DISASTER MANAGEMENT FOR BOILING GLOBE BY WORLD'S 441 NUCLEAR-HEATED WATER

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ABSTRACT

The present paper firstly outlines the 'unstoppable' nature of nuclear power generation as exemplified by the system lifecycle of ageing nuclear reactors, the decommissioning of reactors, and the nuclear waste disposal problem, which stakeholders find difficult to understand. Secondly, it highlights the sea-temperature rise in the northern hemisphere, specifically the North Pacific and North Atlantic, as a result of the thermal effluent water from nuclear power plants which is a product of today's nuclear industry. Thirdly, it presents the hypothesis of the 'Boiling Globe' caused by this thermal effluent water, whereby the overheating of whole oceans compounds CO_2–based atmospheric warming and accelerates the spread of infectious tropical diseases to the northern hemisphere. The paper points to the unsustainability of this global boiling caused by the world's 441 nuclear plants with an average lifespan of 30 years. The traumatic experience of the Fukushima disaster has become a 'disaster anchor' based on psychological and cultural aspects, comparable to the career anchors of Edgar Schein (1978), and is a cultural function forming the premise of decision-making. From the standpoint of Japan, which has experienced Fukushima and other frequent disasters, it is therefore important to make the world aware of the necessity of disaster management for our sustainable future.

Keywords: disaster management; resilience; global boiling; sustainability; disaster anchor

1 COMPLEXITY FROM NATURAL AND HUMAN-MADE DISASTER: UNSTOPPABLE NUCLEAR POWER GENERATIONS

1.1 Risk and Crisis of the World Aging Reactors: 441 Reactors and 40years Operation

The disaster that occurred in March 2011 at the Fukushima nuclear power station in Japan sent shock waves around the world (NAIIC, 2012). With this now the third major nuclear-power disaster, following Three Mile Island in America and Chernobyl in the former Soviet Union (Yablokov et al., 2009), the safety of nuclear power has begun to be questioned. In western countries and other developed nations that have introduced nuclear power, the disaster has raised the issue of 'aging nuclear reactors', whose environmental impact, including the issue of 'decommissioning of reactors', has become a concern.

[†] 'Un–safety: Systems Pathology of the Fukushima Nuclear Catastrophe', ISSS Proceedings, 2013

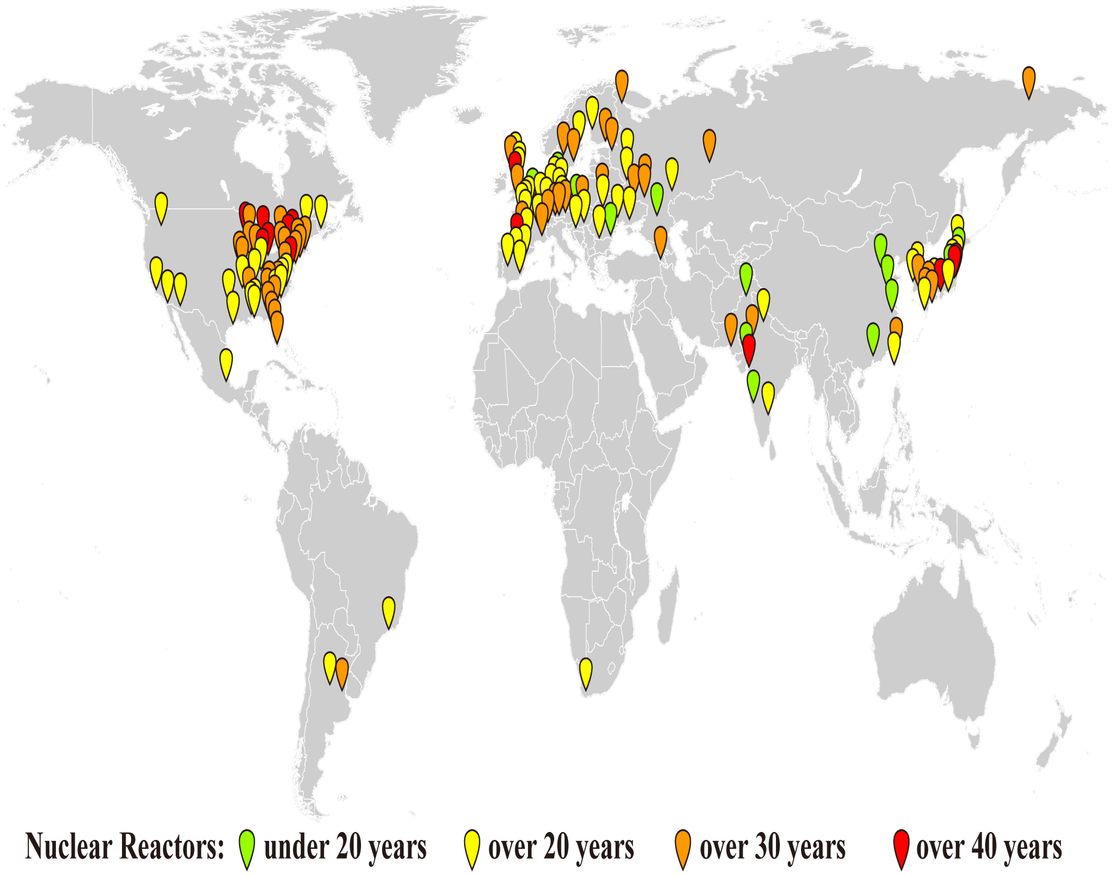

Figure 1. The world's aging nuclear reactors (2011)
Note: Mapped by Fujimoto and Atsuji based on Nuclear Database, World Nuclear Association. (Presented at ISSS 2011)

Figure 1 charts the world's nuclear power stations by duration of operation and shows a large number that have been operating for 30 years or more in North America, Europe, and Japan. Of those stations currently in operation, approximately 37 percent are in the 'aging' category—that is, 30 years old or more—in which the lifecycle has been extended beyond the normal operational lifespan of nuclear reactors. Meanwhile, standards for the decommissioning of nuclear reactors do not exist either at the international or the national level, and in the profit-driven and highly lucrative business of nuclear-power generation, there is a history of operational lifespan being extended without allowing for 'decommissioning' and decontamination costs or accident clear-up costs. Calculations of costs have failed to consider expenditures and time periods falling outside the operational lifespan, at the planning and construction stage or in the dismantling and decommissioning of reactors. Table 1 summarizes the systemic lifecycle of the nuclear power station including these stages. Normally, the lifecycle of a nuclear power station has been set at twenty years, but many countries extend the operational lifespan beyond 40 years. The United States has permitted a 20-year extension of a nuclear power station already in operation for 40 years to a total of 60 years. Meanwhile, in Japan, the approval plan of extensions up to 60 years had been suggested in October 2010, the year before the Fukushima nuclear accident.

Table 1. Systemic lifecycle of a nuclear power station

Planning stage	Planning	Approx. 4 years
	Application	
Construction stage	Construction operations	
Operation stage	Operation and inspection	20-40 years*
Reactor decommissioning stage	Nuclear fuel discharge	20-30 years* not including disposal of spent fuel
	System decontamination	
	Safe storage	
Dismantling and removal stage	Interiors	
	Buildings	
Total no. of years		80-100 years

*Operational lifespan: 60 years where extension permitted.
Source data: legislation on nuclear source materials, nuclear fuel materials, and nuclear reactor regulations.

The period required for the decommissioning of nuclear reactors is said to be 40 years, which means that the lifecycle from construction through to decommissioning, even excluding the disposal of spent nuclear fuel, is more than 80 years. The cost of decommissioning is estimated at around 350–480 million dollars for a small reactor (in the 500,000 kW range), around 430–610 million dollars for a medium reactor (in the 800,000 kW range), and around 560–760 million dollars for a large reactor (in the 1.1-million-kW range) (Agency for Natural Resources and Energy, 2013). Moreover, the planning and application process—from the establishment of a nuclear power station through to the decommissioning of the reactors, including approval and licensing procedures with the regulatory government authority—is complicated. It is also crucial to take into account the costs and time needed for the substrata inspection required before the construction of an electricity-generating station, the trial operation required before full operation, and the 'radiation-decontamination operations' necessary at the time of decommissioning, while nuclear waste in the form of spent nuclear fuel also consumes massive costs and time. The decommissioning of nuclear reactors has thus become a global issue today.

Spent nuclear fuel is stored for three to five years in a 'cold storage pool' within the station. Subsequent processes differ by country, but the waste is generally sent to a reprocessing plant to extract re-usable uranium and plutonium, after which it is subject to long-term storage, for instance in an underground facility at a treatment plant for highly radioactive waste. In Japan, highly radioactive waste is vitrified and kept in cold storage for 30–50 years, then disposed of underground through burial at a depth of at least 300 m in the geological strata. In November 2013, former Prime Minister Junichirō Koizumi called for an immediate end to nuclear power. To support his argument, he cited the fact that there was still no decision made on a 'spent-nuclear-fuel storage' facility and, despite the yearly increasing volume of nuclear waste, no confirmed plans as to the disposal system and technology to be used or the location of the disposal site.

1.2 Unsought Consequences of Nuclear Energy: Accumulations of Nuclear Radioactive Effluents

Today, in the wake of Japan's Fukushima nuclear accident, the world's nuclear power stations are under increasing scrutiny from the viewpoint of safety. Fukushima has taught the world that accidents could involve not only natural disasters such as earthquakes, tsunamis, typhoons, torrential rain, flooding, and drought, but also terrorism, war, coup d'état or other events that, instead of attacking the nuclear reactor itself, interrupt the functioning of the electricity-generating facilities used for cooling, causing the reactor to go into meltdown. As a result, the possibility of nuclear-power facilities becoming terrorism targets has been pointed out. In France, 'Greenpeace' activists made an experimental break-in at a nuclear reactor building, while in the United States a group of three elderly protestors reportedly penetrated a nuclear reactor facility supposedly under heavy security. They are finding the 'security holes'.

From the start, the systemic lifecycle of nuclear-power generators, from initiation to the decommissioning of reactors, the disposal of radioactive waste, and other aspects, has remained a matter of uncertainty. As shown above in Table 1 (Systemic lifecycle of a nuclear power station), four years were estimated for the initiation including the initial operating period, and 20–40 years for operation, but as noted above the original 20-year lifespan of a nuclear power station has been extended in a common worldwide development. When decommissioning of reactors and radioactive half-life are taken into account, we arrive at a period of more than *100 years of continuing cost* and labor requirements. These are not all included in calculations of the unit cost of electricity generation. There is already a history of worldwide marine disposal of drums containing radioactive nuclear waste, the cumulative total of which over 50 years has exceeded 100,000 tons according to the IAEA (IAEA, 1999). Figure 2 shows the cumulative total of sea-disposed nuclear waste by some countries.

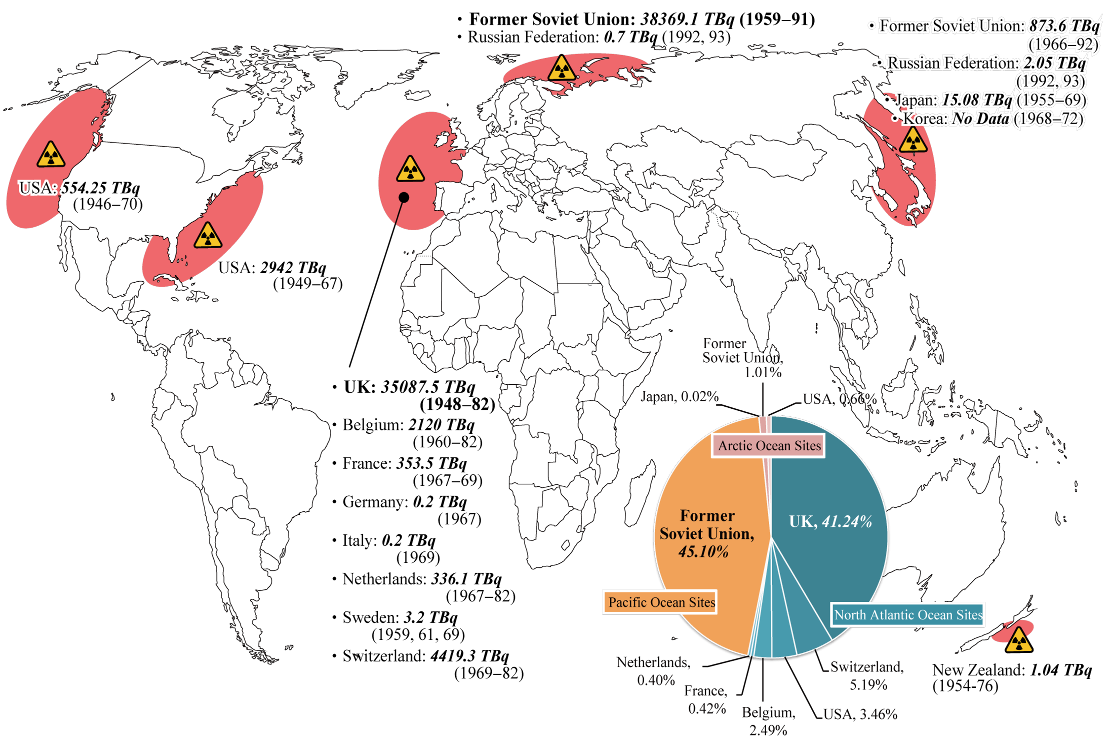

Figure 2. Cumulative total of sea-disposed nuclear waste

Note: Mapping based on IAEA-TECDOC-1105, 'Inventory of Radioactive Waste Disposals at Sea', 1999.

In 1993, when an international treaty banned marine disposal of nuclear waste, America, Germany, Finland, and other countries built facilities for deep underground storage. In some cases, for instance at 'Areva's La Hague' facility in France, disposal in undersea pipelines or similar was reported. The operation of nuclear power stations thus invites Barnard's 'unsought consequences' (Barnard, 1938). Nuclear power's unsought consequences or 'unexpected results' by P.F. Drucker (Drucker, 1985) are represented in the problematic by-products of radioactive contamination from station operation: in addition to (1) limits to the manageability of nuclear power (technological issues of metal fatigue and deterioration) we also face (2) radioactive contamination, and (3) disposal of nuclear waste and decommissioning of reactors when operation ceases (legislation, systems, technology). Additionally, there is (4) the trend for local communities to petition for continued operation, for instance where local businesses have been commissioned with related projects or local governments have received legally mandated payments in return for the exploitation of electric-power resources. Thus, once a nuclear power station has begun operation, in almost all cases it continues to operate even after the inspection period is finished. This means that they are in the generation of 'unstoppable nuclear'. Once a nuclear power station is in place, it is permanent.

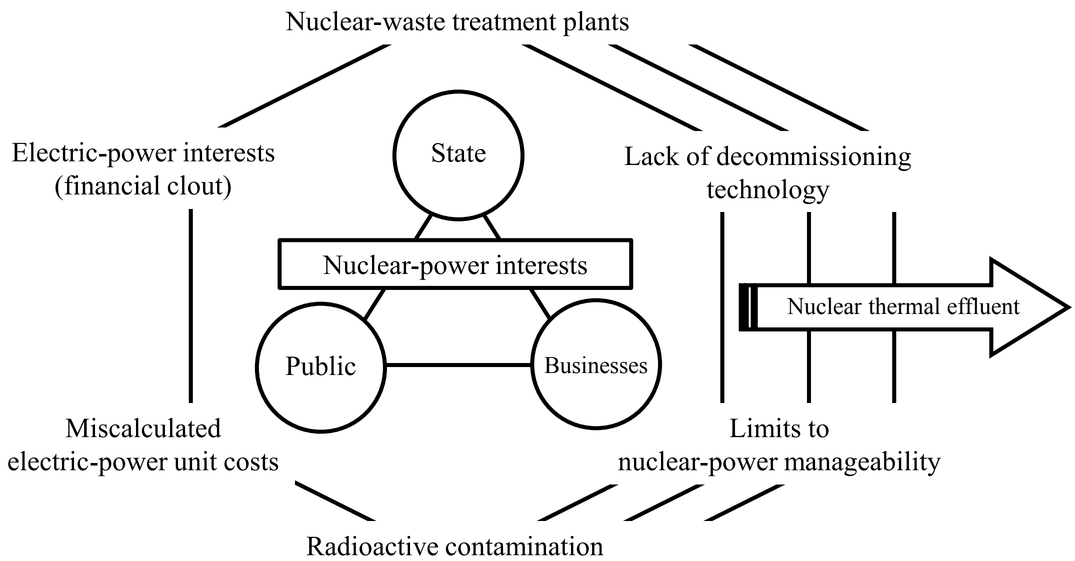

Figure 3. Unstoppable nuclear power generation in the worldwide

Note: Based on 'Unstoppable nuclear power generation' by Atsuji and Fujimoto from 'Systems Pathology Following the Fukushima Nuclear Catastrophe', *Social and Economic Systems Studies*, Tokyo University 2011.

Underlying the 'unstoppability' of nuclear power generation outlined in Figure 3 are (1) a lack of standards for the decommissioning of reactor technology; (2) 'failure' to decide on sites for disposal of accumulating nuclear waste; (3) softening up of communities local to nuclear-power facilities with financial incentives through payment of compensation, consolation money, etc; (4) calculation of electricity-generation unit costs without factoring in costs for decommissioning of reactors, 'decontamination, or waste treatment'; (5) falsification of radioactive-contamination measurements; and (6) limits to the operational manageability of nuclear power stations and 'concealment' of the environmental impact of large amounts of thermal effluent. This illustrates the interconnected factors around the nonterminating of nuclear power.

Moreover, a stakeholder group has formed around the vested interests of local communities, power companies, and the regulatory 'government authorities' in charge of approval and 'licensing operations'. Massive grants from central government are not only allotted to local businesses and residents and electric-power-related associations and companies, but are also distributed in the world of academia to nuclear-power research organizations and as expenses to related corporations. Among the parties involved, this is perhaps accepted to a large extent as a kind of 'tacit payment for inconvenience', 'danger money', or compensation for contamination, but as was shown by the Fukushima nuclear accident, these short-term handouts are no consolation when the worst comes to pass and the living environment, agricultural land, fishing grounds, and other resources are all lost semi-permanently.

However, 'stakeholders' with connections of interest to nuclear power are not limited to the state, commercial enterprises, and local communities. The radioactive contamination that rains down on local people can cross borders to cause exposure in other areas, as at Chernobyl. It was reported by the investigation after the Chernobyl accident that radioactivity had spread across Europe (Yablokov et al., 2009). In the Como region of Italy, the entire rabbit population was culled, while restrictions were placed on the export of German dairy products such as cheese and powdered milk. However, today, in Belarus and the Chernobyl district of the Ukraine, livestock and dairy farmers continue to drink contaminated milk. Of particular note is that residents of communities close to Chernobyl, and especially the children, have rates of leukemia and thyroid cancer almost five times the normal level. Following the recent Fukushima nuclear accident, radioactive contamination has been detected in coastal waters and is becoming an international issue through spread by sea currents, creating a situation for which no restitution is possible. Beyond this, what kinds of issues lie latent in regular nuclear-power-station effluent, which contains waste heat?

1.3 Unexpected Results: Health and Livelihoods by Radioactive Contaminations

In the Fukushima nuclear accident precipitated by the Great East Japan Earthquake of 2011, and other nuclear-power-related accidents and disasters such as the 1999 JCO (which is nuclear fuel fabrication facility in Japan) criticality accident, the Chernobyl accident in the former Soviet Union, and the Three Mile Island accident in the United States, the radiation that is released in the form of cesium, strontium, and other 'elements destroys DNA', not only taking human life but also depriving people of their livelihoods. Radioactive contamination from nuclear power stations and other sources threatens human life and property and infringes on the right to life and human rights, thereby violating constitutional law; cancer and other harms resulting from radiation inflict damage on life and future generations so that it also violates criminal law; by destroying the living environment and communities and undermining livelihoods by damaging workplaces, agricultural land, fishing grounds, and other environments, it also violates civil law. The problem of radioactive contamination from nuclear power stations is a supra-legal issue not susceptible to control by current law.

Today, Fukushima's contaminated waters present a difficult problem. With Tokyo chosen as the host city of the 2020 Olympics, the International Olympic Committee views with misgiving Prime Minister Shinzō Abe's statement that 'the radioactive contamination at Fukushima is completely under control'. At present, as of the end of 2013, accumulated in the contaminated-water storage tanks are 334,000 tons of effluents, enough to fill 800 25-meter swimming pools (Tokyo Shimbun, 2013). The cumulative total of 27,000 trillion becquerels of radioactive contamination that it has already released is said to be equivalent to approximately '1,100 times that of a Hiroshima-type atomic bomb', causing concern over the damage to local communities, human health, and the ecosystem. To illustrate the potential threat, Table 2 summarizes the average amount of the main nuclear species contained per ton of spent nuclear fuel, their half-life, and the potential damage to human health.

Table 2. Half-life and damage to human body of species contained in spent nuclear fuel

Nuclear fuels Nuclide	Half-life	Content per 1000 kg of concentrated spent fuel (kg)	Site of accumulation in human body/ biological half-life
Uranium 238	4.48 billion years	950 kg	Bone/50 years, liver/20 years
Uranium 235	704 million years	10 kg	Bone/50 years, liver/20 years
Plutonium 239	24,000 years	10 kg	Bone/50 years, liver/20 years, reproductive glands/unknown
Strontium 90	29.1 years	26 kg	Bone/50 years
Cesium 134/137	2 years/30.1 years		Muscle, whole body/2–110 days
Tritium	12.3 years	—	Whole body/10–45 days
Iodine 129/131	15.7 million years/8 days	1.2 kg	Thyroid/80 days Rest of body/12 days
Americium 241	433 years	0.6 kg	Bone/50 years, liver/20 years
Neptunium 237	2.14 million years		
Curium 242	162.8 days		

Notes: 1. The above table covers the main nuclear species contained in spent nuclear fuel and is not specific to the Fukushima accident, which has been confirmed to involve 31 radioactive substances.
2. In Japan and other countries, after extraction at the reprocessing plant of reusable uranium and plutonium, the remaining material is buried in concrete.
3. Spent nuclear fuel may be directly buried in concrete depending on the country.
4. Abstraction based on Citizens' Nuclear Information Center.

Historically, against the background of the nuclear arms race during the 'Cold War' between the United States and the Soviet Union, nuclear waste (plutonium, californium, yellow cake, depleted uranium) from nuclear-power facilities under the western 'nuclear umbrella' was mostly collected by the United States as material for intercontinental ballistic missiles and other nuclear weapons. However, after the launch of talks under the Strategic Arms Reduction Treaty (START) between the United States and the Soviet Union, nuclear waste had to be dealt with by the individual country.

The problems associated with the aging of nuclear power stations are not limited to the decommissioning of reactors and the treatment of nuclear waste, but also involve the elevated risk of nuclear-related accidents and disasters as well as terrorism and related incidents. Accidents have already taken place at the Three Mile Island nuclear power station in the United States (Kemeny, 1979), the Chernobyl nuclear power station in the former Soviet Union, and during the crisis accompanying the atmospheric reentry of the nuclear-reactor-equipped 'Soviet space station Mir'. In each of these cases involving the nuclear-power issues of the superpowers, the facts were not sufficiently reported to other countries. However, with the collapse of the former Soviet Union, the details of the Chernobyl accident came to light, and it was reported to have caused the 'China syndrome'. This is the name for the phenomenon which occurs when a nuclear reactor goes out of control and melts and the gravitational force of the heavy uranium sends it sinking toward the center of the earth. It was found out that, as the uncontrollable nuclear reactor reached a high temperature and the building of the Chernobyl station subsided (Reason, 1987), soldiers of the former Soviet army injected ultra-cooled liquid nitrogen into the ground below the reactor to prevent the reactor core from sinking. In this accident, not only were employees and local residents evacuated, but many surrounding villages and towns were also shut off. It was later found out that the radioactive substances released at Chernobyl traveled on the prevailing west wind to Germany, Italy, and other nearby countries and in time to all the countries of Europe, where they spread damage by contaminating animal products.

In the JCO criticality accident of 1999 (NSC, 1999), twelve years before the Fukushima nuclear accident, Japan had already experienced unexpected radiation exposure from a nuclear-power-related facility. Despite warnings of the dangers of such facilities and the systemic defects and other issues within Japan's nuclear-power regulatory administration, protective measures were insufficiently stringent, and the same mistakes were repeated. It has become clear that it is no longer possible for enterprises to cope singlehandedly with the situation of a nuclear accident or disaster, which can become an issue for the government authority that decides nuclear-power policy, or a focus of international conflict. This is thus a problem shared by the whole of humanity.

2 UNSUSTAINABILITY BY GLOBAL OCEAN WARMING

2.1 Systems Pathology: Structural Inertia of Social Organization

JCO used a secret manual that ordered alteration of the procedures laid down by government safety-inspection standards to make shortcuts, and committed human error due to labor-saving of 'administrative systems error' (Reason, 1997). In other words it committed what F.W. Taylor calls 'systematic soldiering' (Taylor, 1903) and 'natural soldiering', resulting in an organizational disaster in the form of a criticality accident. The issues involved in nuclear-power accidents and disasters lead us to a moral position in which all citizens of the globe are recognized as 'various stakeholders' (Berle and Means, 1932).

In the relationship between society and the organization, there are stakeholders such as consumers, the public and shareholders, institutional investors, suppliers, partner financial institutions, the regulatory authority, and the local community. Decision-making on organizational behavior is not possible without considering these interest groups. In contrast, some electric company's interest groups were limited exclusively to the public sector and included for instance the Science and Technology Agency, which was in charge of approval and licensing operations. No consideration was shown to plant operatives and local residents through activities such as safety and 'information disclosure'. Specifically, local residents had not even been informed that the plant manufactured nuclear fuel. The risks from nuclear-fuel operations naturally do not only affect the employees, who are members of the organization, but are shared by members of the public and local residents. Corporate concern should not have been oriented exclusively toward business partners in the 'uranium nuclear-fuel supply industry' and the Science and Technology Agency, which was the regulatory authority.

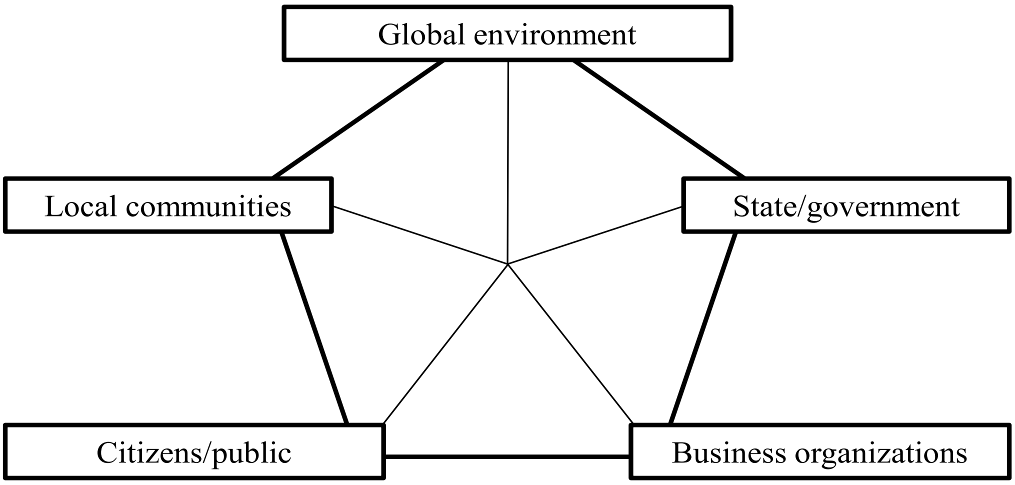

Figure 4. Global stakeholders involved in nuclear power generation

Note: Integrated from charts by T. Persons, H. Ulrich, J.P. Kotter, D.J. Isenberg, D.A. Gioia, and H.P. Sims.

The nuclear criticality accidents in nuclear-fuel-handling operations at JCO mentioned above, and the nuclear accidents at Fukushima, Chernobyl, and Three Mile Island, were not accidents limited to the locality, but disasters that grew in scale to become catastrophes that affected surrounding regions and even neighboring countries. This kind of nuclear disaster develops from an accident into a massive disaster. Thus, as shown in Figure 4, the citizens of the world have felt their impact directly at a global level as 'global stakeholders'. For example, the radioactive substances released in the Chernobyl nuclear accident contaminated Europe's pasturage. Among the many examples of the associated blight was Cesium contamination of livestock, affecting cheese, milk, and other animal products in Germany and resulting in mass culling of contaminated rabbits in the Como region of Italy. Through food, water, and the air, radioactive contamination comes back to haunt humanity.

When accidents and disasters occur, the nuclear-power stakeholders who end up suffering the damage are residents and members of the public. The granting of rights to nuclear-power generation brought gain to some stakeholders, such as the nuclear-power industry, politicians close to the industry, and communities in the vicinity of power stations, but now, faced with the pressing issues of already-aging facilities and decommissioning, the negative side of nuclear-based electricity generation is becoming clear. A potential aspect of this is the contribution to 'global warming' through rising sea temperatures due to 'thermal effluent'. Nuclear-power electricity generation requires massive volumes of water to cool down the reactors, which reach high temperatures in the nuclear-fission process. This is why nuclear power stations in all countries are located on the coast or beside large rivers. For a nuclear reactor of average size with an output of 1 million kW, approximately 70 tons of water is required every second as coolant (Koide, 2011, p. 119). The waste water is released into the sea or rivers at a temperature approximately 7°C higher than when it was taken in.

2.2 A Possibility as Global Warming from Overheating Oceans by Nuclear-Heated Water

Currently, the major cause of global warming is said to be CO_2-based atmospheric warming. However, as the specific heat of water is much higher than that of the atmosphere, the rise in sea-surface temperature due to the continuous retention of heat energy has a greater impact on global warming than the increase in CO_2. It cannot therefore be ruled out that the cumulative effect of the human-made disaster caused by 'nuclear thermal effluent' is connected with natural disasters.

It is said that the rise in sea temperature—and the rise in sea-surface levels due to glacier flows which result in inflows of freshwater into the sea from the Big Melt in the polar regions, leading to lower atmospheric pressure due to the change in specific gravity, higher levels of brackish water, and further warming—will all combine synergistically to cause sea levels to rise. From COP19, the developing countries and the developed nations were at loggerheads over the question of compensation, which the former claimed for loss of territory due to sea-level rise caused by warming (November 22, 2013). Loss of territory in low-lying countries, for instance the Maldives and Tuvalu, is indeed feared due to the effect of sea temperature on global warming and rising sea-surface.

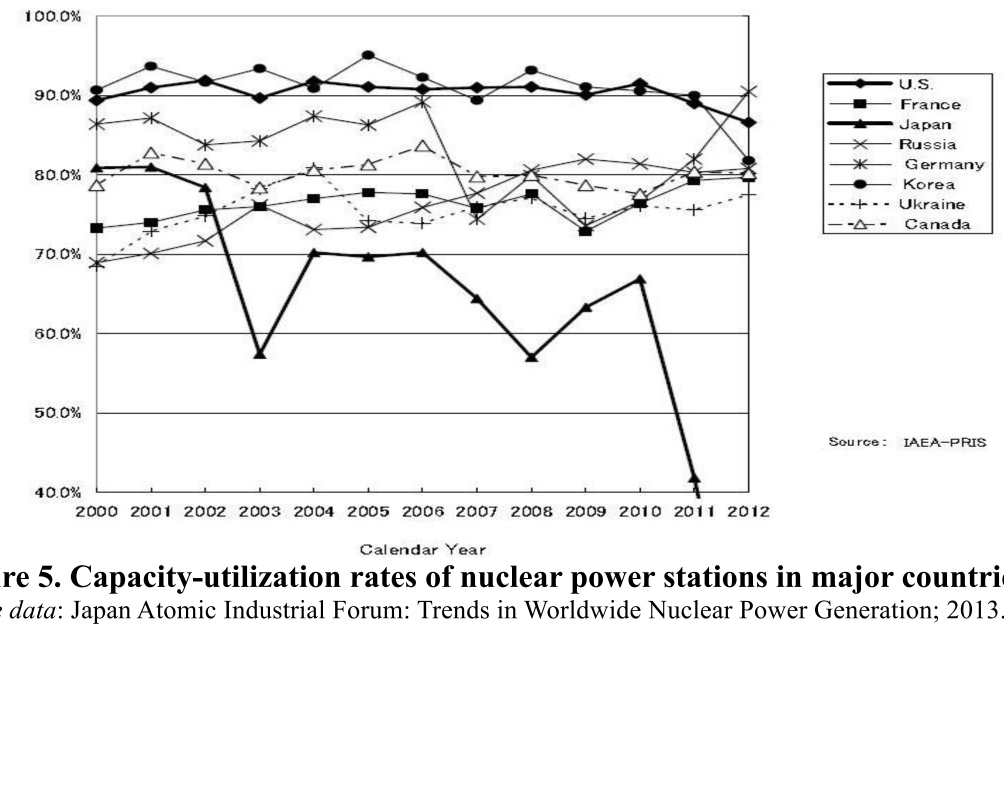

Figure 5. Capacity-utilization rates of nuclear power stations in major countries

Source data: Japan Atomic Industrial Forum: Trends in Worldwide Nuclear Power Generation; 2013.

In Japan, which has 54 reactors, the world's third-highest number of nuclear power stations, according to the rough calculations of Hiroaki Koide of Kyoto University's Research Reactor Institute, every year 100 billion tons of nuclear thermal effluent is discharged, which means that a volume of water equal to one quarter of the total flow volume of Japan's rivers—that is, 400 billion tons—is released having been raised by approximately 7°C in temperature (Koide, 2011, p. 120). Figure 5 shows the average percentage of operating capacity used by nuclear reactors in the main countries, indicating an operating rate of at least 70 percent of capacity even as a low-end estimate after the Fukushima nuclear disaster 2011 (previously 80 percent of capacity).

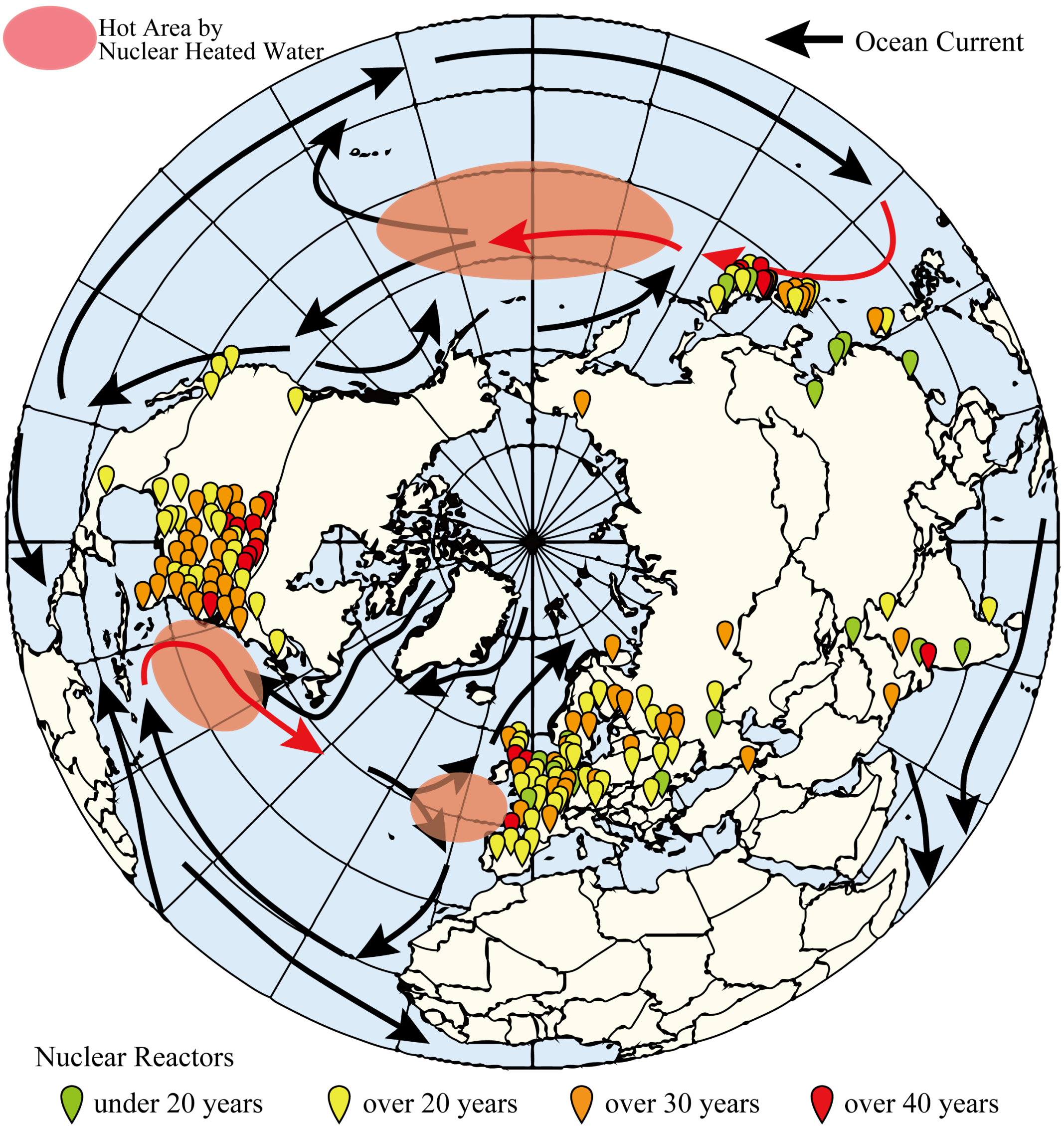

Figure 6. Northern-hemisphere sea-temperature rise caused by effluent from nuclear power stations

Note: Mapping by Atsuji and Fujimoto calculated using data from Nuclear Database (World Nuclear Association, 2011).
Presented at ISSS 2013 (adapted from Figure 1).

Approximately 90 percent of the world's population lives in the northern hemisphere, and due to the electricity consumption that accompanies economic development, 435 of the world's 441 nuclear reactors are also located in the northern hemisphere; the total of six in the southern hemisphere consists of two each in Brazil, Argentina, and South Africa. Moreover, 39.4 percent of the northern hemisphere's surface area is land, compared to only 19.0 percent in the southern hemisphere, meaning that the land surface is relatively large and the sea surface correspondingly smaller. Figure 6 shows the northern hemisphere's 435 nuclear reactors by number of years of operation and estimates the total volume of thermal effluent released by them, thus indicating the possibility of a 'boiling globe' phenomenon through overheating of seawater in the northern hemisphere.

Table 3. Calculation of total nuclear thermal effluent

Area	Number of reactors	Age (Avg.)	Total power output (Mwe)	Average power output (Mwe/reactor)	Estimated total volume of thermal effluent			
					t/sec.	t/year	t/40 years	t/age
World	441	30.8†	372023†	843.6	26,042	8.21×10^{11}	3.29×10^{13}	2.53×10^{13}
Japan	55	24.8†	47535†	864.3	3,328	1.05×10^{11}	4.20×10^{12}	2.60×10^{12}
Northern	435	30.9†	367350†	844.5	25,715	8.11×10^{11}	3.24×10^{13}	2.51×10^{13}

Calculation

$$70\ (\text{tons/reactor}) \times \frac{844.5\ (\text{Mwe})}{1000\ (\text{Mwe})} \approx 60\ (\text{tons/reactor})$$

$$V \approx 60 \times 864000\ (\text{sec./day}) \times 365\ (\text{day/year}) \times 31\ (\text{year}) \times 435\ (\text{reactor}) \times \frac{70}{100} \approx 1.79\times10^{13}$$

$$S \approx \frac{61}{100} \times \frac{1}{2} \times 4\pi \times (6.37 \times 10^{6})^{2} \approx 1.56 \times 10^{14}\ \text{m}^2$$

$$\frac{V}{S} \approx \frac{1.79 \times 10^{13}}{1.56 \times 10^{14}} \approx 0.115\text{m}$$

Case	Total nuclear thermal effluent of 435 reactors in northern hemisphere	Depth of sea surface occupied by thermal effluent (cm) = thermal effluent volume/sea surface area
31 yrs at 70% of operating capacity	1.75×10^{13} t	11 cm depth (7°C rise)

†Average number of years of operation and total power output from World Nuclear Association, Nuclear Database 2011

Note: Calculation supported by N. Yoshida of Kansai University.

Assuming that the 435 reactors have an operating-capacity utilization rate of 70 percent, have operated for approximately 31 years, and cause a 7°C rise in 60 tons of water per second in the northern hemisphere, based on an average of 844.5 Mwe/reactor, this means that the total discharge volume of thermal effluent amounts to 17.9 trillion tons, forming a layer of approximately 11 cm on the northern hemisphere's sea surface that consists of thermal effluent heated to 7°C above the normal sea temperature or a layer of 77 cm at 1°C above (Table 3). In addition, due to convection in the atmosphere and water, temperatures are highest at the sea surface; seawater with high levels of salinity sinks, while the warming effect is greatest on the low-salinity upper layers of water, which stay on the sea surface. The greatest influence is therefore likely to be not on sea temperature as a whole but on sea-surface temperature. The sea covers approximately 70 percent of the earth's surface, and because heat energy is more easily stored in water than in the atmosphere, it is retained for longer periods with long-lasting effects.

3 DISASTER MANAGEMENT AND 'DISASTER ANCHOR'

3.1 Global Warming Compounded by CO_2 + Nuclear Heated Water

Figure 7 presents data on the deviation of 2013 sea-surface temperature from average values for the period 1981–2010 together with a map of the locations of nuclear power stations. As the figure shows, sea-surface temperature has risen mainly in the northern hemisphere, with a particularly high rate of rise in the North Atlantic, where there is a concentration of nuclear power stations, which may be due to the effect of thermal effluent. In a current-affairs program called *Close-up Gendai* made by the Japanese broadcaster NHK, it was suggested that the rise in sea-surface temperature shown in this figure could have repercussions as far away as Asia in the form of abnormal weather patterns and natural disasters such as floods and typhoons (NHK, August 29, 2013). The program thus sounded the alarm over the potential threat of 'teleconnection'.

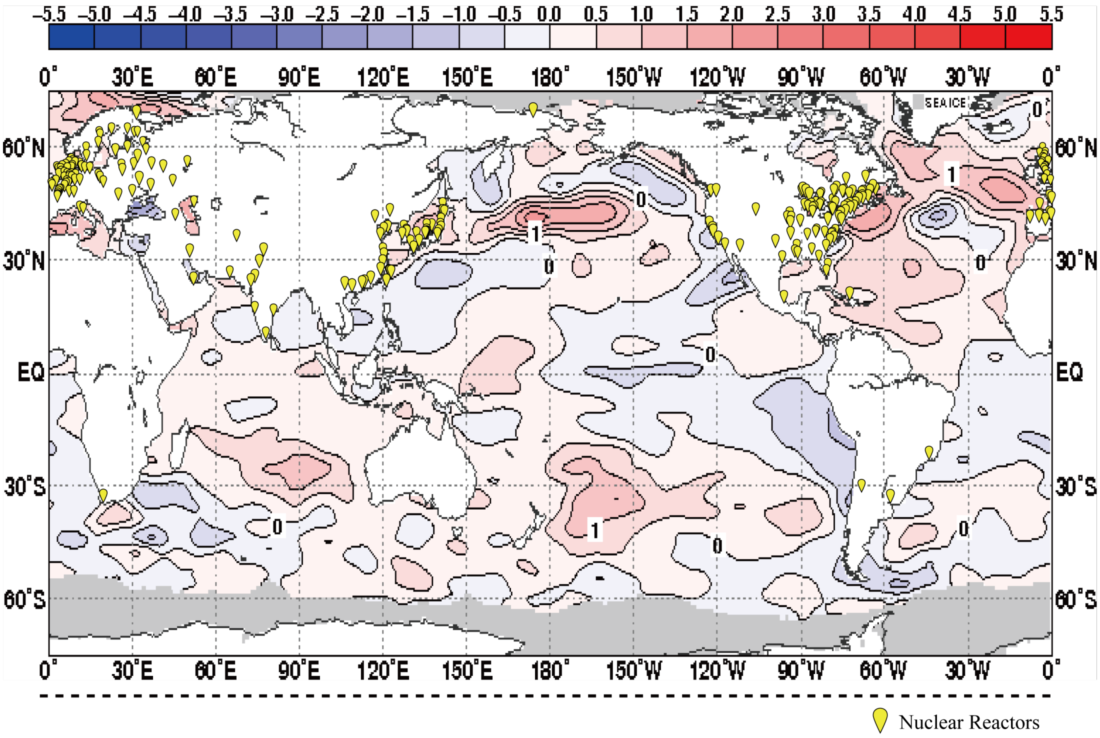

Figure 7. Climate crisis by nuclear-heated oceans (by *permission* of JMA)
Note: Redrawing of 'Teleconnection Curve' based on JMA map.
Source: JMA: Japan Meteorological Agency (URL: http://www.jma.go.jp/)

Approximately two months after the program was broadcast, on November 8, 2013, the largest typhoon ever recorded (Typhoon 30 named *Haiyan*) struck the Philippines and is estimated to have claimed over 10,000 lives, constituting a major disaster of previously unknown magnitude (NHK, November 18, 2013). The U.S. Navy's Joint Typhoon Warning Center reported it as the strongest-recorded typhoon at landfall, with maximum wind speed of 315 km/h and gusts of up to 378 km/h. Japan has also been hit by damage from unprecedented typhoons and torrential rain. In the season up to November 2013, 31 typhoons had been recorded, the first time since 1994 that the typhoon count had exceeded 30. The typhoons have also become increasingly powerful year after year, and the connection between this expanding scale and global warming has been pointed out in the Intergovernmental Panel on Climate Change (IPCC) reports (IPCC, 2013).

In the wake of the super-typhoon that hit the Philippines (with winds averaging 324 km/h, and atmospheric pressure of 945 hectopascals), every building on the island of Leyte was left flattened, an aftermath tragically similar to that of the Japanese earthquake and tsunami disaster of March 2011. The reach of the rainstorm's winds was limited by rising land, but the formidable winds destroyed all buildings, crops, and trees on Leyte. What caused this super-typhoon of a kind never before seen in human history? It was known already in August 2013 that the surface temperature of the sea off the Philippines had risen by 2–3°C. Together with the atmospheric warming caused by CO_2 and methane emissions, sea-temperature rise is an insidious threat. Nuclear effluent directly heats the ocean, unlike CO_2 and methane which hold thermal energy, the possibility of 'Climate Crisis.'

The rise in sea temperature causes a problem of increased seawater volume leading to sea-level rise due to the melting not only of the land-based ice at the poles but also the glaciers of eastern Siberia, Greenland, the Arctic and Antarctica ice sheets, and frozen seabed. The last of these causes methane gasification and further accelerates atmospheric warming. As for the buildup of nuclear thermal effluent over the years, those who have observed nuclear-power generation and have seen the amounts of effluent involved at first hand will, like me, have been overwhelmed by its scale. This year-on-year accumulation of nuclear thermal effluent, amounting to 17.9 trillion tons, whose temperature has been raised by 7°C in an 11-cm seawater layer (by 1°C in a 77-cm layer), cannot be ruled out as a factor in the abnormal weather patterns observed worldwide. Figure 8 shows the global surface temperature from average values for the period 1940-1980.

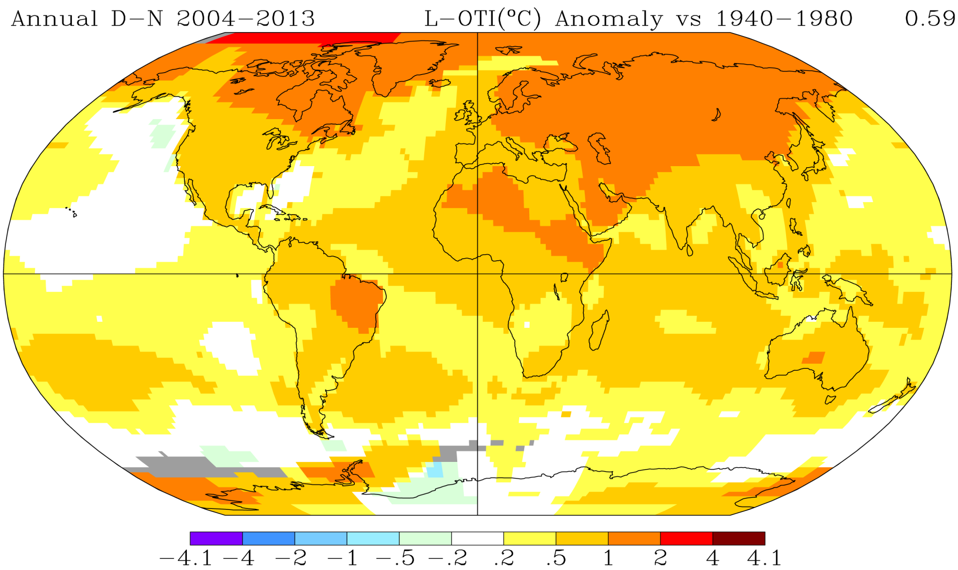

Figure 8. Global surface temperature analysis by NASA

Source data: NASA, GISS Surface Temperature Analysis (http://data.giss.nasa.gov/gistemp/maps/)

The IPCC also predicts a rise in atmospheric temperature of up to 4.8°C by 2100, which will be accompanied by an 82-cm rise in sea levels, while the 19th session of the Conference of the Parties to the United Nations Framework Agreement on Climate Change (COP19) in Warsaw, Poland, saw conflict as developing countries insisted that developed nations should compensate them for floods and typhoons caused by warming and for loss of submerged territory and other damage. This clash between developed and developing nations led to an impasse at the 2013 conference, which had to be extended. The extreme phenomena already being reported worldwide include unprecedented super-typhoons with air pressure under 900 hectopascals, great floods, summer snowfall in France, floods in Germany and Austria, landslides in Vietnam and Japan's Izu Islands, and massive tornados in America. Posited as a remote cause of this is a possibility of 'global ocean warming' caused by effluent from the nuclear power plants? If true, this demonstrates that 'a chain of human-made disasters adds up to the natural disaster' and that ultimately the two types of disaster are intertwined via teleconnection.

In a project to predict the situation with global warming around the end of the 21st century, conducted by research groups including the Meteorological Research Institute of the Japan Meteorological Agency and the Advanced Earth Science and Technology Organization (Meteorological Research Institute of JMA and AESTO), it is stated that the number of very strong tropical low-pressure systems with maximum wind speeds over sea or land of more than 162 km/h is on a rising trend due to the increasing scale worldwide of typhoons, hurricanes, and cyclones, with a rise in sea level caused by extremely low air pressure like the 895 hectopascals of the Haiyan super typhoon of 2013, and other weather events accompanying global warming. If human activity, including such thermal effluent, is promoting global warming, then there is, underlying natural disasters such as typhoons and torrential rain, floods and earthquakes, an accumulation of human-made disasters. As with the Fukushima nuclear disaster, which arose out of the Great East Japan Earthquake, there are cases where natural disasters develop into human-made disasters; but conversely, there are also cases where natural disasters develop out of unnatural disasters. The cumulative chain of human cooperation thus creates a situation where 'human-made disasters and natural disasters are interconnected', and contributes to the un-safety.

Even more so than the global warming caused by the protected thermal energy of the globe by CO_2 and methane, the 'boiling globe' effect of the total thermal energy of the globe by heated water has the potential to produce 'unexpected consequences'. For instance, the permanently frozen glaciers of Greenland and Antarctica could melt under the influence of global warming and form a moraine. The moraine would cause water to flow in and gather two to three kilometers below the ice sheet, which would lift the glacier so that the whole ice cap might plunge into the sea in one piece, setting off a huge wave. As the ice cap lifted with further melting, the rising sea-levels of the continents of Greenland, Siberia, the Arctic and Antarctica, which had until then been subject to subsidence of several kilometers, might suddenly be forced upward and release a tsunami. In such an event, there would be a threat of un-safety to the coastlines of countries around the North Sea, such as Norway, Iceland, and Great Britain.

The nuclear accidents and the possibility of warming caused by thermal effluent accumulation, which are presented here as examples, point precisely to the 'interconnection of human-related natural disasters'. This highlights further aspects of the multiple impacts of nuclear power on the environment, including atmospheric and marine pollution in the event of an accident, and thermal effluent. The impact on the environment means direct impact on the ecosystem and people living in the environment. Going forward, in response to the danger which has passed the limits of manageability by businesses and central governments, there is a need for a preventive social function to oppose the collusive relationship between business management and government policy over nuclear power. Essential here is a global eco-civilization in which individual citizenship has preventive power.

3.2 Viral Outbreaks Caused by Global Warming

New viral strains and infectious diseases are one form of 'unsafety threatening humankind'. Historically, tuberculosis, cholera, plague, influenza, AIDS, and other infectious diseases have claimed many victims. More recently, the worldwide spread of SARS and avian influenza in 2003 is fresh in our memory. There are fears of epidemics of the three major infectious diseases (AIDS, malaria, and tuberculosis) arising from the 'biological hazard' caused by the world population explosion to 7.2 billion. The particular danger of biological hazard is its exponential pattern of spread. Explosive damage arises through bacterial and viral infection via living organisms, person-to-person infection, or cross-species infection, for example from cattle to humans through bovine spongiform encephalopathy (BSE), variant Creutzfeld-Jakob disease (vCJD), and foot-and-mouth disease. Moreover, rubella infection in pregnant women may cause cataracts and glaucoma, congenital heart disease, hearing impairment, and other conditions in the fetus, while congenital rubella syndrome (CRS) poses the risk of damage to the next generation. Whether this is regarded as a case of human-made or natural selection, the result is the same: the disaster leads to an indivisible resonance phenomenon, the negative interaction of which causes the accelerated spread of 'unsafety'.

The WHO has published Figure 9 worldwide to signal the risk from biological hazards. The northward spread of infectious tropical diseases caused by recent global warming is proceeding at an ever-accelerating pace. Among the hazards facing the world, the proportion represented by these biological hazards is second in number only to natural disasters such as earthquakes, tsunamis, volcanoes, typhoons and hurricanes, and accounts for one-third of all hazards.

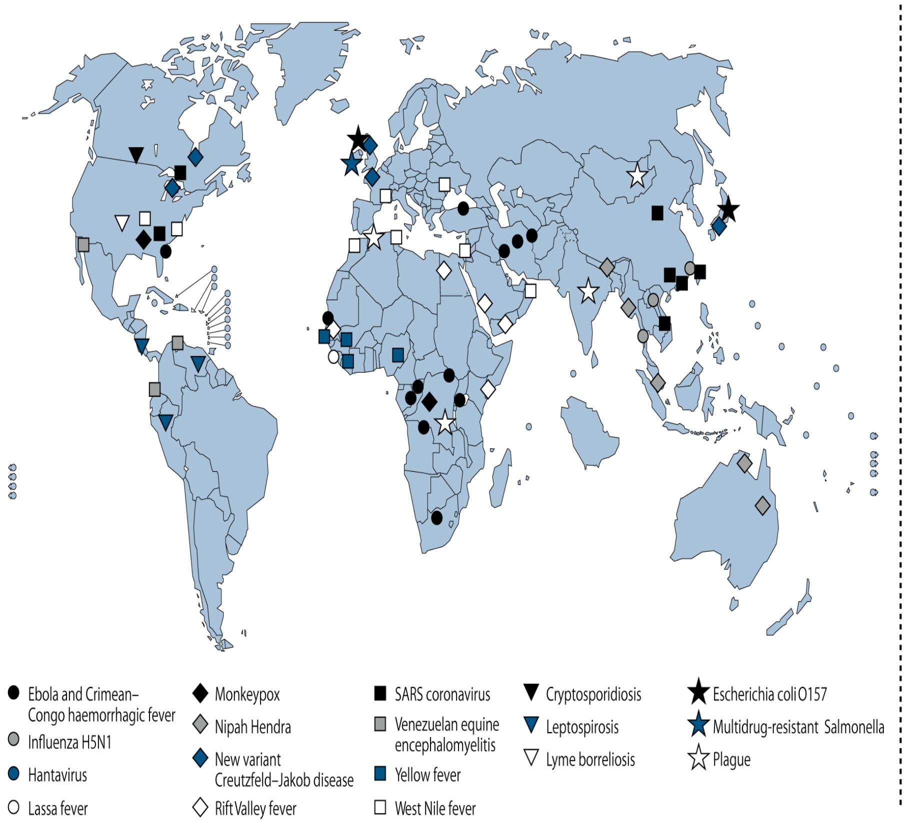

Figure 9. Selected emerging and re-emerging infectious diseases: 1996–2004
Source: WHO, *World Health Report 2007: A Safer Future: Global Public Health Security in the 21st Century*, p. 12.

Meanwhile, there is concern that global warming's disruption of the energy balance may allow the spread of infectious tropical diseases to the northern hemisphere. The serious prevalence of West Nile fever in the United States resulted from its being spread to the temperate zone of North America by travelers. In Japan, similarly, the example of the redback spider (*Latrodectus hasseltii*), which was discovered in Osaka Prefecture and has extended its habitat to the whole country, demonstrates that this is not an insubstantial problem. In particular the recent prevalence of Dengue fever, whose incidence has increased thirty-fold in the last fifty years, means that over 100 countries are threatened by the growth of the domain of infection (WHO, 2012). Figure 10 shows areas with high risk of Dengue-fever infection as of 2011. The lines to the north and south of the figure indicate the minimum temperature of 10°C delineating the habitat limit of the mosquito that transmits the Dengue-fever virus. Advancing northward like an army, global warming is extending the habitat of the mosquitoes that transmit tropical viruses and is pushing the infection toward the northern hemisphere, which has a large land mass and is home to a large proportion of the human race. This poses a threat to the populations of these areas, who have no experience of or resistance to tropical viruses, diehard by global-warming.

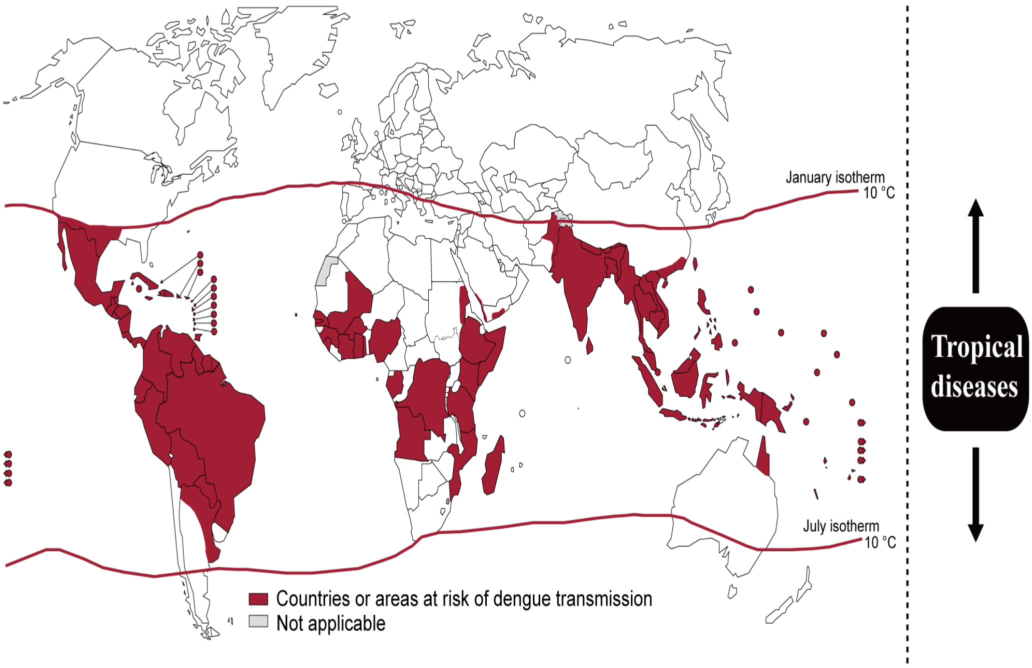

Figure 10. Global distribution of countries or areas at risk of Dengue transmission, 2011

Note: Based on the discussions with participants at 'Climate Change and Global Warming' of WWF Japan, 2011.
Source: 'Sustaining the drive to overcome the global impact of neglected tropical diseases', WHO, 2012, p. 25.

Not only the abovementioned infectious tropical diseases transmitted by bacteria and viruses, but also the risk of infection spread through global warming and the resulting crisis, will be of increasing concern going forward. For instance, since cholera bacteria live in symbiosis with plankton in seawater, the rise in sea temperatures, causing plankton to breed more prolifically, also leads to an increase in cholera bacteria, which has extended its infection zone northward. Already, it is reported that the 1991 El Niño phenomenon in South America has led to sharp year-on-year increases in cholera cases. The IPCC report from the end of September 2013 states that the world's average atmospheric temperature rose by 0.85 degrees from 1880 to 2012 and predicts that the temperature rise by the year 2100 will be up to a maximum of 4.8°C, leading to fears of a 'Global Big Melt', which will precipitate a worldwide struggle over water and food resources (IPCC, 2013). The freshwater available on the planet for human consumption as drinking water is said to represent 0.008 percent of all the earth's H_2O, so a Global Big Melt would mean the depletion of the water resources for the human population of 7.2 billion now. Especially in the northern hemisphere, which contains a high proportion of the planet's land mass, the melting of glaciers and permafrost soil to which the Big Melt refers is predicted to lead to the spread of viral infection to previously unaffected areas. Combined with 'trans-global' movement of travelers and migrants, and biological weapons, terrorism, and other disasters arising from human-made unsafety, these outbreaks could spread worldwide.

3.3 'Disaster Anchor' based on Fukushima Experiences: Psychological and Cultural Aspects

Humanity faces a large number of dangers as the unsought consequences of civilization, from human-made disasters such as those caused by nuclear power and natural disasters of increasing scale to the poleward spread of infectious tropical diseases caused by global warming. This means that the time has come to increase resilience to these disasters and work toward a 'low-disaster society' through disaster management. Figure 11 represents the structure of disaster management, focusing on individual psychology in addition to unsustainability from the perspective of social organization and disaster complexity from the perspective of phenomenology.

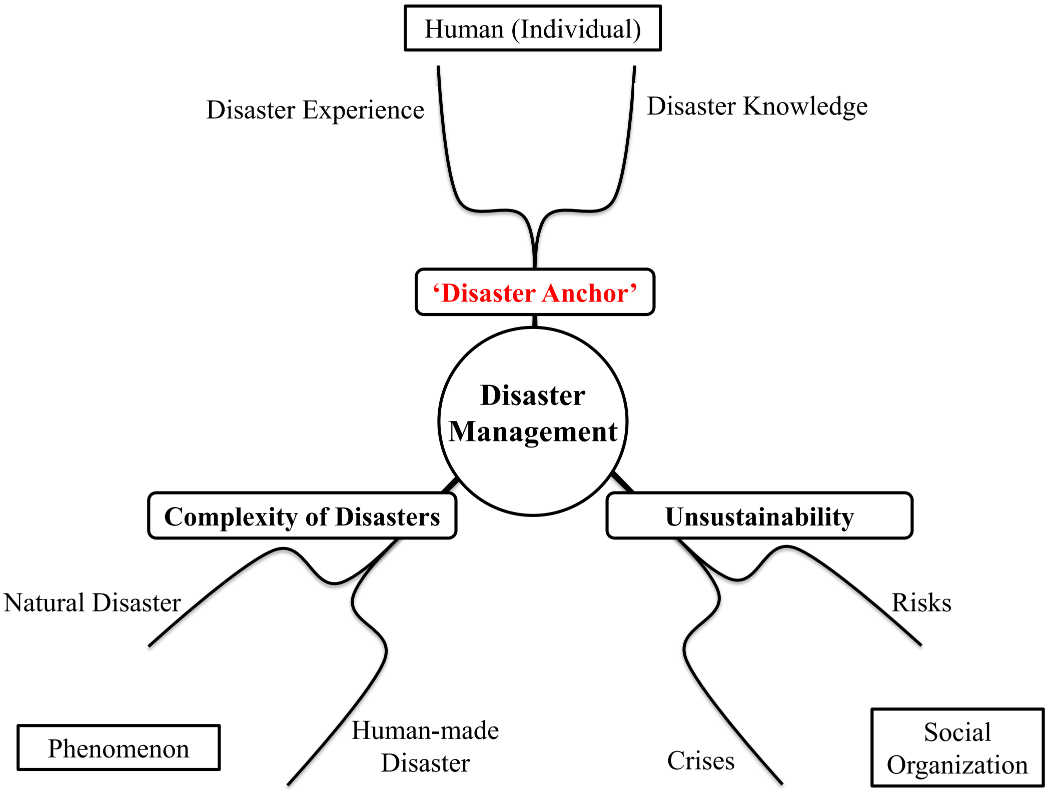

Figure 11. Disaster anchor: structure of disaster management

Based on E. H. Schein's concept of 'career anchors' (Schein, 1978), which are a set of psychological motives that form the basis of career attitudes, disaster anchors are psychological motives formed by the individual's experience of disaster. For the Japanese, the Great East Japan earthquake and tsunami and the radioactive contamination in the wake of the Fukushima nuclear disaster represent powerful and symbolic anchors etched into the psyche by the actuality of individual experience, and they continue to influence subsequent decision-making and behavior. When the disaster and accident experience at the foundation of individual psychology, like the anchor of a ship, is shared at the level of the deep psychology of the individuals with expanded to the local community, it becomes a cultural anchor. The shared disaster anchor is transmitted to posterity through physical monuments and oral communication together with records and memories of the disaster. This process can be said to determine the direction of disaster prevention and limitation policy.

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