the number of evacuees

City, town or village	*Population before 11 March 2011* [a]				*Rounded number of evacuees* [b]		
	<20 km	*20–30 km*	*>30 km*	*Total*	*Evacuated by 15 March 2011*	*Population of deliberate evacuation area*	*Total* [c]
Minamisoma	14 300	47 400	9 200	70 900	14 300	<100	32 000
Katsurao	300	1 300		1 600	300	1 300	1 600
Namie	19 600	1 000	300	20 900	19 600	1 300	20 900
Tamura	600	3 200	36 600	40 400	600		3 000
Futaba	6 900			6 900	6 900		6 900
Okuma	11 500			11 500	11 500		11 500
Kawauchi	1 100	1 700		2 800	2 800[d]		2 800[d]
Tomioka	16 000			16 000	16 000		16 000
Naraha	7 700			7 700	7 700		7 700
Hirono	200	5 200		5 400	5 200		5 200
Iitate		300	5 900	6 200		6 200	6 200
Kawamata			15 600	15 600		1 300	1 300
Iwaki		2 200	340 000	342 200			2 700
Total	**78 200**	**62 300**	**407 600**	**548 100**	**84 900**	**10 200**	**117 800**

[a] Approximate number based on the 2010 Flash Report of National Census of 2010 [MIC, 2011].
[b] The numbers reported in [MEXT, 2020]; those were adjusted to be consistent with the population data.
[c] The number of evacuees may also include evacuees who lived outside of the 30-km radius and people evacuated for other reasons than radiological protection. (Translation from p. 2 of [MEXT, 2020]). For that reason, the total number of evacuees may be larger than the sum of people evacuated before 15 March 2011 and from the deliberate evacuation area.
[d] Evacuated from the evacuation zone (<20 km) by 15 March 2011, and from the whole village immediately after the village mayor's instruction on 16 March 2011. (The interim report of the Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company.)

2. For the UNSCEAR 2013 Report, detailed information about the destinations of those evacuated in the precautionary and deliberate evacuations was presented in table 11 of attachment C-12 [UNSCEAR, 2014]. The dose assessment for the period before and during the evacuation was based on the results from a questionnaire survey issued by the local authorities to all residents within Fukushima Prefecture (two million people) to ascertain their activities and, specifically, their locations and movements. Approximately 21% of the population completed the questionnaires. The National Institute for Radiological Science (NIRS) used the results of this survey to define 18 scenarios representative of the movements of residents local to FDNPS, following the accident [Akahane et al., 2013].

3. In a recent study, Ohba et al. further refined the evacuation scenarios by conducting a hierarchical clustering analyses of 100 to 300 randomly sampled behavioural questionnaire sheets of children from each of the seven municipalities in the evacuation area [Ohba et al., 2020]. This resulted in 37 new representative evacuation scenarios, which have been used for the assessment of doses to residents of evacuated communities, as outlined in table A-11.2. These 37 new evacuation scenarios did not include residents from the evacuated communities of Hirono Town and Katsurao Village. Thus, the Committee additionally included those three of the original 18 evacuation scenarios representing evacuated residents from Hirono Town and Katsurao Village (resulting in 40 evacuation scenarios in total, see table A-11.2).

Table A-11.2. Evacuation scenarios from Ohba et al. [Ohba et al., 2020] (#01-37) and NIRS survey [Akahane et al., 2013] (#38-40)

Scenario	*Location at 11 March 2011*	*Start > Route > Destination*	*Destination prefecture*	*Destination location*	*Evacuation start time*[a,b]	*Number of evacuees*
01(FT1)	Futaba Town	Futaba > Kawamata > OOP[c]	Saitama Ken	Saitama Shi	AM2 on 12 March	5 009
02(FT2)	Futaba Town	Futaba > Iwaki > OOP	Ibaraki Ken	Kasama Shi	PM1 on 12 March	421
03(FT3)	Futaba Town	Futaba > Odaka > Fukushima > OOP	Ibaraki Ken	Yuki Shi	AM2 on 12 March	421
04(FT4)	Futaba Town	Futaba > Haramachi> Koriyama	Fukushima Ken	Koriyama Shi	PM2 on 12 March	421
05(FT5)	Futaba Town	Futaba > Namie > Kawamata > OOP	Tochigi Ken	Sano Shi	PM1 on 12 March	628
06(TM1)	Tomioka Town and Kawauchi Village[d]	Kawauchi > OOP	Niigata Ken	Niigata Shi	PM2 on 15 March	3 384
07(TM2)	Tomioka Town	Tomioka > Ono > OOP	Chiba Ken	Chiba Shi	PM1 on 12 March	1 504
08(TM3)	Tomioka Town	Tomioka > Kawauchi > Koriyama > OOP	Chiba Ken	Chiba Shi	AM2 on 12 March	12 972
09(TM4)	Tomioka Town	Tomioka > Iwaki	Fukushima Ken	Iwaki Shi	PM1 on 12 March	940
10(NR1)	Naraha Town	Naraha > Iwaki > OOP	Tochigi Ken	Nasushiobara Shi	AM2 on 12 March	862
11(NR2)	Naraha Town	Naraha > Iwaki > OOP	Chiba Ken	Chiba Shi	AM2 on 12 March	2 672
12(NR3)	Naraha Town	Naraha > Iwaki	Fukushima Ken	Iwaki Shi	AM2 on 12 March	470
13(NR4)	Naraha Town	Naraha > Hirono > Aizu> OOP	Tochigi Ken	Mooka Shi	AM2 on 12 March	3 457
14(NR5)	Naraha Town	Naraha > Iwaki > OOP > Iwaki	Fukushima Ken	Iwaki	AM2 on 12 March	239
15(OK1)	Okuma Town	Okuma > Tamura > Aizu	Fukushima Ken	Aizuwakamatsu Shi	PM1 on 12 March	4 205
16(OK2)	Okuma Town	Okuma > Tamura	Fukushima Ken	Tamura Shi	AM2 on 12 March	5 800
17(OK3)	Okuma Town and Futaba Town[d]	Futaba > Kawamata > Iwaki > OOP	Tokyo Metropolitan	Shinjuku Ku	AM2 on 12 March	1 015
18(OK4)	Okuma Town and Tamura City[d]	Tamura	Fukushima Ken	Tamura Shi	(no further evacuation)	2 755
19(OK5)	Okuma Town	Okuma Town > Odaka > Haramachi > Sukagawa > OOP	Tochigi Ken	Nasushiobara Shi	AM1 on 12 March	725
20(NM1)	Namie Town	Namie > Haramachi > OOP	Tokyo Metropolitan	Shinjuku Ku	AM2 on 12 March	3 344
21(NM2)	Namie Town	Namie > Soma	Fukushima Ken	Soma Shi	PM1 on 12 March	1 254
22(NM3)	Namie Town	Namie > Tsushima > Koriyama	Fukushima Ken	Koriyama Shi	AM2 on 12 March	11 495
23(NM4)	Namie and Tsushima[d]	Tsushima > Nihonmatsu	Fukushima Ken	Nihonmatsu Shi	AM2 on 16 March	1 463

Scenario	*Location at 11 March 2011*	*Start > Route > Destination*	*Destination prefecture*	*Destination location*	*Evacuation start time*[a,b]	*Number of evacuees*
24(NM5)	Namie Town	Namie > Kawamata > OOP	Yamagata Ken	Yonezawa Shi	AM2 on 13 March	3 344
25(IT1)	Iitate Village	Iitate > Koriyama	Fukushima Ken	Koriyama Shi	AM2 on 16 March	1 860
26(IT2)	Iitate Village	Iitate > Kawamata > Fukushima > Aizu	Fukushima Ken	Kitashiobara Mura	AM2 on 15 March	1 488
27(IT3)	Iitate Village	Iitate > OOP	Saitama Ken	Saitama Shi	AM2 on 19 March	1 550
28(IT4)	Iitate Village	Iitate	Fukushima Ken	Iitate Mura	22 June	1 302
29(OD1)	Odaka ward of Minamisoma City	Odaka > Haramachi > Iwaki > OOP	Tokyo Metropolitan	Shinjuku Ku	PM2 on 12 March	1 008
30(OD2)	Odaka ward of Minamisoma City	Odaka > Kawamata > Aizu > OOP	Yamagata Ken	Tsuruoka Shi	PM1 on 12 March	1 536
31(OD3)	Haramachi ward of Minamisoma City	Haramachi > Date > Haramachi > OOP	Kanagawa Ken	Yokohama Shi	AM2 on 12 March	1 008
32(OD4)	Odaka ward of Minamisoma City	Odaka > Haramachi > Fukushima > OOP	Tokyo Metropolitan	Shinjuku Ku	PM2 on 12 March	11 440
33(OD5)	Odaka ward of Minamisoma City	Odaka > Haramachi > Soma > OOP	Saitama Ken	Saitama Shi	PM1 on 12 March	1 008
34(HK1)	Haramachi ward of Minamisoma City	Haramachi > Fukushima > OOP	Kanagawa Ken	Yokohama Shi	PM1 on 17 March	12 880
35(HK2)	Iitate Village	Iitate > Koriyama > OOP	Yamagata Ken	Yamagata Shi	AM1 on 12 March	1 088
36(HK3)	Kashima ward of Minamisoma City	Kashima > Haramachi > Iitate > OOP	Kanagawa Ken	Yokohama Shi	AM2 on 12 March	608
37(HK4)	Haramachi ward of Minamisoma City	Haramachi > Soma	Fukushima Ken	Soma Shi	PM1 on 18 March	1 424
38 (10 in UNSCEAR 2013 Report)	Hirono Town	Ono Town Office	Fukushima Ken	Ono Shi	12 March	5 200
39 (12 in UNSCEAR 2013 Report)	Katsurao Village	Azuma Gymnasium	Fukushima Ken	Fukushima Shi	14 March	800
40 (14 in UNSCEAR 2013 Report)	Katsurao Village Office	Azuma General Gymnasium	Fukushima Ken	Fukushima Shi	21 March	800

[a] AM1, AM2, PM1, PM2 refer to early morning, late morning, early afternoon and late afternoon, respectively.
[b] The focus of Ohba et al. [Ohba et al., 2020] was on evacuation before 26 March 2011. The timings of later evacuations (in particular, of the municipalities of Iitate Village and parts of Tamura City in May and June 2011) are as set out in the UNSCEAR 2013 Report [UNSCEAR, 2014].
[c] OOP denotes out of prefecture and indicates that the destination was a prefecture other than Fukushima Prefecture.
[d] In these scenarios, people were evacuated from the first named location to the second named location on the day of the earthquake (11 March 2011).

4. Within these 40 evacuation scenarios, four types of human activities were considered:

(a) Normal living conditions;

(b) Residents preparing for evacuation;

(c) Evacuation; and

(d) Sheltering.

5. For the normal living conditions, the assumptions on human behaviour were the same as those used in the external and inhalation exposure calculations for the non-evacuated areas. For the evacuation preparation, evacuation and sheltering activities, the Committee assumed occupancy factors, dose reduction factors (see table A-11.3) and breathing rates that reflected the nature of activities undertaken (distinct from those considered for normal living conditions). The dose reduction factor for "normal living" is lower than the dose reduction factor for "sheltering" since it is assumed that people stay indoors in wooden houses (with a shielding factor of 0.4) during sheltering 100% of the time, while for "normal living" it is assumed that they stay:

(a) Indoors in wooden houses for 60% of the time (for adults; for children 70% is assumed);

(b) In concrete buildings (with a shielding factor of 0.1) for 30% of the time (for adults) and 20% (for children) is assumed; and

(c) Outdoors for the remaining 10% of the time (without shielding, i.e., a shielding factor of 1.0).

Table A-11.3. Dose reduction factors for different exposure pathways and types of activities related to the modelling of evacuation scenarios

Type of activity	*Infant 1 year/Child 10 years*			*Indoor worker*		
	Groundshine	*Cloudshine*	*Inhalation*	*Groundshine*	*Cloudshine*	*Inhalation*
Normal living	0.37	0.37	0.55	0.34	0.34	0.55
Sheltering	0.4	0.4	0.5	0.4	0.4	0.5
Evacuation (also Evacuation preparation)	0.675	0.675	1.0	0.675	0.675	1.0

6. The assessments of public exposure for the 40 evacuation scenarios used the deposition density and air concentration results from atmospheric transport, dispersion and deposition model simulations of Terada et al. [Terada et al., 2020]. Otherwise, the same input parameters and methods as for the assessment for external exposure and dose from inhalation for the non-evacuated areas were applied (see attachments A-1 and A-10).

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